

HIGHLY ACCURATE LINEAR CLASSIFIER WITH APPLICATIONS IN HEALTH  
INSURANCE COVERAGE

Songkomkrit Chaiyakan

A Dissertation Submitted in Partial Fulfillment of the Requirements  
for the Degree of Doctor of Philosophy Program  
in Business Analytics and Data Science  
Graduate School of Applied Statistics  
National Institute of Development Administration  
Academic Year 2024

Copyright of National Institute of Development Administration

|                |  |
|----------------|--|
| Thesis Title   | HIGHLY ACCURATE LINEAR CLASSIFIER WITH APPLICATIONS IN HEALTH INSURANCE COVERAGE |
| By             | Songkomkrit Chaiyakan  |
| Field of Study | Business Analytics and Data Science  |
| Thesis Advisor | Assistant Professor Preecha Vichitthamaros, Ph.D.                                |

---

Accepted by Graduate School of Applied Statistics, National Institute of Development Administration in Partial Fulfillment of the Requirements for the Doctoral Degree

..... Dean of Graduate School of Applied Statistics  
(Siwiga Dusadenoad, Ph.D.)

#### DISSERTATION COMMITTEE

..... Chairman  
(Associate Professor Ohm Sornil, Ph.D.)

..... Thesis Advisor  
(Assistant Professor Preecha Vichitthamaros, Ph.D.)

..... Examiner  
(Associate Professor Surapong Auwatanamongkol, Ph.D.)

..... Examiner  
(Associate Professor Pachitjanut Siripanich, Ph.D.)

..... External Examiner  
(Assistant Professor Boonyarit Intiyot, Ph.D.)

## 6310432002: MAJOR BUSINESS ANALYTICS AND DATA SCIENCE

KEYWORDS: BOX CLASSIFICATION / OPTIMIZATION / 0-1 MIXED INTEGER PROGRAMMING / DIMENSIONALITY REDUCTION / CONTINUOUS DATA / CATEGORICAL DATA / HEALTH INSURANCE

SONGKOMKRIT CHAIYAKAN: HIGHLY ACCURATE LINEAR CLASSIFIER WITH APPLICATIONS IN HEALTH INSURANCE COVERAGE. ADVISOR: Assistant Professor Preecha Vichitthamaros, Ph.D., 485 pp.

This work proposes a multiclass box classifier both theoretically and empirically proven to produce the highest training accuracy through the rigorous formulation of 0-1 mixed integer programming problem. It can also determine significant factors. Unlike a decision tree classifier well-known for simplicity and fast execution, the proposed classifier has control over a maximal number of features of interest, whether continuous or categorical, and a number of splitting values on all features. The use of this method is illustrated on 2020 Current Population Survey (CPS) Annual Social and Economic Supplement (ASEC) health insurance dataset with, as a result of the exponential time complexity of the model, only three independent variables univariately preselected by the SelectKBest technique. Compared to decision tree classifiers of different depths, the proposed classification model can keep a balance between the number of total splitting values and the number of decision boxes, and it achieves a relatively high training accuracy at the expense of significantly high computational time and storage usage. Nonetheless, both give the same set of contributing factors. The fast algorithm of decision box merging is also suggested when the number of selected features can be further reduced after optimization.

|                  |  |                           |
|------------------|--|---------------------------|
| Graduate School: | Applied Statistics                     | Student's Signature ..... |
| Field of Study:  | Business Analytics and<br>Data Science | Advisor's Signature ..... |
| Academic Year:   | 2024                                   |                           |

## Acknowledgements

I would like to express my thankfulness to my dissertation advisor Assistant Professor Preecha Vichitthamaros for his consistent help throughout the entire dissertation. Further thanks extend to Jessica Barnett and Laryssa Mykyta, U.S. Census Bureau, for their advice on public use files and technical documentation of Current Population Survey (CPS) Annual Social and Economic Supplement (ASEC) health insurance datasets. I am especially indebted to my parents, Songsak and Kanjanee, and to my sister, Kanokkan, for their continual support, encouragement, and love. This dissertation is partially supported by National Institute of Development Administration for publication and Google Cloud research program for free access to a remote compute engine.

# Contents

|  | Page     |
|--|----------|
| <b>Abstract</b> . . . . .                          | iii      |
| <b>Acknowledgements</b> . . . . .                  | iv       |
| <b>Contents</b> . . . . .                          | v        |
| <b>List of Tables</b> . . . . .                    | vii      |
| <b>List of Figures</b> . . . . .                   | viii     |
| <b>List of Codes</b> . . . . .                     | ix       |
| <b>Nomenclature</b> . . . . .                      | x        |
| <b>Chapter</b>                                     |          |
| <b>1 Introduction</b> . . . . .                    | <b>1</b> |
| 1.1 Objectives . . . . .                           | 2        |
| 1.2 Limitations . . . . .                          | 2        |
| <b>2 Literature Review</b> . . . . .               | <b>3</b> |
| 2.1 Health Insurance Coverage . . . . .            | 3        |
| 2.2 Feature Selection . . . . .                    | 4        |
| 2.2.1 Decision Tree . . . . .                      | 4        |
| 2.2.2 SelectKBest . . . . .                        | 4        |
| <b>3 Research Methods</b> . . . . .                | <b>6</b> |
| 3.1 Overview . . . . .                             | 6        |
| 3.2 SSH Key Generation . . . . .                   | 6        |
| 3.3 Remote Virtual Machine Setup . . . . .         | 9        |
| 3.3.1 Specifications . . . . .                     | 9        |
| 3.3.2 SSH Key-Based Authentication . . . . .       | 9        |
| 3.3.3 Python Installation . . . . .                | 9        |
| 3.3.3.1 Introduction to Compilation in C . . . . . | 10       |
| 3.3.3.2 Basic Object Types . . . . .               | 10       |
| 3.3.3.3 String Interning . . . . .                 | 13       |
| 3.3.3.4 Configuration and Build . . . . .          | 14       |
| 3.3.4 Backup to OCI Object Storage . . . . .       | 17       |
| 3.3.4.1 Introduction to OCI . . . . .              | 17       |
| 3.3.4.2 OCI Object Storage . . . . .               | 18       |
| 3.4 GitHub Repository . . . . .                    | 19       |

| Chapter   | Page       |
|---|------------|
| 3.5 Health Insurance Dataset . . . . .                        | 22         |
| 3.5.1 Background . . . . .                                    | 22         |
| 3.5.2 Scope of Study . . . . .                                | 23         |
| 3.5.3 Metadata . . . . .                                      | 23         |
| 3.5.4 Python Modules . . . . .                                | 105        |
| 3.5.5 Python Classes . . . . .                                | 113        |
| 3.5.6 Exploratory Data Analysis (EDA) . . . . .               | 119        |
| 3.5.7 Data Encoding . . . . .                                 | 234        |
| 3.5.8 Sampling using SelectKBest . . . . .                    | 237        |
| 3.5.9 Setting Number of Variable Splits . . . . .             | 240        |
| <b>4 Proposed Classifier . . . . .</b>                        | <b>243</b> |
| 4.1 Proposed Model for Selecting Continuous Factors . . . . . | 243        |
| 4.2 Selection of Mixed-Type Features . . . . .                | 248        |
| 4.3 CPLEX OPL Modeling . . . . .                              | 252        |
| 4.4 Recalculation of Decision Boxes . . . . .                 | 276        |
| <b>5 Results on Health Insurance . . . . .</b>                | <b>314</b> |
| 5.1 Training Data . . . . .                                   | 314        |
| 5.2 Decision Tree . . . . .                                   | 317        |
| 5.3 Proposed Model . . . . .                                  | 326        |
| <b>6 Concluding Remarks . . . . .</b>                         | <b>377</b> |
| <b>Appendix</b>   |            |
| <b>Appendix A CPLEX Engine Log . . . . .</b>                  | <b>380</b> |
| <b>Biography . . . . .</b>                                    | <b>485</b> |

## List of Tables

| Table   | Page |
|---|------|
| 3.1 Example of advanced NTFS permissions in Windows . . . . .   | 8    |
| 3.2 Python options for third-party dependencies . . . . .   | 16   |
| 3.3 Basic Git commands . . . . .  | 19   |
| 3.4 Class codes of insurance coverage combination . . . . .   | 23   |
| 3.5 Categories of health insurance factors . . . . .  | 120  |
| 3.6 Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) . . . . . | 124  |
| 4.1 Relevant CPLEX parameters . . . . .   | 252  |
| 5.1 Cross tabulation of sample data by preselected variables and health insurance coverage types . . . . .  | 315  |
| 5.2 Comparison between multiple decision tree and proposed classifier . . . . .   | 328  |
| 5.3 Splitting values on features of multiple decision tree and proposed classifier . . . . .  | 329  |
| 5.4 Training accuracy, execution time, minimum storage usage, relative MIP gap and number of inconsistent data across all iterations . . . . .  | 330  |
| 5.5 Selected variables and groups of values across all iterations . . . . .   | 331  |
| 5.6 Decision regions and predicted class labels across all iterations . . . . .   | 341  |
| 5.7 Inconsistency between numerical CPLEX and true decision regions . . . . .   | 353  |

# List of Figures

| Figure   | Page |
|--|------|
| 3.1 Directory tree structure of the template GitHub repository . . . . . | 21   |
| 5.1 Decision tree with depth 3 and 8 leaf nodes . . . . .                | 317  |
| 5.2 Decision tree with depth 4 and 12 leaf nodes . . . . .               | 319  |
| 5.3 Decision tree with depth 5 and 16 leaf nodes . . . . .               | 320  |



# List of Codes

| Code  | Page |
|---|------|
| 3.1 Utility module . . . . .                            | 105  |
| 3.2 Encoding module . . . . .                           | 106  |
| 3.3 Dataset module . . . . .                            | 107  |
| 3.4 EDA module . . . . .                                | 109  |
| 3.5 ThesisExtension class . . . . .                     | 113  |
| 3.6 Data class . . . . .                                | 116  |
| 3.7 Info class . . . . .                                | 118  |
| 3.8 Exploratory data analysis (EDA) . . . . .           | 232  |
| 3.9 Data encoding . . . . .                             | 234  |
| 3.10 SelectKBest . . . . .                              | 237  |
| 3.11 Setting number of variable splits . . . . .        | 241  |
| 4.1 Main OPL model . . . . .                            | 253  |
| 4.2 Box classifier OPL model . . . . .                  | 271  |
| 4.3 Basic utility for recalculation of region . . . . . | 278  |
| 4.4 Typecasting . . . . .                               | 284  |
| 4.5 Recalculation of regions . . . . .                  | 286  |
| 4.6 Feature selection . . . . .                         | 290  |
| 4.7 Cuts or split values . . . . .                      | 291  |
| 4.8 True decision regions . . . . .                     | 294  |
| 4.9 CPLEX decision regions . . . . .                    | 296  |
| 4.10 Classification correctness . . . . .               | 298  |
| 4.11 Final mixed box classifier . . . . .               | 300  |
| 5.1 Gini-based decision tree classifier . . . . .       | 321  |

# Nomenclature

|                                     |   |
|-------------------------------------|---|
| $\tilde{d}$                         | full dimension of given training instances  |
| $d$                                 | number of both continuous and categorical features of interest  |
| $d_{\text{cat}}$                    | number of categorical features of interest  |
| $\tilde{\mathcal{C}}_{\text{cont}}$ | index set of given continuous features  |
| $\tilde{\mathcal{C}}_{\text{cat}}$  | index set of given categorical features   |
| $\mathcal{C}_{\text{cont}}$         | index set of new continuous features before optimization  |
| $\mathcal{C}_{\text{cat}}$          | index set of intermediate categorical features before optimization  |
| $\tilde{x}^i$                       | given training instance $i$   |
| $x^i$                               | training instance $i$ as a classifier input of lower continuous and full categorical dimensions             |
| $x_j^i$                             | value of feature $j$ of instance $x^i$  |
| $y_k^i$                             | whether a given instance $\tilde{x}^i$ is in class $k$  |
| $c_{j,\tilde{j}}$                   | whether a new continuous feature $j$ comes from an original continuous feature $\tilde{j}$                  |
| $f_j$                               | whether categorical feature $j$ is selected or, equivalently, significant                                   |
| $p_j$                               | number of splitting values on feature $j$   |
| $b_{j,q}$                           | $q^{\text{th}}$ splitting value on continuous feature $j$   |
| $u_j$                               | new group labels on categorical feature $j$   |
| $v_{j,x_j^i}$                       | new group label of instance $x_j^i$ on categorical feature $j$  |
| $B$                                 | number of total decision boxes  |
| $S_\beta$                           | $\beta^{\text{th}}$ decision box  |
| $\alpha_{j,q}^i$                    | whether $x_j^i$ is in open interval $(b_{j,q}, b_{j,q+1})$  |
| $M$                                 | sufficiently large positive number  |
| $m_j$                               | sufficiently small positive number on feature $j$ that can distinguish individual feature values of $x_j^i$ |
| $l_{j,q}^i$                         | $\alpha_{j,q}^i(b_{j,q} + m_j)$   |
| $r_{j,q}^i$                         | $\alpha_{j,q}^i(b_{j,q+1} - m_j)$   |
| $\gamma_\beta^i$                    | whether instance $x_j^i$ is in decision box $S_\beta$   |
| $\Theta_\beta$                      | set of most frequent classes in decision box $S_\beta$  |
| $h_\beta$                           | negative value of number of correctly classified training instances   |

# CHAPTER I

## INTRODUCTION

Social science research heavily relies on the traditional use of logistic regression or structural equation modeling (SEM) to explore or confirm the linkage between multiple factors with the ultimate goal of causal explanation. In addition to the significance test of coefficients, the utilization of mediators, moderators, confounders and covariates provides the convincing magnitude and direction of estimated effects. On the rare occasion of classification with numerous independent variables measured on nominal scales, the excessive number of required dummy variables nevertheless imposes a limitation on these two approaches.

To address this problem, classification algorithms in machine learning are used to identify key characteristics of a separate group despite lack of important statistical tests. For example, a decision tree constructs a set of rules individually formed by minimal attributes to fully describe a training data, and a neural network employs a hidden layer to account for nonlinear interaction between attributes and therefore increases model accuracy. The first maximizes an information gain, whereas the latter minimizes a residual sum of square. Both objective functions are usually smooth and enable real-time data processing.

Despite their advantage, a decision tree and a neural network may provide undesirable inaccuracy, evidently because their performance metrics are not accuracy. As a result, a multiclass box classifier developed from conventional support vector machine (SVM) through the application of 0-1 mixed integer linear programming (MILP) by counting the number of misclassified instances through majority voting will be proposed in the dissertation to ensure maximum accuracy without overfitting simply due to its linearity. In this case, external testing seems redundant unless a training data contains an outlier. As early-stage research, the classifier will serve no purpose of real-time analytics. This modified approach will be adopted for illustrative purposes to examine without consideration of interrelationship contributing factors, including their groups of values, on coverage types of health insurance in the United States in 2019. The classification model is trained on the entire survey data because in this dissertation all responses collected from different participants are of equal importance and no prediction about future health insurance coverage is made.

## 1.1 Objectives

1. To propose a multiclass box classifier that yields highest training accuracy.
2. To apply the proposed classification method to investigate significant factors, whether continuous or categorical, influencing health insurance coverage.

## 1.2 Limitations

1. Nonlinear classification in addition to logistic regression are beyond the scope of the study because no interaction between health insurance factors is investigated and splitting values on any two factors should be independent.
2. The health insurance sample data only includes Americans. It was collected in 2020 to reflect health insurance coverage for entire calendar year 2019.
3. Despite its high training accuracy, the proposed classifier takes a significantly long training time and requires enormous space to store a branch-and-cut tree. Its approximation algorithm is not developed in this dissertation although mitigating both problems to some extent. Furthermore, only three factors are preselected and investigated with a sample size of 100. Even in this simple circumstance, the model training lasts longer than a day, but the early-exit classifiers are nonetheless more accurate and parsimonious than a Gini-based decision tree.

# CHAPTER II

## LITERATURE REVIEW

### 2.1 Health Insurance Coverage

A variety of statistical tools have long been used to study the factors related to health insurance coverage of multiple subpopulations across different countries. These analytical techniques include linear probability modeling (Cebula, 2006), probit regression analysis (Mulenga et al., 2021) and logistic regression analysis (Jin et al., 2016; Dolinsky and Caputo, 1997; Markowitz et al., 1991).

Generally, health insurance coverage across the U.S. states was positively associated with median family income, female labor force rate, the proportion of population aged 65 and over, and it was negatively linked with the percentages of household with husband absence and Hispanic household (Cebula, 2006). Psychological characteristics also greatly affected the influence of demographic factors among American women (Dolinsky and Caputo, 1997). After controlling for psychological variables, health status and employment were significant determinants only for married and unmarried women respectively. Income and education played important roles in both groups. Americans aged 18 to 24 with permanent, full-time employment were more likely to be insured than those with permanent, part-time employment (Markowitz et al., 1991). This trend became reverse specifically for the students. Low income, less education, rural residence, unmarried status, Hispanic ethnicity and Western residency were indicators of being uninsured in general.

Outside the United States, many research works on health insurance coverage have also been of interest. Income, education, health status and employment correlated with the coverage types among Chinese people aged 45 and over (Jin et al., 2016). Males dominated in both public and private health insurance. Migrants appeared to be covered by both rural and urban public insurance, private insurance or no insurance in comparison to local residents. Rural residents were more inclined to have public insurance coverage. Furthermore, private health insurance in Zambia tended to be purchased by males with service, skilled and unskilled occupations and rural residency as well as women in marital union and clerical duties (Mulenga et al., 2021).

## 2.2 Feature Selection

### 2.2.1 Decision Tree

Each parent node partitions a feature space by splitting a specific training variable into two intervals, left and right nodes (Scikit-learn, 2024a). A splitting value is chosen to minimize the weighted average of the impurities of both child nodes by their number of training instances. This dissertation uses as an impurity measure the Gini index defined by the probability of a sample at a node being wrongly classified.

A categorical feature can be handled by one-hot encoding. A multiway tree can be transformed into a binary tree by performing the following operation recursively. For a node having more than two successors, its new successor is created by negating the predicate of one of its preexisting successors and becomes the predecessor of the rest. This procedure maintains the decision regions.

### 2.2.2 SelectKBest

The SelectKBest technique (Scikit-learn, 2024b) serving as univariate feature selection finds top  $K$  features relating to a target variable based on a score function, for example the mutual information for a discrete target in this dissertation. The mutual information (Cover and Thomas, 2005) is a statistic for measuring relationship between two random variables or in practice two datasets.

**Definiton 2.1.** The *Kullback-Leibler distance*  $D(f||g)$  between two densities  $f$  and  $g$  is defined by

$$D(f||g) = \int f \log \frac{f}{g}.$$

**Definiton 2.2.** The *mutual information*  $I(X;Y)$  between two random variables with joint density  $f(x,y)$  is defined as

$$I(X;Y) = D(f(x,y)||f(x)f(y)).$$

Two random variables share no mutual information, i.e.  $I = 0$ , only when both are independent. Suppose  $X$  is a training variable and  $Y$  a discrete target or class. A continuous feature requires an estimation of mutual information, for example by the  $k$ -nearest neighbor method (Ross, 2014), because its true probability remains practically unknown. Suppose the  $k$ -nearest neighbor of a training instance  $x^i$  of the same class has  $m_i$  instances of all classes and there are  $N_i$  out of  $N$  that share the same class with  $x^i$ . Compute

$$I_i = \psi(N) - \psi(N_i) + \psi(k) - \psi(m_i)$$

where the digamma function  $\psi$  is the logarithmic derivative of the gamma function. The mutual information  $I(X; Y)$  is estimated by averaging  $I_i$  over all training instances.

**Definiton 2.3.** The *gamma function*  $\Gamma$  and *digamma function*  $\psi$  are defined on the set of positive real numbers by

$$\Gamma(z) = \int_0^{\infty} t^{z-1} e^{-t} dt$$

and

$$\psi(z) = \frac{d}{dz} \log \Gamma(z)$$

respectively.

# CHAPTER III

## RESEARCH METHODS

### 3.1 Overview

1. Propose a multiclass box classifier which is able to predict continuous contributing factors, produces disconnected decision regions and provides minimum misclassification.
2. Extend the classifier when certain features of training data are allowed to be categorical.
3. Connect to a cloud virtual machine using secure shell (SSH) and install Python from source as well as CPLEX.
4. Illustrate the use of the proposed classification method on the health insurance dataset.
5. Compare multiple facets of results with the use of a decision tree.
6. Back up the scripts and results to Oracle Cloud Infrastructure (OCI) Object Storage.
7. Publish the project to GitHub.

### 3.2 SSH Key Generation

The Secure Shell (SSH) protocol is employed for secure connection to a remote compute engine through one-way client authentication by a pair of asymmetric keys: private and public. SSH keys can be generated with the OpenSSH command `ssh-keygen` by using a native SSL/TLS library provided by an operating system: Secure Channel (Schannel) in Windows or OpenSSL in Linux. The latter keys are very specific to a currently active OpenSSL version especially when an alternative OpenSSL is manually built and installed. In this dissertation, the SSH keys are created on a local computer with the elliptic-curve Ed25519 algorithm (Bernstein et al., 2012), proven to be faster and more efficient than the RSA algorithm (Rivest et al., 1978).

```
cd ~/.ssh  
ssh-keygen -f <output_keyfile> -C <comment> -t ed25519
```

A Google Cloud virtual machine requires the comment at the end of a public key file to be a Google username.



Since the dissertation results are uploaded to a GitHub repository using SSH, an additional key pair specific to this purpose is suggested to tighten security. Unless the default private key `id_rsa` is used for authentication, a `Host` (named host) must be specified in the configuration file `~/.ssh/config` by, for example, `HostName`, `User` (username) and `IdentityFile` (path to a private key file). The `Host` field can have wildcard patterns to match multiple hosts. If it contains an IP address or a domain name, the `HostName` field becomes unnecessary.

```
Host <named_host>
    HostName <hostname>
    User <username>
    IdentityFile <private_keypath>
```

Unlike Windows, Linux has the `.ssh` directory hidden, directly by the use of a dot character at the beginning, and partially inheritable POSIX access control list (ACL). A Linux parent directory does not reapply its new ACL to existing descendants, and it simply acts as during path resolution a gate with its execute permission. An SSH connection may be refused in the case of loose private key permissions to prevent privilege escalation attacks. In order to resolve this issue, the principle of least privilege (PoLP) should always be applied to generated keys. Basically, only a key owner can read his/her private key, and the read-only permission on a public key can be granted up to everyone.

In Linux, there are three POSIX permission levels: owner, group and other. Each level is represented by three permission bits: read (r), write(w) and execute (x). They are usually rewritten in base 10, ranging from 0 to 7. The `chmod` command is used to set all three levels of permission with three numerical digits.

```
chmod 400 <private_key>
chmod 444 <public_key>
```

In Windows, the command `icacls` is used, and additional rights can be denied due to more fine-grained permission control as displayed in Table 3.1. An SSH key should be hidden and have no inherited NTFS permission. Its ownership should also be nontransferable. In this dissertation, a key pair is generated on a personal computer (PC) on which the key owner is the only administrator. Under this circumstance, the private key is not accessible to the SYSTEM account. Furthermore, the Administrators group can only read, but neither change nor delete, its content, regular and extended attributes, and permissions. This set of access privileges on the public key can also be granted up to the Everyone group and the SYSTEM account.

```

icaccls <key> /inheritancelevel:d
icaccls <key> /grant ${Env:USERNAME}:F Administrators:F SYSTEM:F `
    Everyone:F
attrib +h <key>
icaccls <key> /remove ${Env:USERNAME} Administrators SYSTEM `
    Everyone
icaccls <key> /deny "${Env:USERNAME}:(WD,AD,WA,WEA,DE,WDAC,WO)" `
    "Administrators:(WD,AD,WA,WEA,DE,WDAC,WO)"
icaccls <key> /grant ${Env:USERNAME}:R Administrators:R
icaccls <private_key> /deny SYSTEM:F
icaccls <public_key> /deny "SYSTEM:(WD,AD,WA,WEA,DE,WDAC,WO)" `
    "Everyone:(WD,AD,WA,WEA,DE,WDAC,WO)"
icaccls <public_key> /grant SYSTEM:R Everyone:R

```

Table 3.1: Example of advanced NTFS permissions in Windows

| Permission | Description                     |
|------------|---------------------------------|
| WD         | Write data or add file          |
| AD         | Append data or add subdirectory |
| WA         | Write attributes                |
| WEA        | Write extended attributes       |
| DE         | Delete                          |
| WDAC       | Write DAC (change permissions)  |
| WO         | Write owner (take ownership)    |

### 3.3 Remote Virtual Machine Setup

#### 3.3.1 Specifications

All codes are executed on a Google Cloud compute engine with a 64-bit 8-vCPU 4-core CPU, 64 GB RAM and 250 GB SSD persistent disk running on Ubuntu Server 24.04 LTS. The instance locates in region `us-central1` (Iowa) and zone `us-central1-f`. The standard provisioning model, although noticeably more high-priced than the spot counterpart, is chosen to prevent VM preemption primarily because the proposed classifier has exponential time complexity, thereby requiring exceptionally high CPU utilization. The network traffic is routed in a premium tier to provide low latency. A static external IPv4 address is reserved and assigned to the instance for remote connection.

#### 3.3.2 SSH Key-Based Authentication

Password authentication should be disabled by uncommenting the following line in the SSH configuration file `/etc/ssh/sshd_config`.

```
PasswordAuthentication no
```

SSH authentication requires adding a public key of a local computer to the key file `~/.ssh/authorized_keys`.

```
echo <public_keyfile> >> ~/.ssh/authorized_keys
```

#### 3.3.3 Python Installation

Ubuntu Server 24.04 LTS is equipped with outdated Python 3.12.3. The installation of latest Python 3.13.0 at the current stage inevitably requires building from source. As opposed to Python 3.12, Python 3.13 experimentally supports multithreading without global interpreter lock (GIL). However, disabling GIL prevents the successful installation of `scikit-learn` package which is required to build a decision tree in Chapter 5. In this circumstance, the binary distribution, commonly known as wheel, of `scikit-learn` is unavailable. Its compilation by Rust and Cargo with the build system requirements specified in `pyproject.toml` also fails. Therefore, GIL remains in this dissertation as a default mechanism of mutual exclusion lock.

### 3.3.3.1 Introduction to Compilation in C

All Python source codes are written in C, and they require a C compiler such as GNU Compiler Collection (GCC) and Clang/Low Level Virtual Machine (LLVM). This dissertation chooses the first compiler. GCC 13 can be installed by using the Advanced Package Tool (APT), an interface to a packaging system on Debian and its derivatives such as Ubuntu.

```
sudo apt install build-essential
```

A newer version of GCC, currently GCC 14 release and GCC 15 experimental, can optionally be built from source by its previous version. The C/C++ compiler commands, including versions, and flags can be added to the environment variables `CC`, `CXX`, `CFLAGS` and `CXXFLAGS` respectively.

GNU Make is used as a build automation tool by reading instructions from `Makefile`. Parallelism is supported by utilizing multiple CPU threads with the `-j` or `--jobs` flag.

```
make -j<N>
make -j<N> install
```

The parameter `<N>` is the maximum allowable number of jobs executed in parallel which should not exceed the number of available CPU threads.

### 3.3.3.2 Basic Object Types

Python object structures are declared in the header file `Include/object.h`. A Python object is stored in memory, it has a C structure named `_object`, and it can be referenced as a `PyObject*` pointer. With GIL enabled by default, it declares a reference counter `ob_refcnt` of type `Py_ssize_t` and a pointer to the object type `*ob_type` of type `PyTypeObject`. When GIL is disabled by configuring Python with the `--disable-gil` option, a local reference counter is declared by `ob_ref_local` of type `uint32_t` is only adjusted by an owner thread, whereas a shared counterpart `ob_ref_shared` of type `Py_ssize_t` is adjusted by remaining threads. Its actual reference counter can be computed by merging both. When its reference counter is decremented to zero, it is deleted by a garbage collector (GC). If it only has a cyclic reference, a generational garbage collection is employed. A variable-size Python object can be cast further to `PyVarObject*` with an additional field `ob_size` of type `Py_ssize_t` which holds the number of its items.

```
#ifndef Py_GIL_DISABLED
struct _object {
```

```

    #if (defined(__GNUC__) || defined(__clang__)) \
    && !(defined __STDC_VERSION__ && __STDC_VERSION__ >= 201112L)
    // On C99 and older, anonymous union is a GCC and clang extension
    __extension__
    #endif

    #ifdef _MSC_VER
    // Ignore MSC warning C4201: "nonstandard extension used:
    // nameless struct/union"
    __pragma(warning(push))
    __pragma(warning(disable: 4201))
    #endif
    union {
        Py_ssize_t ob_refcnt;
        #if SIZEOF_VOID_P > 4
        PY_UINT32_T ob_refcnt_split[2];
        #endif
    };

    #ifdef _MSC_VER
    __pragma(warning(pop))
    #endif

    PyTypeObject *ob_type;
};

#else
// Objects that are not owned by any thread use a thread id (tid) of
// zero.
// This includes both immortal objects and objects whose reference
// count
// fields have been merged.
#define _Py_UNOWNED_TID 0

// The shared reference count uses the two least-significant bits to
// store
// flags. The remaining bits are used to store the reference count.
#define _Py_REF_SHARED_SHIFT 2
#define _Py_REF_SHARED_FLAG_MASK 0x3

```

```

// The shared flags are initialized to zero.
#define _Py_REF_SHARED_INIT 0x0
#define _Py_REF_MAYBE_WEAKREF 0x1
#define _Py_REF_QUEUED 0x2
#define _Py_REF_MERGED 0x3

// Create a shared field from a refcnt and desired flags
#define _Py_REF_SHARED(refcnt, flags) (((refcnt) <<
    _Py_REF_SHARED_SHIFT) + (flags))

struct _object {
    // ob_tid stores the thread id (or zero). It is also used by the
    // GC and the
    // trashcan mechanism as a linked list pointer and by the GC to
    // store the
    // computed "gc_refs" refcount.
    uintptr_t ob_tid;
    uint16_t _padding;
    PyMutex ob_mutex; // per-object lock
    uint8_t ob_gc_bits; // gc-related state
    uint32_t ob_ref_local; // local reference count
    Py_ssize_t ob_ref_shared; // shared (atomic) reference count
    PyTypeObject *ob_type;
};

#endif

/* Cast argument to PyObject* type. */
#define _PyObject_CAST(op) _Py_CAST(PyObject*, (op))

typedef struct {
    PyObject ob_base;
    Py_ssize_t ob_size; /* Number of items in variable part */
} PyVarObject;

```

### 3.3.3.3 String Interning

Python interns strings, which are immutable objects, of the same value mainly through the function `_PyUnicode_InternInPlace()` defined in the source file `Objects/unicodeobject.c` by retaining only one copy in memory. This reduces memory usage and speeds up certain operations, for example equality comparison. The reference to all interned strings is stored in the per-interpreter dictionary `interned` initialized during the first invocation. As opposed to a release build, a debug build denies with an assertion the addition of a process-global interned string into the existing dictionary to prevent the possibility of getting a duplicate.

```
static /* non-null */ PyObject*
intern_static(PyInterpreterState *interp, PyObject *s /* stolen */)
{
    // Note that this steals a reference to `s`, but in many cases
    // that
    // stolen ref is returned, requiring no decref/incref.

    assert(s != NULL);
    assert(_PyUnicode_CHECK(s));
    assert(_PyUnicode_STATE(s).statically_allocated);
    assert(!_PyUnicode_CHECK_INTERNED(s));

#ifdef Py_DEBUG
    /* We must not add process-global interned string if there's
       already a
       * per-interpreter interned_dict, which might contain duplicates.
       */
    PyObject *interned = get_interned_dict(interp);
    assert(interned == NULL);
#endif

    /* Look in the global cache first. */
    PyObject *r = (PyObject *)_Py_hashtable_get(INTERNED_STRINGS, s);
    /* We should only init each string once */
    assert(r == NULL);
    /* but just in case (for the non-debug build), handle this */
}
```

```

if (r != NULL && r != s) {
    assert(_PyUnicode_STATE(r).interned ==
           SSTATE_INTERNED_IMMORTAL_STATIC);
    assert(_PyUnicode_CHECK(r));
    Py_DECREF(s);
    return Py_NewRef(r);
}

if (_Py_hashtable_set(INTERNED_STRINGS, s, s) < -1) {
    Py_FatalError("failed to intern static string");
}

_PyUnicode_STATE(s).interned = SSTATE_INTERNED_IMMORTAL_STATIC;
return s;
}

```

Soon after Python 3.13.0 had been released, JupyterLab could not be launched in the debug build despite its successful installation. This problem can be fixed by commenting the following assert statement, though discouraged, and rebuilding the Python.

```
//assert(interned == NULL);
```

This can also be done by using the `sed` command.

```

sed -i -e \
    's/assert(interned == NULL);/\\/\\/assert(interned == NULL);/g' \
    Objects/unicodeobject.c

```

However, the source code modification is not required for running the latest JupyterLab.

### 3.3.3.4 Configuration and Build

It is recommended to have three separate directories: source, build and install. In this dissertation, Python is built against OpenSSL whose runtime library directory `rpath` is automatically detected, and it respects the OpenSSL crypto policy `openssl.cnf` by overriding the default Python cipher list.

```

--with-openssl=<openssl_rootdir>
--with-openssl-rpath=auto
--with-ssl-default-suites=openssl

```



As opposed to the built-in Python, a static library (with `.a` extension) is built from source by default. This dissertation builds a dynamic library (with `.so` extension) by adding the `--enable-shared` flag to minimize disk footprint of several programs because Python 3.13.0 will intentionally be built as a new primary version, but inside a home directory. It is entirely separate from the latest system Python library, shared by multiple native applications, `/usr/lib/python3.12/config-3.12-x86_64-linux-gnu/libpython3.12.so` which currently points to another symbolic link `/usr/lib/x86_64-linux-gnu/libpython3.12.so.1` and finally to the actual shared library `/usr/lib/x86_64-linux-gnu/libpython3.12.so.1.0`, of which all interfaces remain unchanged (interface version 1) and the library source code is unmodified (revision 0).

Although a release build, default in Python, is more optimized but harder to debug, this dissertation chooses the Python debug build by passing the `--with-pydebug` flag. The source codes are compiled to intermediate object codes in an attempt to reduce the code size and execution time. A linker produces shared libraries and executables from objects without duplicate definitions. Both compilation and linking are optimized by turning on the `--enable-optimizations` and `--with-lto` flags. C assertions are enabled in debug mode by default. Python can be compiled with profiling turned on by using the `--enable-profiling` flag. The GNU profiler `gprof` collects data during Python execution and outputs the file `gmon.out` in a current working directory. Based on this information, the code performance can be analyzed in terms of execution time and memory consumption, and its bottleneck is identifiable. Nonetheless, this dissertation omits the profiling flag.

Python optimization, if specified, is profile-guided (PGO) based on collected data from sequential test runs. For the PGO generation task, Python by default uses the following arguments assigned to the environment variable `PROFILE_TASK`.

```
-m test --pgo --timeout=
```

The `-m` flag searches for all files matching a given pattern, in this case `test*` in the `Lib/test` subdirectory. The `--pgo` flag enables PGO training and selects 44 out of 478 test runs. Python 3.13 sets no timeout for an individual test, in contrast to Python 3.12 a default timeout of 20 minutes, and no longer ignores a test failure. Its build time is partly impacted by these test runs and can significantly improve by ignoring through the `-i` flag time-consuming tests which can be detected, for instance, by setting a custom timeout. This dissertation excludes the test for embedding APIs located at `Lib/test/test_embedded.py` and sets a timeout of 5 minutes.

```
export PROFILE_TASK="-m test --pgo --timeout=300 -i test_embded"
```

No timeout error is raised, and all remaining 43 tests pass.

Furthermore, the `pyexpat` module can be built using an installed `expat` library by the `--with-system-expat` flag. `DTrace`, `Valgrind` and loadable extensions in the `_sqlite` extension module are supported by the `--with-dtrace`, `--with-valgrind` and `--enable-loadable-sqlite-extensions` flags. Address sanitizer (ASAN) and memory sanitizer (MSAN) are disabled by default. Certain flags requires additional dependencies. Their environment variables for C compiler and linker flags, required libraries, Python modules to be optionally built, and corresponding APT packages are given in Table 3.2.

Table 3.2: Python options for third-party dependencies

| Environment Variables     | Library     | Module       | APT Package        |
|---------------------------|-------------|--------------|--------------------|
| BZIP2_[LIBS CFLAGS]       | libbz2      | bz2          | libbz2-dev         |
| CURSES_[LIBS CFLAGS]      | libncurses  | curses       | libncurses-dev     |
| GDBM_[LIBS CFLAGS]        | gdbm        |              | libgdbm-compat-dev |
| LIBB2_[LIBS CFLAGS]       | libb2       | hashlib      | libb2-dev          |
| LIBEDIT_[LIBS CFLAGS]     | libedit     | readline     | libreadline-dev    |
| LIBFFI_[LIBS CFLAGS]      | libffi      | ctypes       | libffi-dev         |
| LIBMPDEC_[LIBS CFLAGS]    | libmpdec    | decimal      |                    |
| LIBLZMA_[LIBS CFLAGS]     | liblzma     | lzma         | liblzma-dev        |
| LIBREADLINE_[LIBS CFLAGS] | libreadline | readline     | libreadline-dev    |
| LIBSQLITE3_[LIBS CFLAGS]  | libsqlite3  | sqlite3      | libsqlite3-dev     |
| LIBUUID_[LIBS CFLAGS]     | libuuid     | uuid         | uuid-dev           |
| PANEL_[LIBS CFLAGS]       | libpanel    | curses.panel | libpanel-dev       |
| TCLTK_[LIBS CFLAGS]       | TCLTK       |              | tk-dev             |
| ZLIB_[LIBS CFLAGS]        | libzlib     | gzip         | zlib1g-dev         |

After Python is completely installed in the destination directory, both source and build directories can be removed. The `bin` directory should be added to the `PATH` so that the executables are accessible from any location. The system environment variables `LD_LIBRARY_PATH` and `LD_FLAGS` should include the `lib` directory so that the library code can be loaded into memory at runtime and compile time respectively. The recently built version must precede the system-wide version.

```
export PATH="<install_dir>/bin:$PATH"
export LD_LIBRARY_PATH="<install_dir>/lib:${LD_LIBRARY_PATH}"
export LDFlags="-L<install_dir>/lib $LDFlags"
```

This migration should be made to the Bash configuration file `~/.bashrc`. Deprecation warnings may be emitted during runtime, but they can be suppressed by setting the Python environment variable `PYTHONWARNINGS`.

```
export PYTHONWARNINGS="ignore::DeprecationWarning"
```

The changes are not applied until the configuration file is reread.

```
source ~/.bashrc
```

### 3.3.4 Backup to OCI Object Storage

#### 3.3.4.1 Introduction to OCI

Oracle Cloud Infrastructure (OCI) basically has two logical concepts of organization management: tenancy and compartment. A *tenancy* is a root container for administering cloud resources. During the signup process, a parent tenancy is provisioned and tied to a specified, unchangeable home region which is `ap-singapore-1` in this dissertation. Multiple child tenancies can be created and managed by the parent tenancy. A *compartment* belongs to a tenancy, controls access to cloud resources, supports up to six levels, and brings clearer separation. It must be specified when a resource is created. A tenancy can be considered as a root compartment.

The OCI command line interface (CLI) can be installed by the `oci-cli` package in an isolated Python environment to prevent dependency conflicts. The `source` command is used to activate this environment. After the installation finishes, the executables including `oci` and its libraries are in the `bin` and `lib` directories. Only the first is additionally added to the `PATH` so that the `oci` command can be executed in the global environment, not limited to the virtual counterpart.

```
~$ python3 -m venv <env_dir>
~$ source <env_dir>/bin/activate
(env_dir)$ pip3 install oci-cli
(env_dir)$ deactivate
```

Before accessing an OCI resource or service, a basic OCI configuration must be made in an interactive mode from a terminal, for instance.

```
oci setup config
```

This can also be done from a custom configuration file by setting the environment variable `OCI_CLI_RC_FILE` to its full path. The file has two main components: section and key. A section except the default should be specified via the `--profile` option in the CLI.

```
[DEFAULT]
user=<user>
fingerprint=<fingerprint>
key_file=<key_file>
tenancy=<tenancy>
region=ap-singapore-1
```

### 3.3.4.2 OCI Object Storage

An Object Storage *namespace* serves as the top-level container for all buckets and objects, it is unique to a tenant, and it spans all compartments within a region. Although region-specific, its name remains the same across all regions. An *object* is any type of data along with its metadata stored in a logical container called *bucket* unique in a namespace. Object Storage is highly scalable, cost-effective and structurally flat, compared to block and file storage. There are two default tiers. A *standard tier* has a higher cost and no retention period. In a low-cost *archive tier*, an object must be retained for at least 90 days, and restoration takes very long time to retrieve all data bytes. OCI Object Storage supports auto-tiering, object versioning and multipart uploading which is greatly resilient for a very large object. Uncommitted or failed multipart uploads can be cleaned either manually or through a predefined lifecycle policy rule.

In this dissertation, only a full backup of scripts and results, not only due to its small size but also to avoid the possibility of a corrupted incremental or differential backup, is stored in OCI Object Storage. A total of 20 GB in all tenancies is always free, and no upgrade to a paid account is required. A bucket is created without auto-tiering and versioning. All buckets in a compartment can be listed along with their namespace.

```
oci os bucket list -c <compartment_id>
```

A backup is performed by a one-way synchronization, and each version is uniquely identified by an object prefix such as a timestamp. An object that exists in a destination but not in a source is deleted.

```
oci os object sync -ns <namespace> -bn <bucket> \
```

```
--prefix <obj_prefix> --src-dir <src_dir> --delete
```

Furthermore, an object can be renamed and deleted where bulk deletion is also permitted.

```
oci os object rename -ns <namespace> -bn <bucket> \
  --name <obj_name> --new-name <obj_new_name>
oci os object delete -ns <namespace> -bn <bucket> \
  --name <obj_name>
oci os object bulk-delete -ns <namespace> -bn <bucket> \
  --prefix <obj_prefix>
```

### 3.4 GitHub Repository

The template GitHub repository for this dissertation is available at <https://github.com/songkomkrit/phd-template>. The basic Git commands are included in Table 3.3. The path to the Git global configuration file `.gitconfig` specific to a user is given by the environment variable `GIT_CONFIG_GLOBAL`. The username and the email address can be set up either by the `git config` command with the `--global` option or by editing the configuration file.

```
git config --global user.name <username>
git config --global user.email <email_address>
```

The following settings should appear in the file.

```
[user]
  name = <username>
  email = <email_address>
```

Table 3.3: Basic Git commands

| Command                       | Description  |
|-------------------------------|--|
| <code>git clone</code>        | Clean copy   |
| <code>git pull</code>         | Update with local changes kept                     |
| <code>git reset --hard</code> | Update with local changes discarded                |
| <code>git clean -fdx</code>   | Clean with untracked files and directories removed |
| <code>git push</code>         | Remote update with local commits                   |

The JSON-format metadata of both independent and dependent variables are at `Data/Original/metadata/meta-indep.json` and `Data/Original/metadata/meta-dep.json`. The health insurance in SAS7BDAT format is omitted, but its feather file of smaller size is already included in the directory `Data/Original/feature`. This dissertation further limits the number of participants and features to smaller size before fed to a classification model. Since data sampling is random, the sample is put in the directory `Samples/cplex`.

The box classifier proposed in Chapter 4 is located in the CPLEX Optimization Programming Language (OPL) project `Projects/box` where its `input` subdirectory contains a sample data including additional information and its `output` counterpart all relevant results such as splitting values and predicted class label per decision box. The model can be executed by the `oplrun` command and logged into file and on console by the `tee` command.

```
oplrun -p <project_dir> 2>&1 | tee <log_file>
```

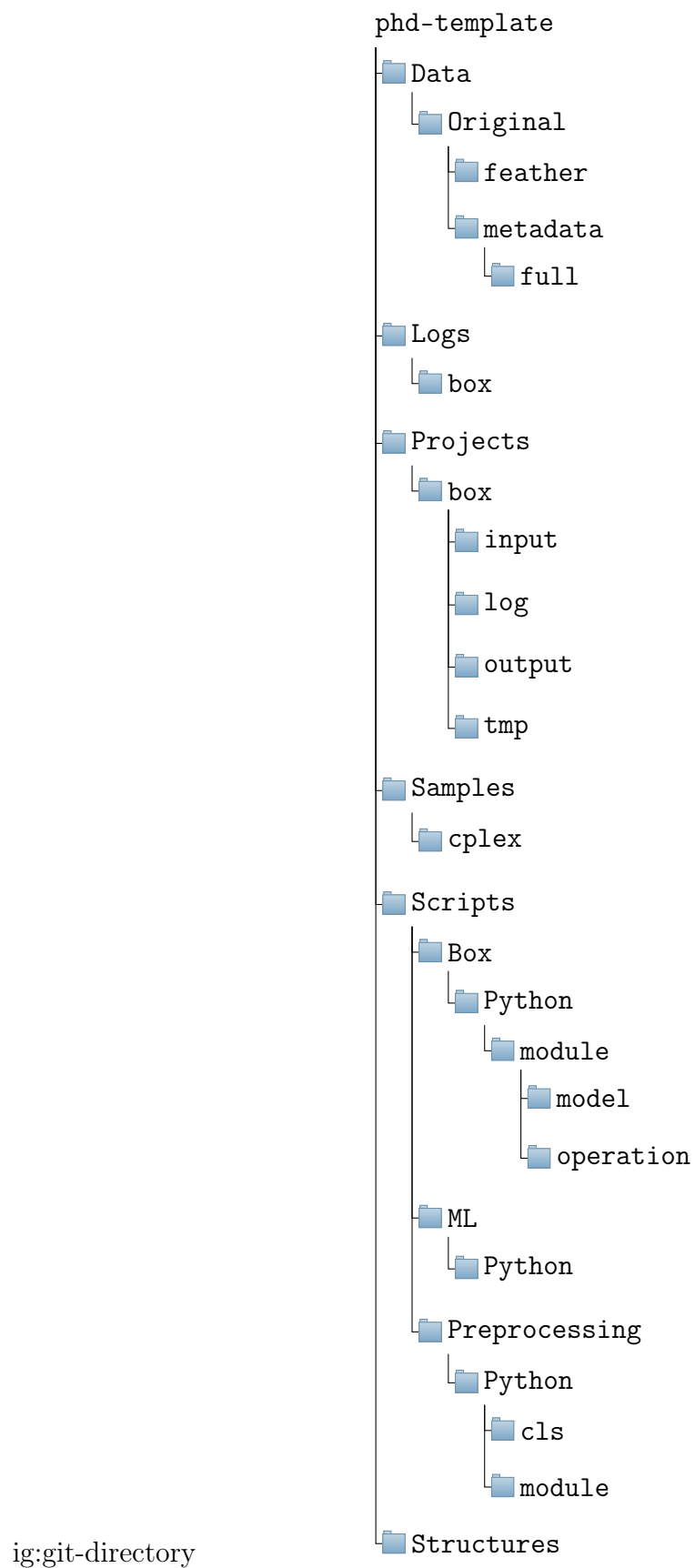
The `<project_dir>` is `Projects/box`. Thanks to its comparative low-resource consumption, using the `oplrun` executable in a terminal is preferred to starting the CPLEX Studio IDE by executing the `oplide` command. The manual backup of the CPLEX engine log is stored in the directory `Logs/box`. The Python scripts for data preprocessing, decision tree building and decision box merging can be found in `Scripts/Preprocessing/Python`, `Scripts/ML/Python` and `Scripts/Box/Python` respectively. The directory and file tree structures can be printed in terminal by using the `tree` command, and they are saved to `Structures/directory.txt` and `Structures/file.txt`.

```
tree -d . > Structures/directory.txt
tree -f . > Structures/file.txt
```

There are currently 29 directories and 60 files. The directory structure is displayed in Figure ??.

The template repository is very minimal with merely output files generated by a CPLEX optimizer. Its main purpose is to allow users to generate a new repository with the same structure before further Python execution such as exploratory data analysis (EDA). The up-to-date repository based on the template with additional outputs included is available at <https://github.com/songkomkrit/phd>.

Figure 3.1: Directory tree structure of the template GitHub repository



### 3.5 Health Insurance Dataset

#### 3.5.1 Background

The 2020 U.S. Census Bureau’s Current Population Survey (CPS) Annual Social and Economic Supplement (ASEC) dataset will be used in the dissertation. Questions were asked for the information on a previous calendar year. Therefore, the person-level dataset provides the estimates of individual health insurance coverage for calendar year 2019.

An individual may simultaneously have different coverages. Private health insurance includes an employment-based plan and a direct-purchase plan. Public health insurance comprises Medicare, means-tested coverage (i.e., Medicaid, Peace Church Health Insurance or PCHIP and others), military healthcare (i.e., TRICARE formerly known as Civilian Health and Medical Program of the Uniformed Services or CHAMPUS, Civilian Health and Medical Program of the Department of Veterans Affairs or CHAMPVA and Veterans Affairs or VA) and the combination of Indian Health Service (IHS) and other coverages. Those who only have IHS are considered uninsured.

Since there are in total 10 subtypes of insurance coverage, quantitative data analysis may involve up to  $2^{10} + 1 = 1,025$  possible classes. In fact, the maximum number of subtypes of an overall class can be determined by the total sum of the indicator variables of the first ten subtypes. Furthermore, the dataset has at least 150,000 records and 750 attributes which are mostly measured on nominal scales. In addition to their allocation and topcode flags, the dataset variables cover a broad spectrum of characteristics: demographics, work experience, income (i.e., earnings, other income, non-cash benefits and tax), poverty, health insurance (i.e., government, private, employment-based, direct-purchase, subsidized marketplace, unsubsidized marketplace, non-marketplace, Medicaid, other means-tested, PHCIP, Medicare, IHS, TRICARE, CHAMPVA, VA and employer-sponsored), health status and migration. They also include basic CPS items (i.e., labor force and earnings) and medical out-of-pocket (OOP) expenditures.



### 3.5.2 Scope of Study

Within existing conceptual frameworks, certain independent variables will be preselected in the dissertation before further investigation. A group of infant born after the calendar year is excluded in the analysis. The combination of three following coverages is merely considered: employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB). There are eight possible binary tuples (GRP, DIR, PUB) which are regrouped into five following classes in Table 3.4.

Table 3.4: Class codes of insurance coverage combination

| Class | Code | Combination of insurance coverages |     |     |
|-------|------|------------------------------------|-----|-----|
|       |      | GRP                                | DIR | PUB |
| 0     | NNN  | No                                 | No  | No  |
| 1     | NNY  | No                                 | No  | Yes |
| 2     | NY_  | No                                 | Yes | Yes |
|       |      | No                                 | Yes | No  |
| 3     | YNN  | Yes                                | No  | No  |
| 4     | Y1Y  | Yes                                | No  | Yes |
|       |      | Yes                                | Yes | Yes |
|       |      | Yes                                | Yes | No  |

### 3.5.3 Metadata

Metadata 3.1 and 3.2 contain related information on dependent and independent variables in JSON format with a variable symbol as a main key and all of the following as its informative value in dictionary format: label, universe, type (either continuous or categorical), topic, subtopic and possible values including NIU (not in universe).

Metadata 3.1: Dependent variables (data/original/metadata/meta-dep.json)

```

1 {
2   "NOW_COV": {
3     "label": "Currently covered by health insurance coverage",

```

```

4      "universe": "All Persons",
5      "type": "Categorical",
6      "role": "Dependent",
7      "topic": "Health insurance",
8      "subtopic": "Any health insurance coverage",
9      "values": {
10         "1": "Yes",
11         "2": "No"
12     }
13 },
14 "NOW_PUB": {
15     "label": "Current public coverage",
16     "universe": "All Persons",
17     "type": "Categorical",
18     "role": "Dependent",
19     "topic": "Health insurance",
20     "subtopic": "Public coverage",
21     "values": {
22         "1": "Yes",
23         "2": "No"
24     }
25 },
26 "NOW_PRIV": {
27     "label": "Current private coverage",
28     "universe": "All Persons",
29     "type": "Categorical",
30     "role": "Dependent",
31     "topic": "Health insurance",
32     "subtopic": "Private coverage",
33     "values": {
34         "1": "Yes",
35         "2": "No"
36     }
37 },
38 "NOW_GRP": {
39     "label": "Any current employment-based coverage",

```

```

40     "universe": "All Persons",
41     "type": "Categorical",
42     "role": "Dependent",
43     "topic": "Health insurance",
44     "subtopic": "Employment-based coverage",
45     "values": {
46         "1": "Yes",
47         "2": "No"
48     }
49 },
50 "NOW_DIR": {
51     "label": "Any current direct-purchase coverage",
52     "universe": "All Persons",
53     "type": "Categorical",
54     "role": "Dependent",
55     "topic": "Health insurance",
56     "subtopic": "Direct-purchase coverage",
57     "values": {
58         "1": "Yes",
59         "2": "No"
60     }
61 },
62 "NOW_MCARE": {
63     "label": "Current Medicare coverage",
64     "universe": "All Persons",
65     "type": "Categorical",
66     "role": "Dependent",
67     "topic": "Health insurance",
68     "subtopic": "Medicare coverage",
69     "values": {
70         "1": "Yes",
71         "2": "No"
72     }
73 },
74 "NOW_MCAID": {
75     "label": "Current Medicaid, PCHIP, or other means-tested coverage",

```

```

76     "universe": "All Persons",
77     "type": "Categorical",
78     "role": "Dependent",
79     "topic": "Health insurance",
80     "subtopic": "Medicaid or other means-tested coverage",
81     "values": {
82         "1": "Yes",
83         "2": "No"
84     }
85 },
86 "NOW_CAID": {
87     "label": "Current Medicaid coverage",
88     "universe": "All Persons",
89     "type": "Categorical",
90     "role": "Dependent",
91     "topic": "Health insurance",
92     "subtopic": "Medicaid coverage",
93     "values": {
94         "1": "Yes",
95         "2": "No"
96     }
97 },
98 "NOW_PCHIP": {
99     "label": "Current PCHIP coverage",
100     "universe": "All Persons",
101     "type": "Categorical",
102     "role": "Dependent",
103     "topic": "Health insurance",
104     "subtopic": "PCHIP coverage",
105     "values": {
106         "1": "Yes",
107         "2": "No"
108     }
109 },
110 "NOW_OTHMT": {
111     "label": "Current other means-tested coverage",

```

```

112     "universe": "All Persons",
113     "type": "Categorical",
114     "role": "Dependent",
115     "topic": "Health insurance",
116     "subtopic": "Other means-tested coverage",
117     "values": {
118         "1": "Yes",
119         "2": "No"
120     }
121 },
122 "NOW_MIL": {
123     "label": "Any current TRICARE coverage",
124     "universe": "All Persons",
125     "type": "Categorical",
126     "role": "Dependent",
127     "topic": "Health insurance",
128     "subtopic": "TRICARE coverage",
129     "values": {
130         "1": "Yes",
131         "2": "No"
132     }
133 },
134 "NOW_CHAMPVA": {
135     "label": "Current CHAMPVA coverage",
136     "universe": "All Persons",
137     "type": "Categorical",
138     "role": "Dependent",
139     "topic": "Health insurance",
140     "subtopic": "CHAMPVA coverage",
141     "values": {
142         "1": "Yes",
143         "2": "No"
144     }
145 },
146 "NOW_VACARE": {
147     "label": "Current VACARE coverage",

```

```

148     "universe": "All Persons",
149     "type": "Categorical",
150     "role": "Dependent",
151     "topic": "Health insurance",
152     "subtopic": "VACARE coverage",
153     "values": {
154         "1": "Yes",
155         "2": "No"
156     }
157 },
158 "NOW_IHSFLG": {
159     "label": "Current coverage through the Indian Health Service",
160     "universe": "All Persons",
161     "type": "Categorical",
162     "role": "Dependent",
163     "topic": "Health insurance",
164     "subtopic": "Indian Health Service coverage",
165     "values": {
166         "1": "Yes",
167         "2": "No"
168     }
169 }
170 }

```

Metadata 3.2: Independent variables (data/original/metadata/meta-indep.json)

```

1 {
2     "A_AGE": {
3         "label": "Age",
4         "universe": "All Persons",
5         "type": "Continuous",
6         "role": "Independent",
7         "topic": "Demographics",
8         "subtopic": "Individual characteristics",
9         "values": {

```

```

10         "00-79": "0-79 years of age",
11         "80": "80-84 years of age",
12         "85": "85+ years of age"
13     }
14 },
15 "A_EXPRRP": {
16     "label": "Expanded relationship code",
17     "universe": "All Persons",
18     "type": "Categorical",
19     "role": "Independent",
20     "topic": "Demographics",
21     "subtopic": "Individual characteristics",
22     "values": {
23         "1": "Reference person with relatives",
24         "2": "Reference person without relatives",
25         "3": "Husband",
26         "4": "Wife",
27         "5": "Own child",
28         "7": "Grandchild",
29         "8": "Parent",
30         "9": "Brother/sister",
31         "10": "Other relative",
32         "11": "Foster child",
33         "12": "Nonrelative with relatives",
34         "13": "Partner/roommate",
35         "14": "Nonrelative without relatives"
36     }
37 },
38 "A_FAMTYP": {
39     "label": "Family type",
40     "universe": "All Persons",
41     "type": "Categorical",
42     "role": "Independent",
43     "topic": "Demographics",
44     "subtopic": "Individual characteristics",
45     "values": {

```

```

46         "1": "Primary family",
47         "2": "Nonfamily householder",
48         "3": "Related subfamily",
49         "4": "Unrelated subfamily",
50         "5": "Secondary individual"
51     }
52 },
53     "A_HGA": {
54         "label": "Educational attainment",
55         "universe": "All Persons",
56         "type": "Categorical",
57         "role": "Independent",
58         "topic": "Demographics",
59         "subtopic": "Individual characteristics",
60         "values": {
61             "0": "Children",
62             "31": "Less than 1st grade",
63             "32": "1st,2nd,3rd,or 4th grade",
64             "33": "5th or 6th grade",
65             "34": "7th and 8th grade",
66             "35": "9th grade",
67             "36": "10th grade",
68             "37": "11th grade",
69             "38": "12th grade no diploma",
70             "39": "High school graduate - high school diploma or equivalent",
71             "40": "Some college but no degree",
72             "41": "Associate degree in college - occupation/vocation",
73                 "program",
74             "42": "Associate degree in college - academic program",
75             "43": "Bachelor's degree (for example: BA,AB,BS)",
76             "44": "Master's degree (for example: MA,MS,MENG,MED,MSW, MBA)",
77             "45": "Professional school degree (for example: MD,DDS,DVM,LLB,",
78                 JD)",
79             "46": "Doctorate degree (for example: PHD,EDD)"
80         }
81     }

```



```

79     },
80     "A_MARITL": {
81         "label": "Marital status",
82         "universe": "All Persons",
83         "type": "Categorical",
84         "role": "Independent",
85         "topic": "Demographics",
86         "subtopic": "Individual characteristics",
87         "values": {
88             "1": "Married - civilian spouse present",
89             "2": "Married - AF spouse present",
90             "3": "Married - spouse absent (exc.separated)",
91             "4": "Widowed",
92             "5": "Divorced",
93             "6": "Separated",
94             "7": "Never married"
95         }
96     },
97     "A_PFREL": {
98         "label": "Primary family relationship",
99         "universe": "All Persons",
100        "type": "Categorical",
101        "role": "Independent",
102        "topic": "Demographics",
103        "subtopic": "Individual characteristics",
104        "values": {
105            "0": "Not in primary family",
106            "1": "Husband",
107            "2": "Wife",
108            "3": "Own child",
109            "4": "Other relative",
110            "5": "Unmarried reference person"
111        }
112    },
113    "A_SEX": {
114        "label": "Sex",

```

```

115     "universe": "All Persons",
116     "type": "Categorical",
117     "role": "Independent",
118     "topic": "Demographics",
119     "subtopic": "Individual characteristics",
120     "values": {
121         "1": "Male",
122         "2": "Female"
123     }
124 },
125 "P_STAT": {
126     "label": "Status of person identifier",
127     "universe": "All Persons",
128     "type": "Categorical",
129     "role": "Independent",
130     "topic": "Demographics",
131     "subtopic": "Individual characteristics",
132     "values": {
133         "1": "Civilian 15+",
134         "2": "Armed forces",
135         "3": "Children 0-14"
136     }
137 },
138 "PEAFEVER": {
139     "label": "Did you ever serve on active duty in the U.S. Armed
140         Forces?",
141     "universe": "A_AGE greater than or equal to 17",
142     "type": "Categorical",
143     "role": "Independent",
144     "topic": "Demographics",
145     "subtopic": "Individual characteristics",
146     "values": {
147         "-1": "Not in universe",
148         "1": "Yes",
149         "2": "No"
150     }

```

```

150     },
151     "PEDISDRS": {
152         "label": "Does...have difficulty dressing or bathing?",
153         "universe": "PRPERTYP = 2",
154         "type": "Categorical",
155         "role": "Independent",
156         "topic": "Demographics",
157         "subtopic": "Individual characteristics",
158         "values": {
159             "-1": "Not in universe",
160             "1": "Yes",
161             "2": "No"
162         }
163     },
164     "PEDISEAR": {
165         "label": "Is...deaf or does ...have serious difficulty hearing?",
166         "universe": "PRPERTYP = 2",
167         "type": "Categorical",
168         "role": "Independent",
169         "topic": "Demographics",
170         "subtopic": "Individual characteristics",
171         "values": {
172             "-1": "Not in universe",
173             "1": "Yes",
174             "2": "No"
175         }
176     },
177     "PEDISEYE": {
178         "label": "Is...blind or does...have serious difficulty seeing even
179             when wearing glasses?",
180         "universe": "PRPERTYP = 2",
181         "type": "Categorical",
182         "role": "Independent",
183         "topic": "Demographics",
184         "subtopic": "Individual characteristics",
185         "values": {

```

```

185         "-1": "Not in universe",
186         "1": "Yes",
187         "2": "No"
188     }
189 },
190 "PEDISOUT": {
191     "label": "Because of a physical, mental, or emotional condition,
192             does...have difficulty doing errands along such as visiting a
193             doctor's office or shopping?",
194     "universe": "PRPERTYP = 2",
195     "type": "Categorical",
196     "role": "Independent",
197     "topic": "Demographics",
198     "subtopic": "Individual characteristics",
199     "values": {
200         "-1": "Not in universe",
201         "1": "Yes",
202         "2": "No"
203     }
204 },
205 "PEDISPHY": {
206     "label": "Does...have serious difficulty Walking or climbing stairs
207             ?",
208     "universe": "PRPERTYP = 2",
209     "type": "Categorical",
210     "role": "Independent",
211     "topic": "Demographics",
212     "subtopic": "Individual characteristics",
213     "values": {
214         "-1": "Not in universe",
215         "1": "Yes",
216         "2": "No"
217     }
218 },
219 "PEDISREM": {

```

```

217     "label": "Because of a physical, mental, or emotional condition,
        does...have serious difficulty concentrating, remembering, or
        making decisions?",
218     "universe": "PRPERTYP = 2",
219     "type": "Categorical",
220     "role": "Independent",
221     "topic": "Demographics",
222     "subtopic": "Individual characteristics",
223     "values": {
224         "-1": "Not in universe",
225         "1": "Yes",
226         "2": "No"
227     }
228 },
229 "PRDISFLG": {
230     "label": "Does this person have any of these disability conditions?
        ",
231     "universe": "PRPERTYP = 2",
232     "type": "Categorical",
233     "role": "Independent",
234     "topic": "Demographics",
235     "subtopic": "Individual characteristics",
236     "values": {
237         "-1": "Not in universe",
238         "1": "Yes",
239         "2": "No"
240     }
241 },
242 "PRCITSHP": {
243     "label": "Citizenship group",
244     "universe": "All persons",
245     "type": "Categorical",
246     "role": "Independent",
247     "topic": "Demographics",
248     "subtopic": "Individual characteristics",
249     "values": {

```

```

250         "1": "Native, born in US",
251         "2": "Native, born in PR or US outlying area",
252         "3": "Native, born abroad of US parent(s)",
253         "4": "Foreign born, US cit by naturalization",
254         "5": "Foreign born, not a US citizen"
255     }
256 },
257 "PRDTRACE": {
258     "label": "Race",
259     "universe": "All persons",
260     "type": "Categorical",
261     "role": "Independent",
262     "topic": "Demographics",
263     "subtopic": "Individual characteristics",
264     "values": {
265         "1": "White only",
266         "2": "Black only",
267         "3": "American Indian, Alaskan Native only (AI)",
268         "4": "Asian only",
269         "5": "Hawaiian/Pacific Islander only (HP)",
270         "6": "White-Black",
271         "7": "White-AI",
272         "8": "White-Asian",
273         "9": "White-HP",
274         "10": "Black-AI",
275         "11": "Black-Asian",
276         "12": "Black-HP",
277         "13": "AI-Asian",
278         "14": "AI-HP",
279         "15": "Asian-HP",
280         "16": "White-Black-AI",
281         "17": "White-Black-Asian",
282         "18": "White-Black-HP",
283         "19": "White-AI-Asian",
284         "20": "White-AI-HP",
285         "21": "White-Asian-HP",

```

```

286         "22": "Black-AI-Asian",
287         "23": "White-Black-AI-Asian",
288         "24": "White-AI-Asian-HP",
289         "25": "Other 3 race comb.",
290         "26": "Other 4 or 5 race comb."
291     }
292 },
293     "A_MJIND": {
294         "label": "Major industry code",
295         "universe": "A_CLSWKR = 1-7",
296         "type": "Categorical",
297         "role": "Independent",
298         "topic": "Basic CPS items",
299         "subtopic": "Edited labor force items",
300         "values": {
301             "0": "Not in universe, or children",
302             "1": "Agriculture, forestry,fishing, and hunting",
303             "2": "Mining",
304             "3": "Construction",
305             "4": "Manufacturing",
306             "5": "Wholesale and retail trade",
307             "6": "Transportation and utilities",
308             "7": "Information",
309             "8": "Financial activities",
310             "9": "Professional and business services",
311             "10": "Educational and health services",
312             "11": "Leisure and hospitality",
313             "12": "Other services",
314             "13": "Public administration",
315             "14": "Armed forces"
316         }
317     },
318     "A_MJOCC": {
319         "label": "Major occupation recode",
320         "universe": "A_CLSWKR = 1-7",
321         "type": "Categorical",

```

```

322     "role": "Independent",
323     "topic": "Basic CPS items",
324     "subtopic": "Edited labor force items",
325     "values": {
326         "0": "Not in universe or children",
327         "1": "Management, business, and financial occupations",
328         "2": "Professional and related occupations",
329         "3": "Service occupations",
330         "4": "Sales and related occupations",
331         "5": "Office and administrative support occupations",
332         "6": "Farming, fishing, and forestry occupations",
333         "7": "Construction and extraction occupations",
334         "8": "Installation, maintenance, and repair occupations",
335         "9": "Production occupations",
336         "10": "Transportation and material moving occupations",
337         "11": "Armed forces"
338     }
339 },
340 "PEIO1COW": {
341     "label": "Individual class of worker on first job",
342     "universe": "All persons",
343     "type": "Categorical",
344     "role": "Independent",
345     "topic": "Basic CPS items",
346     "subtopic": "Edited labor force items",
347     "values": {
348         "0": "NIU",
349         "1": "Government-federal",
350         "2": "Government-state",
351         "3": "Government - local",
352         "4": "Private, for profit",
353         "5": "Private, nonprofit",
354         "6": "Self-employed, incorporated",
355         "7": "Self-employed, unincorporated",
356         "8": "Without pay"
357     }

```



```

358     },
359     "PRDISC": {
360         "label": "Discouraged worker recode",
361         "universe": "All persons",
362         "type": "Categorical",
363         "role": "Independent",
364         "topic": "Basic CPS items",
365         "subtopic": "Edited labor force items",
366         "values": {
367             "0": "NIU",
368             "1": "Discouraged worker",
369             "2": "Conditionally interested",
370             "3": "Not available"
371         }
372     },
373     "PRUNTYPE": {
374         "label": "Individual class of worker on first job",
375         "universe": "All persons",
376         "type": "Categorical",
377         "role": "Independent",
378         "topic": "Basic CPS items",
379         "subtopic": "Edited labor force items",
380         "values": {
381             "0": "NIU",
382             "1": "Job loser/on layoff",
383             "2": "Other job loser",
384             "3": "Temporary job ended",
385             "4": "Job leaver",
386             "5": "Re-entrant",
387             "6": "New-entrant"
388         }
389     },
390     "A_GRSWK": {

```

```

391     "label": "How much does ... usually earn per week at this job
        before deductions , subject to topcoding, the higher of either
        the amount of item 25a times Item 25c or the actual item 25d
        entry will be present",
392     "universe": "PRERELG=1",
393     "type": "Continuous",
394     "role": "Independent",
395     "topic": "Basic CPS items",
396     "subtopic": "Edited earnings items",
397     "values": {
398         "0": "Not in universe or children or armed forces",
399         "0001-2885": "Dollar amount"
400     }
401 },
402 "A_HRLYWK": {
403     "label": "Is ... paid by the hour on this job?",
404     "universe": "PRERELG=1",
405     "type": "Categorical",
406     "role": "Independent",
407     "topic": "Basic CPS items",
408     "subtopic": "Edited earnings items",
409     "values": {
410         "0": "Not in universe or children and armed forces",
411         "1": "Yes",
412         "2": "No"
413     }
414 },
415 "A_HRSPAY": {
416     "label": "How much does ... earn per hour?",
417     "universe": "A_HRLYWK=1",
418     "type": "Continuous",
419     "role": "Independent",
420     "topic": "Basic CPS items",
421     "subtopic": "Edited earnings items",
422     "values": {
423         "0": "Not in universe or children or armed forces",

```

```

424         "0001-9999": "Entry (2 implied decimal places)"
425     }
426 },
427 "PRERELG": {
428     "label": "Earnings eligibility flag",
429     "universe": "All persons",
430     "type": "Categorical",
431     "role": "Independent",
432     "topic": "Basic CPS items",
433     "subtopic": "Edited earnings items",
434     "values": {
435         "0": "Not earnings eligible",
436         "1": "Earnings eligible"
437     }
438 },
439 "A_CIVLF": {
440     "label": "Civilian labor force",
441     "universe": "All persons",
442     "type": "Categorical",
443     "role": "Independent",
444     "topic": "Basic CPS items",
445     "subtopic": "Labor force person recodes",
446     "values": {
447         "0": "Not in universe or children and Armed Forces",
448         "1": "In universe"
449     }
450 },
451 "A_CLSWKR": {
452     "label": "Class of worker",
453     "universe": "PEMLR=1-3 or (PEMLR=4-7 and person worked in the last
454         12 months)",
455     "type": "Categorical",
456     "role": "Independent",
457     "topic": "Basic CPS items",
458     "subtopic": "Labor force person recodes",
459     "values": {

```

```

459         "0": "Not in universe or children and armed forces",
460         "1": "Private",
461         "2": "Federal government",
462         "3": "State government",
463         "4": "Local government",
464         "5": "Self-employed-incorporated",
465         "6": "Self-employed-not incorporated",
466         "7": "Without pay",
467         "8": "Never worked"
468     }
469 },
470 "A_EXPLF": {
471     "label": "Experienced labor force employment status",
472     "universe": "PEMLR=1-4",
473     "type": "Categorical",
474     "role": "Independent",
475     "topic": "Basic CPS items",
476     "subtopic": "Labor force person recodes",
477     "values": {
478         "0": "Not in experienced labor force",
479         "1": "Employed",
480         "2": "Unemployed"
481     }
482 },
483 "A_LFSR": {
484     "label": "Labor force status recode",
485     "universe": "All persons",
486     "type": "Categorical",
487     "role": "Independent",
488     "topic": "Basic CPS items",
489     "subtopic": "Labor force person recodes",
490     "values": {
491         "0": "Children or Armed Forces",
492         "1": "Working",
493         "2": "With job, not at work",
494         "3": "Unemployed, looking for work",

```

```

495         "4": "Unemployed, on layoff",
496         "7": "Nilf"
497     }
498 },
499 "A_UNCOV": {
500     "label": "On this job, is ... covered by a union or employee
501             association contract?",
502     "universe": "A_UNMEM=2",
503     "type": "Categorical",
504     "role": "Independent",
505     "topic": "Basic CPS items",
506     "subtopic": "Labor force person recodes",
507     "values": {
508         "0": "Not in universe or children and armed forces",
509         "1": "Yes",
510         "2": "No"
511     }
512 },
513 "A_UNMEM": {
514     "label": "On this job, is ... a member of a labor union or of an
515             employee association similar to a union?",
516     "universe": "PRERELG=1",
517     "type": "Categorical",
518     "role": "Independent",
519     "topic": "Basic CPS items",
520     "subtopic": "Labor force person recodes",
521     "values": {
522         "0": "Not in universe or children and armed forces",
523         "1": "Yes",
524         "2": "No"
525     }
526 },
527 "A_UNTYPE": {
528     "label": "Reason for unemployment",
529     "universe": "A_LFSR=3 or 4",
530     "type": "Categorical",

```

```

529     "role": "Independent",
530     "topic": "Basic CPS items",
531     "subtopic": "Labor force person recodes",
532     "values": {
533         "0": "Not in universe or children and Armed Forces",
534         "1": "Job loser - on layoff",
535         "2": "Other job loser",
536         "3": "Job leaver",
537         "4": "Re-entrant",
538         "5": "New entrant"
539     }
540 },
541 "A_USLHRS": {
542     "label": "How many hrs per week does ... usually work at this job?"
543     ,
544     "universe": "All persons",
545     "type": "Continuous",
546     "role": "Independent",
547     "topic": "Basic CPS items",
548     "subtopic": "Labor force person recodes",
549     "values": {
550         "-4": "Hours vary",
551         "-1": "Not in universe",
552         "00": "None, no hours",
553         "01-99": "Entry"
554     }
555 },
556 "A_WKSCH": {
557     "label": "Labor force by time worked or lost",
558     "universe": "All persons",
559     "type": "Categorical",
560     "role": "Independent",
561     "topic": "Basic CPS items",
562     "subtopic": "Labor force person recodes",
563     "values": {
564         "0": "Not in universe",

```

```

564         "1": "At work",
565         "2": "With job, not at work",
566         "3": "Unemployed, seeks FT",
567         "4": "Unemployed, seeks PT"
568     }
569 },
570 "A_WKSLK": {
571     "label": "Duration of unemployment",
572     "universe": "PEMLR=3 or 4",
573     "type": "Continuous",
574     "role": "Independent",
575     "topic": "Basic CPS items",
576     "subtopic": "Labor force person recodes",
577     "values": {
578         "000": "NIU, Children or Armed Forces",
579         "001-999": "Entry"
580     }
581 },
582 "A_WKSTAT": {
583     "label": "Full/part-time status",
584     "universe": "All persons",
585     "type": "Categorical",
586     "role": "Independent",
587     "topic": "Basic CPS items",
588     "subtopic": "Labor force person recodes",
589     "values": {
590         "0": "Children or Armed Forces",
591         "1": "Not in labor force",
592         "2": "Full-time schedules",
593         "3": "Part-time for economic reasons, usually FT",
594         "4": "Part-time for non-economic reasons, usually PT",
595         "5": "Part-time for economic reasons, usually PT",
596         "6": "Unemployed FT",
597         "7": "Unemployed PT"
598     }
599 },

```

```

600     "PEHRUSLT": {
601         "label": "Hours usually worked last week",
602         "universe": "All persons",
603         "type": "Continuous",
604         "role": "Independent",
605         "topic": "Basic CPS items",
606         "subtopic": "Labor force person recodes",
607         "values": {
608             "-4": "Hours vary",
609             "-1": "NIU - adult civilian",
610             "000": "NIU - children or Armed Forces or no hours",
611             "1-198": "# of hours"
612         }
613     },
614     "PEMLR": {
615         "label": "Major labor force recode",
616         "universe": "All persons",
617         "type": "Categorical",
618         "role": "Independent",
619         "topic": "Basic CPS items",
620         "subtopic": "Labor force person recodes",
621         "values": {
622             "0": "NIU",
623             "1": "Employed - at work",
624             "2": "Employed - absent",
625             "3": "Unemployed - on layoff",
626             "4": "Unemployed - looking",
627             "5": "Not in labor force - retired",
628             "6": "Not in labor force - disabled",
629             "7": "Not in labor force - other"
630         }
631     },
632     "PRCOW1": {
633         "label": "Class of worker recode-job 1",
634         "universe": "All persons",
635         "type": "Categorical",

```



```

636     "role": "Independent",
637     "topic": "Basic CPS items",
638     "subtopic": "Labor force person recodes",
639     "values": {
640         "0": "NIU",
641         "1": "Federal govt",
642         "2": "State govt",
643         "3": "Local govt",
644         "4": "Private (incl. self-employed incorp.)",
645         "5": "Self-employed, unincorp.",
646         "6": "Without pay"
647     }
648 },
649 "PRPTREA": {
650     "label": "Detailed reason for part-time",
651     "universe": "Part time workers",
652     "type": "Categorical",
653     "role": "Independent",
654     "topic": "Basic CPS items",
655     "subtopic": "Labor force person recodes",
656     "values": {
657         "0": "NIU",
658         "1": "Usually FT - slack work/business conditions",
659         "2": "Usually FT - seasonal work",
660         "3": "Usually FT - job started/ended during week",
661         "4": "Usually FT - vacation/personal day",
662         "5": "Usually FT - own illness/injury/medical appt",
663         "6": "Usually FT - holiday (religious or legal)",
664         "7": "Usually FT - child care problems",
665         "8": "Usually FT - other fam/pers obligations",
666         "9": "Usually FT - labor dispute",
667         "10": "Usually FT - weather affected job",
668         "11": "Usually FT - school/training",
669         "12": "Usually FT - civic/military duty",
670         "13": "Usually FT - other reason",
671         "14": "Usually PT - slack work/business conditions",

```

```

672         "15": "Usually PT - PT could only find PT work",
673         "16": "Usually PT - seasonal work",
674         "17": "Usually PT - child care problems",
675         "18": "Usually PT - other fam/pers obligations",
676         "19": "Usually PT - health/medical limitations",
677         "20": "Usually PT - school/training",
678         "21": "Usually PT - retired/social security limit on earnings",
679         "22": "Usually PT - workweek<35 hours",
680         "23": "Usually PT - other"
681     }
682 },
683 "PRWKSTAT": {
684     "label": "Full/part-time work status",
685     "universe": "All persons",
686     "type": "Categorical",
687     "role": "Independent",
688     "topic": "Basic CPS items",
689     "subtopic": "Labor force person recodes",
690     "values": {
691         "0": "NIU",
692         "1": "Not in labor force",
693         "2": "FT hours (35+), usually FT",
694         "3": "PT for economic reasons, usually FT",
695         "4": "PT for non-economic reasons, usually FT",
696         "5": "Not at work, usually FT",
697         "6": "PT hrs, usually PT for economic reasons",
698         "7": "PT hrs, usually PT for non-economic",
699         "8": "FT hours, usually PT for economic reasons",
700         "9": "FT hours, usually PT for non-economic reasons",
701         "10": "Not at work, usually part-time",
702         "11": "Unemployed FT",
703         "12": "Unemployed PT"
704     }
705 },
706 "CLWK": {
707     "label": "Longest job class of worker (recode)",

```

```

708     "universe": "All persons aged 15+",
709     "type": "Categorical",
710     "role": "Independent",
711     "topic": "Work experience",
712     "subtopic": "General",
713     "values": {
714         "0": "Niu",
715         "1": "Private",
716         "2": "Government",
717         "3": "Self-employed",
718         "4": "Without pay",
719         "5": "Never worked"
720     }
721 },
722 "EARNER": {
723     "label": "Earner status recode",
724     "universe": "All persons aged 15+",
725     "type": "Categorical",
726     "role": "Independent",
727     "topic": "Work experience",
728     "subtopic": "General",
729     "values": {
730         "0": "Niu",
731         "1": "Earner",
732         "2": "Nonearner"
733     }
734 },
735 "HRSWK": {
736     "label": "In the weeks that ... worked how may hours did ...
              usually work per week?",
737     "universe": "WKSWORK > 0",
738     "type": "Continuous",
739     "role": "Independent",
740     "topic": "Work experience",
741     "subtopic": "General",
742     "values": {

```

```

743         "0": "Niu",
744         "1": "1 hour",
745         "2-98": "2-98 hours",
746         "99": "99 hours plus"
747     }
748 },
749 "LJCW": {
750     "label": "Longest job class of worker",
751     "universe": "WKSWORK > 0",
752     "type": "Categorical",
753     "role": "Independent",
754     "topic": "Work experience",
755     "subtopic": "General",
756     "values": {
757         "0": "Niu",
758         "1": "Private",
759         "2": "Federal",
760         "3": "State",
761         "4": "Local",
762         "5": "Self employed incorporated, yes",
763         "6": "Self employed incorporated, no or farm",
764         "7": "Without pay"
765     }
766 },
767 "NWLKWK": {
768     "label": "How many different weeks was ... looking for work or on
       layoff?",
769     "universe": "NWLOOK = 1",
770     "type": "Continuous",
771     "role": "Independent",
772     "topic": "Work experience",
773     "subtopic": "General",
774     "values": {
775         "0": "Niu",
776         "1": "1 week",
777         "2-51": "2-51 weeks",

```

```

778         "52": "52 weeks"
779     }
780 },
781 "NWLOOK": {
782     "label": "Even though ... did not work in 20.. did spend and time
           trying to find a job or on layoff?",
783     "universe": "WORKYN = 2",
784     "type": "Categorical",
785     "role": "Independent",
786     "topic": "Work experience",
787     "subtopic": "General",
788     "values": {
789         "0": "Niu",
790         "1": "Yes",
791         "2": "No"
792     }
793 },
794 "PHMEMPRS": {
795     "label": "For how many employers did ... work in 20..? if more than
           one at same time, only count it as one employer",
796     "universe": "WKSWORK > 0",
797     "type": "Categorical",
798     "role": "Independent",
799     "topic": "Work experience",
800     "subtopic": "General",
801     "values": {
802         "0": "Niu",
803         "1": "One employer",
804         "2": "Two employers",
805         "3": "3 or more employers"
806     }
807 },
808 "RSNNOTW": {
809     "label": "What was the main reason ... did not work in 20..?",
810     "universe": "WORKYN = 2",
811     "type": "Categorical",

```

```

812     "role": "Independent",
813     "topic": "Work experience",
814     "subtopic": "General",
815     "values": {
816         "0": "Niu",
817         "1": "Ill or disabled",
818         "2": "Retired",
819         "3": "Taking care of home",
820         "4": "Going to school",
821         "5": "Could not find work",
822         "6": "Other"
823     }
824 },
825 "WECLW": {
826     "label": "Longest job class of worker (persons 15+)",
827     "universe": "All persons aged 15+",
828     "type": "Categorical",
829     "role": "Independent",
830     "topic": "Work experience",
831     "subtopic": "General",
832     "values": {
833         "0": "Not in universe",
834         "1": "Agriculture (Wage and salary)",
835         "2": "Agriculture (Self-employed)",
836         "3": "Agriculture (Unpaid)",
837         "4": "Nonagriculture (Private household)",
838         "5": "Nonagriculture (Other private)",
839         "6": "Nonagriculture (Government)",
840         "7": "Nonagriculture (Self-employed)",
841         "8": "Nonagriculture (Unpaid)",
842         "9": "Nonagriculture (Never worked)"
843     }
844 },
845 "WEWKRS": {
846     "label": "Weeks worked recode",
847     "universe": "All persons aged 15+",

```

```

848     "type": "Categorical",
849     "role": "Independent",
850     "topic": "Work experience",
851     "subtopic": "General",
852     "values": {
853         "0": "Niu",
854         "1": "Full-year worker (Full time)",
855         "2": "Full-year worker (Part time)",
856         "3": "Part-year worker (Full time)",
857         "4": "Part-year worker (Part time)",
858         "5": "Part-year worker (Nonworker)"
859     }
860 },
861 "WKSWORK": {
862     "label": "During 20.. in how many weeks did ... work even for a few
            hours? (include paid vacation and sick leave as work)",
863     "universe": "Persons 15+ with WORKYN = 1",
864     "type": "Continuous",
865     "role": "Independent",
866     "topic": "Work experience",
867     "subtopic": "General",
868     "values": {
869         "0": "Niu",
870         "1": "1 week",
871         "2-51": "2-51 weeks",
872         "52": "52 weeks"
873     }
874 },
875 "WORKYN": {
876     "label": "Did ... work at a job or business at any time during
            20..?",
877     "universe": "All persons aged 15+",
878     "type": "Categorical",
879     "role": "Independent",
880     "topic": "Work experience",
881     "subtopic": "General",

```

```

882     "values": {
883         "0": "Niu",
884         "1": "Yes",
885         "2": "No"
886     }
887 },
888 "WRK_CK": {
889     "label": "Worked last year recode, including temporary and part-
            time",
890     "universe": "All persons aged 15+",
891     "type": "Categorical",
892     "role": "Independent",
893     "topic": "Work experience",
894     "subtopic": "General",
895     "values": {
896         "0": "Niu",
897         "1": "Yes",
898         "2": "No"
899     }
900 },
901 "WTEMP": {
902     "label": "Did ... do any temporary, part-time, or seasonal work
            even for a few days during 20..?",
903     "universe": "WORKYN = 2",
904     "type": "Categorical",
905     "role": "Independent",
906     "topic": "Work experience",
907     "subtopic": "General",
908     "values": {
909         "0": "Niu",
910         "1": "Yes",
911         "2": "No"
912     }
913 },
914 "ERN_OTR": {
915     "label": "Wage and salary money earned from other work, Y/N",

```



```

916     "universe": "All persons aged 15+",
917     "type": "Categorical",
918     "role": "Independent",
919     "topic": "Income",
920     "subtopic": "Earnings",
921     "values": {
922         "0": "Niu",
923         "1": "Yes",
924         "2": "No"
925     }
926 },
927 "ERN_SRCE": {
928     "label": "Source of earnings from longest job",
929     "universe": "ERN_YN = 1",
930     "type": "Categorical",
931     "role": "Independent",
932     "topic": "Income",
933     "subtopic": "Earnings",
934     "values": {
935         "0": "Niu",
936         "1": "Wage and salary",
937         "2": "Self employment",
938         "3": "Farm self employment",
939         "4": "Without pay"
940     }
941 },
942 "ERN_VAL": {
943     "label": "How much did ... earn from this employer before
          deductions in 20..? what was ... net earnings from this
          business/ farm after expenses during 20..?",
944     "universe": "ERN_YN = 1",
945     "type": "Continuous",
946     "role": "Independent",
947     "topic": "Income",
948     "subtopic": "Earnings",
949     "values": {

```

```

950         "0": "None or Niu",
951         "-9,999 - 9,999,999": "Wages & self-employment"
952     }
953 },
954 "ERN_YN": {
955     "label": "Earnings from employer or net earnings from business/
          farm after expenses from longest job during 20.. ?",
956     "universe": "WORKYN=1 or WTEMP=1",
957     "type": "Categorical",
958     "role": "Independent",
959     "topic": "Income",
960     "subtopic": "Earnings",
961     "values": {
962         "0": "Niu",
963         "1": "Yes",
964         "2": "No"
965     }
966 },
967 "FRM_VAL": {
968     "label": "Amount of farm self-employment earnings from secondary
          source",
969     "universe": "FRMOTR = 1",
970     "type": "Continuous",
971     "role": "Independent",
972     "topic": "Income",
973     "subtopic": "Earnings",
974     "values": {
975         "0": "None or Niu",
976         "-999999-999999": "Farm self employment"
977     }
978 },
979 "FRMOTR": {
980     "label": "Receiving farm self-employment from secondary source",
981     "universe": "ERN_OTR = 1",
982     "type": "Categorical",
983     "role": "Independent",

```

```

984     "topic": "Income",
985     "subtopic": "Earnings",
986     "values": {
987         "0": "Niu",
988         "1": "Yes",
989         "2": "No"
990     }
991 },
992 "FRSE_VAL": {
993     "label": "Total amount of farm self-employment earnings",
994     "universe": "ERN_YN=1 or FRMOTR=1",
995     "type": "Continuous",
996     "role": "Independent",
997     "topic": "Income",
998     "subtopic": "Earnings",
999     "values": {
1000         "0": "None or Niu;",
1001         "-999999-999999": "Farm self employment"
1002     }
1003 },
1004 "FRSE_YN": {
1005     "label": "Receiving any farm self-employment",
1006     "universe": "ERN_YN=1 or FRMOTR=1",
1007     "type": "Categorical",
1008     "role": "Independent",
1009     "topic": "Income",
1010     "subtopic": "Earnings",
1011     "values": {
1012         "0": "Niu",
1013         "1": "Yes",
1014         "2": "No"
1015     }
1016 },
1017 "PEARINVAL": {
1018     "label": "Total persons earnings",
1019     "universe": "All persons aged 15+",

```

```

1020     "type": "Continuous",
1021     "role": "Independent",
1022     "topic": "Income",
1023     "subtopic": "Earnings",
1024     "values": {
1025         "0": "None;",
1026         "negative amt": "Income (loss);",
1027         "positive amt": "Income"
1028     }
1029 },
1030 "SE_VAL": {
1031     "label": "Amount of own business self-employment earnings from
           secondary source",
1032     "universe": "SEOTR = 1",
1033     "type": "Continuous",
1034     "role": "Independent",
1035     "topic": "Income",
1036     "subtopic": "Earnings",
1037     "values": {
1038         "0": "None or niu;",
1039         "-99999-999999": "Own business self employment"
1040     }
1041 },
1042 "SEMP_VAL": {
1043     "label": "Total own business self-employment earnings (combined
           amounts in ern-val, if ern-srce=2, and se-val)",
1044     "universe": "ERN_YN=1 or SEOTR=1",
1045     "type": "Continuous",
1046     "role": "Independent",
1047     "topic": "Income",
1048     "subtopic": "Earnings",
1049     "values": {
1050         "0": "None or niu;",
1051         "-99999-999999": "Own business self employment"
1052     }
1053 },

```

```

1054     "SEMP_YN": {
1055         "label": "Receiving own business self-employment, y/n",
1056         "universe": "ERN_YN=1 or SEOTR=1",
1057         "type": "Categorical",
1058         "role": "Independent",
1059         "topic": "Income",
1060         "subtopic": "Earnings",
1061         "values": {
1062             "0": "Niu",
1063             "1": "Yes",
1064             "2": "No"
1065         }
1066     },
1067     "SEOTR": {
1068         "label": "Receiving own business self-employment, y/n",
1069         "universe": "ERN_YN=1 or SEOTR=1",
1070         "type": "Categorical",
1071         "role": "Independent",
1072         "topic": "Income",
1073         "subtopic": "Earnings",
1074         "values": {
1075             "0": "Niu",
1076             "1": "Yes",
1077             "2": "No"
1078         }
1079     },
1080     "WAGEOTR": {
1081         "label": "Receiving wage and salary earnings from other employers,
1082             y/n",
1083         "universe": "ERN_OTR = 1",
1084         "type": "Categorical",
1085         "role": "Independent",
1086         "topic": "Income",
1087         "subtopic": "Earnings",
1088         "values": {

```

```

1089         "1": "Yes",
1090         "2": "No"
1091     }
1092 },
1093 "WS_VAL": {
1094     "label": "Amount of wage and salary earnings from other employers",
1095     "universe": "ERN_OTR = 1",
1096     "type": "Continuous",
1097     "role": "Independent",
1098     "topic": "Income",
1099     "subtopic": "Earnings",
1100     "values": {
1101         "0": "None or niu;",
1102         "1-9999999": "Wage and salary"
1103     }
1104 },
1105 "WSAL_VAL": {
1106     "label": "Total wage and salary earnings (combined amounts in ern-
1107         val, if ern-srce=1, and ws-val)",
1108     "universe": "ERN_YN=1 or WAGEOTR=1",
1109     "type": "Continuous",
1110     "role": "Independent",
1111     "topic": "Income",
1112     "subtopic": "Earnings",
1113     "values": {
1114         "0": "None or niu;",
1115         "1-9999999": "Wage and salary"
1116     }
1117 },
1118 "WSAL_YN": {
1119     "label": "Receiving wage and salary earnings",
1120     "universe": "ERN_YN=1 or WAGEOTR=1",
1121     "type": "Categorical",
1122     "role": "Independent",
1123     "topic": "Income",
1124     "subtopic": "Earnings",

```

```

1124     "values": {
1125         "0": "Niu",
1126         "1": "Yes",
1127         "2": "No"
1128     }
1129 },
1130 "ANN_VAL": {
1131     "label": "Retirement income, annuities amount",
1132     "universe": "ANN_YN = 1",
1133     "type": "Continuous",
1134     "role": "Independent",
1135     "topic": "Income",
1136     "subtopic": "Other income",
1137     "values": {
1138         "-1": "Niu",
1139         "0-999999": "Dollar amount"
1140     }
1141 },
1142 "ANN_YN": {
1143     "label": "Retirement income, annuities, y/n",
1144     "universe": "All Persons aged 15+",
1145     "type": "Categorical",
1146     "role": "Independent",
1147     "topic": "Income",
1148     "subtopic": "Other income",
1149     "values": {
1150         "0": "Niu",
1151         "1": "Yes",
1152         "2": "No"
1153     }
1154 },
1155 "CAP_VAL": {
1156     "label": "Capital gains value",
1157     "universe": "CAP_YN = 1",
1158     "type": "Continuous",
1159     "role": "Independent",

```

```

1160     "topic": "Income",
1161     "subtopic": "Other income",
1162     "values": {
1163         "0": "None or niu",
1164         "1-999999": "Captial gains amount"
1165     }
1166 },
1167 "CAP_YN": {
1168     "label": "Yes/no answer to 'Did you receive capital gain from your
1169         shares of stock or mutual fund?'",
1170     "universe": "DIV_YN = 1",
1171     "type": "Categorical",
1172     "role": "Independent",
1173     "topic": "Income",
1174     "subtopic": "Other income",
1175     "values": {
1176         "0": "Niu",
1177         "1": "Yes",
1178         "2": "No"
1179     }
1180 },
1181 "DBTN_VAL": {
1182     "label": "Total amount of retirement distributions received (
1183         dst_val1 + dst_val2)",
1184     "universe": "DST_VAL1>0 OR DST_VAL2>0",
1185     "type": "Continuous",
1186     "role": "Independent",
1187     "topic": "Income",
1188     "subtopic": "Other income",
1189     "values": {
1190         "0": "None or niu",
1191         "1-99999999": "Dollar amount"
1192     }
1193 },
1194 "DIS_SC1": {
1195     "label": "What was the source of disability income?",

```



```

1194     "universe": "DIS_YN=1",
1195     "type": "Categorical",
1196     "role": "Independent",
1197     "topic": "Income",
1198     "subtopic": "Other income",
1199     "values": {
1200         "0": "Niu",
1201         "1": "Worker's compensation",
1202         "2": "Company or union disability",
1203         "3": "Federal government disability",
1204         "4": "Us military retirement disability",
1205         "5": "State or local gov't employee disability",
1206         "6": "Us railroad retirement disability",
1207         "7": "Accident or disability insurance",
1208         "8": "Blacklung miners disability",
1209         "9": "State temporary sickness",
1210         "10": "Other or don't know"
1211     }
1212 },
1213 "DIS_SC2": {
1214     "label": "What was the source of disability income?",
1215     "universe": "DIS_YN=1",
1216     "type": "Categorical",
1217     "role": "Independent",
1218     "topic": "Income",
1219     "subtopic": "Other income",
1220     "values": {
1221         "0": "Niu",
1222         "1": "Worker's compensation",
1223         "2": "Company or union disability",
1224         "3": "Federal government disability",
1225         "4": "Us military retirement disability",
1226         "5": "State or local gov't employee disability",
1227         "6": "Us railroad retirement disability",
1228         "7": "Accident or disability insurance",
1229         "8": "Blacklung miners disability",

```

```

1230         "9": "State temporary sickness",
1231         "10": "Other or don't know"
1232     }
1233 },
1234 "DIS_VAL1": {
1235     "label": "How much did ... receive (source type) during 20.. ?",
1236     "universe": "DIS_SC1>0",
1237     "type": "Continuous",
1238     "role": "Independent",
1239     "topic": "Income",
1240     "subtopic": "Other income",
1241     "values": {
1242         "0": "None or niu",
1243         "1-999999": "Disability income"
1244     }
1245 },
1246 "DIS_VAL2": {
1247     "label": "How much did ... receive (source type) during 20.. ?",
1248     "universe": "DIS_SC2>0",
1249     "type": "Continuous",
1250     "role": "Independent",
1251     "topic": "Income",
1252     "subtopic": "Other income",
1253     "values": {
1254         "0": "None or niu",
1255         "1-999999": "Disability income"
1256     }
1257 },
1258 "DIS_YN": {
1259     "label": "Other than social security did ... receive any income in
        20.. as a result of health problems?",
1260     "universe": "All Persons aged 15+",
1261     "type": "Categorical",
1262     "role": "Independent",
1263     "topic": "Income",
1264     "subtopic": "Other income",

```

```

1265         "values": {
1266             "0": "Niu",
1267             "1": "Yes",
1268             "2": "No"
1269         }
1270     },
1271     "DIV_VAL": {
1272         "label": "How much did ... receive in dividends from stocks or
            mutual funds during 20.. ?",
1273         "universe": "DIV_YN = 1",
1274         "type": "Continuous",
1275         "role": "Independent",
1276         "topic": "Income",
1277         "subtopic": "Other income",
1278         "values": {
1279             "0": "None or niu",
1280             "1-999999": "Dividends"
1281         }
1282     },
1283     "DIV_YN": {
1284         "label": "Did ... receive dividends?",
1285         "universe": "All Persons aged 15+",
1286         "type": "Categorical",
1287         "role": "Independent",
1288         "topic": "Income",
1289         "subtopic": "Other income",
1290         "values": {
1291             "0": "Niu",
1292             "1": "Yes",
1293             "2": "No"
1294         }
1295     },
1296     "DSAB_VAL": {
1297         "label": "Total amount of disability income received, combined
            amounts in edited sources one and two",
1298         "universe": "DIS_VAL1>0 OR DIS_VAL2>0",

```

```

1299     "type": "Continuous",
1300     "role": "Independent",
1301     "topic": "Income",
1302     "subtopic": "Other income",
1303     "values": {
1304         "0": "None or niu",
1305         "1-999999": "Disability income"
1306     }
1307 },
1308 "DST_SC1": {
1309     "label": "Retirement income, distribution source 1",
1310     "universe": "DST_VAL1 > 0 and a_age >= 58",
1311     "type": "Categorical",
1312     "role": "Independent",
1313     "topic": "Income",
1314     "subtopic": "Other income",
1315     "values": {
1316         "0": "Niu",
1317         "1": "401k account",
1318         "2": "403b account",
1319         "3": "Roth ira",
1320         "4": "Regular ira",
1321         "5": "Keogh plan",
1322         "6": "Sep plan (simplified employee pension)",
1323         "7": "Other type of retirement account"
1324     }
1325 },
1326 "DST_SC1_YNG": {
1327     "label": "Retirement Distribution source 1, person under age 58",
1328     "universe": "DST_YN_YNG = 1 and a_age < 58",
1329     "type": "Categorical",
1330     "role": "Independent",
1331     "topic": "Income",
1332     "subtopic": "Other income",
1333     "values": {
1334         "0": "Niu",

```

```

1335         "1": "401k account",
1336         "2": "403b account",
1337         "3": "Roth ira",
1338         "4": "Regular ira",
1339         "5": "Keogh plan",
1340         "6": "Sep plan (simplified employee pension)",
1341         "7": "Other type of retirement account"
1342     }
1343 },
1344 "DST_SC2": {
1345     "label": "Retirement income, distribution source 2",
1346     "universe": "DST_VAL2 > 0 and a_age >= 58",
1347     "type": "Categorical",
1348     "role": "Independent",
1349     "topic": "Income",
1350     "subtopic": "Other income",
1351     "values": {
1352         "0": "Niu",
1353         "1": "401k account",
1354         "2": "403b account",
1355         "3": "Roth ira",
1356         "4": "Regular ira",
1357         "5": "Keogh plan",
1358         "6": "Sep plan (simplified employee pension)",
1359         "7": "Other type of retirement account"
1360     }
1361 },
1362 "DST_SC2_YNG": {
1363     "label": "Retirement Distribution source 2, person under age 58",
1364     "universe": "DST_VAL_YNG > 0 and a_age < 58",
1365     "type": "Categorical",
1366     "role": "Independent",
1367     "topic": "Income",
1368     "subtopic": "Other income",
1369     "values": {
1370         "0": "Niu",

```

```

1371         "1": "401k account",
1372         "2": "403b account",
1373         "3": "Roth ira",
1374         "4": "Regular ira",
1375         "5": "Keogh plan",
1376         "6": "Sep plan (simplified employee pension)",
1377         "7": "Other type of retirement account"
1378     }
1379 },
1380 "DST_VAL1": {
1381     "label": "Retirement income amount, distribution source 1",
1382     "universe": "DST_SC1 = 1",
1383     "type": "Continuous",
1384     "role": "Independent",
1385     "topic": "Income",
1386     "subtopic": "Other income",
1387     "values": {
1388         "0": "None or niu",
1389         "1- 999,999": "Amount withdrawn or distributed"
1390     }
1391 },
1392 "DST_VAL1_YNG": {
1393     "label": "Retirement Distribution amount 1, under age 58",
1394     "universe": "DST_SC1_YNG = 1",
1395     "type": "Continuous",
1396     "role": "Independent",
1397     "topic": "Income",
1398     "subtopic": "Other income",
1399     "values": {
1400         "0": "None or niu",
1401         "1- 999,999": "Amount withdrawn or distributed"
1402     }
1403 },
1404 "DST_VAL2": {
1405     "label": "Retirement income amount, distribution source 2",
1406     "universe": "DST_SC2 = 1",

```

```

1407     "type": "Continuous",
1408     "role": "Independent",
1409     "topic": "Income",
1410     "subtopic": "Other income",
1411     "values": {
1412         "0": "None or niu",
1413         "1- 999,999": "Amount withdrawn or distributed"
1414     }
1415 },
1416 "DST_VAL2_YNG": {
1417     "label": "Retirement Distribution amount 2, under age 58",
1418     "universe": "DST_SC2_YNG = 1",
1419     "type": "Continuous",
1420     "role": "Independent",
1421     "topic": "Income",
1422     "subtopic": "Other income",
1423     "values": {
1424         "0": "None or niu",
1425         "1- 999,999": "Amount withdrawn or distributed"
1426     }
1427 },
1428 "DST_YN": {
1429     "label": "Retirement income distribution y/n",
1430     "universe": "Persons aged 58 and over (a_age >= 58)",
1431     "type": "Categorical",
1432     "role": "Independent",
1433     "topic": "Income",
1434     "subtopic": "Other income",
1435     "values": {
1436         "0": "Niu",
1437         "1": "Yes",
1438         "2": "No"
1439     }
1440 },
1441 "DST_YN_YNG": {
1442     "label": "Retirement Distribution Reciprocity, person under age 58",

```

```

1443     "universe": "Persons under age 58 (a_age < 58)",
1444     "type": "Categorical",
1445     "role": "Independent",
1446     "topic": "Income",
1447     "subtopic": "Other income",
1448     "values": {
1449         "0": "Niu",
1450         "1": "Yes",
1451         "2": "No"
1452     }
1453 },
1454 "ED_VAL": {
1455     "label": "Total amount of educational assistance received (combined
           amounts in pell grant and other educational) assistance during
           20.. ?",
1456     "universe": "ED_YN = 1",
1457     "type": "Continuous",
1458     "role": "Independent",
1459     "topic": "Income",
1460     "subtopic": "Other income",
1461     "values": {
1462         "0": "None or niu",
1463         "1- 99,999": "Dollar amount"
1464     }
1465 },
1466 "ED_YN": {
1467     "label": "Did ... receive educational assistance?",
1468     "universe": "All Persons aged 15+",
1469     "type": "Categorical",
1470     "role": "Independent",
1471     "topic": "Income",
1472     "subtopic": "Other income",
1473     "values": {
1474         "0": "Niu",
1475         "1": "Yes",
1476         "2": "No"

```



```

1477     }
1478 },
1479 "FIN_VAL": {
1480     "label": "How much did ... receive in financial assistance income
           during 20.. ?",
1481     "universe": "FIN_YN = 1",
1482     "type": "Continuous",
1483     "role": "Independent",
1484     "topic": "Income",
1485     "subtopic": "Other income",
1486     "values": {
1487         "0": "None or niu",
1488         "1-999999": "Financial assistance"
1489     }
1490 },
1491 "FIN_YN": {
1492     "label": "Did ... receive financial assistance?",
1493     "universe": "All Persons aged 15+",
1494     "type": "Categorical",
1495     "role": "Independent",
1496     "topic": "Income",
1497     "subtopic": "Other income",
1498     "values": {
1499         "0": "Niu",
1500         "1": "Yes",
1501         "2": "No"
1502     }
1503 },
1504 "INT_VAL": {
1505     "label": "Edited total combined interest income",
1506     "universe": "INT_YN = 1",
1507     "type": "Continuous",
1508     "role": "Independent",
1509     "topic": "Income",
1510     "subtopic": "Other income",
1511     "values": {

```

```

1512         "0": "None or niu;",
1513         "1- 999,999": "Dollar amount"
1514     }
1515 },
1516 "INT_YN": {
1517     "label": "Edited total combined interest income, y/n",
1518     "universe": "All Persons aged 15+",
1519     "type": "Categorical",
1520     "role": "Independent",
1521     "topic": "Income",
1522     "subtopic": "Other income",
1523     "values": {
1524         "0": "Niu",
1525         "1": "Yes",
1526         "2": "No"
1527     }
1528 },
1529 "OED_TYP1": {
1530     "label": "Source 1 other than gi bill received (OED_TYP1- source of
        other government assistance)",
1531     "universe": "ED_YN = 1",
1532     "type": "Categorical",
1533     "role": "Independent",
1534     "topic": "Income",
1535     "subtopic": "Other income",
1536     "values": {
1537         "0": "Niu",
1538         "1": "Yes",
1539         "2": "No"
1540     }
1541 },
1542 "OED_TYP2": {
1543     "label": "Source 2 other than gi bill received (OED_TYP2-
        scholarships, grants etc. from the school)",
1544     "universe": "ED_YN = 1",
1545     "type": "Categorical",

```

```

1546     "role": "Independent",
1547     "topic": "Income",
1548     "subtopic": "Other income",
1549     "values": {
1550         "0": "Niu",
1551         "1": "Yes",
1552         "2": "No"
1553     }
1554 },
1555 "OED_TYP3": {
1556     "label": "Source other than gi bill received (OED_TYP3- other
           assistance (employers friends, etc.)",
1557     "universe": "ED_YN = 1",
1558     "type": "Categorical",
1559     "role": "Independent",
1560     "topic": "Income",
1561     "subtopic": "Other income",
1562     "values": {
1563         "0": "Niu",
1564         "1": "Yes",
1565         "2": "No"
1566     }
1567 },
1568 "OI_OFF": {
1569     "label": "Other income sources",
1570     "universe": "OI_YN = 1",
1571     "type": "Categorical",
1572     "role": "Independent",
1573     "topic": "Income",
1574     "subtopic": "Other income",
1575     "values": {
1576         "0": "Niu",
1577         "1": "Social security",
1578         "2": "Private pensions",
1579         "3": "Afdc",
1580         "4": "Other public assistance",

```

```

1581         "5": "Interest",
1582         "6": "Dividends",
1583         "7": "Rents or royalties",
1584         "8": "Estates or trusts",
1585         "9": "State disability payments (worker's comp)",
1586         "10": "Disability payments (own insurance)",
1587         "11": "Unemployment compensation",
1588         "12": "Strike benefits",
1589         "13": "Annuities or paid up insurance policies",
1590         "14": "Not income",
1591         "15": "Longest job",
1592         "16": "Wages or salary",
1593         "17": "Nonfarm self-employment",
1594         "18": "Farm self-employment",
1595         "19": "Anything else",
1596         "20": "Alimony"
1597     }
1598 },
1599     "OI_VAL": {
1600         "label": "How much did ... receive in other incomes",
1601         "universe": "OI_YN = 1",
1602         "type": "Continuous",
1603         "role": "Independent",
1604         "topic": "Income",
1605         "subtopic": "Other income",
1606         "values": {
1607             "0": "None or niu",
1608             "1-999999": "Other income"
1609         }
1610     },
1611     "OI_YN": {
1612         "label": "Did ... receive cash income not already covered from any
                other source?",
1613         "universe": "All Persons aged 15+",
1614         "type": "Categorical",
1615         "role": "Independent",

```

```

1616     "topic": "Income",
1617     "subtopic": "Other income",
1618     "values": {
1619         "0": "None or niu",
1620         "1": "Yes",
1621         "2": "No"
1622     }
1623 },
1624 "PEN_SC1": {
1625     "label": "Retirement income, pension source 1",
1626     "universe": "PEN_YN = 1",
1627     "type": "Categorical",
1628     "role": "Independent",
1629     "topic": "Income",
1630     "subtopic": "Other income",
1631     "values": {
1632         "0": "Niu",
1633         "1": "Company pension",
1634         "2": "Union pension",
1635         "3": "Federal government pension",
1636         "4": "State government pension",
1637         "5": "Local government pension",
1638         "6": "Us military pension",
1639         "7": "Us railroad retirement",
1640         "8": "Other"
1641     }
1642 },
1643 "PEN_SC2": {
1644     "label": "Retirement income, pension source 2",
1645     "universe": "PEN_VAL2 > 0",
1646     "type": "Categorical",
1647     "role": "Independent",
1648     "topic": "Income",
1649     "subtopic": "Other income",
1650     "values": {
1651         "0": "Niu",

```

```

1652         "1": "Company pension",
1653         "2": "Union pension",
1654         "3": "Federal government pension",
1655         "4": "State government pension",
1656         "5": "Local government pension",
1657         "6": "Us military pension",
1658         "7": "Us railroad retirement",
1659         "8": "Other"
1660     }
1661 },
1662 "PEN_VAL1": {
1663     "label": "Retirement income amount, pension source 1",
1664     "universe": "PEN_SC1 > 0",
1665     "type": "Continuous",
1666     "role": "Independent",
1667     "topic": "Income",
1668     "subtopic": "Other income",
1669     "values": {
1670         "0": "None or niu",
1671         "1-999,999": "Pension income"
1672     }
1673 },
1674 "PEN_VAL2": {
1675     "label": "Retirement income amount, pension source 2",
1676     "universe": "PEN_SC2 > 0",
1677     "type": "Continuous",
1678     "role": "Independent",
1679     "topic": "Income",
1680     "subtopic": "Other income",
1681     "values": {
1682         "0": "None or niu",
1683         "1-999,999": "Pension income"
1684     }
1685 },
1686 "PEN_YN": {
1687     "label": "Retirement income, pension y/n",

```

```

1688     "universe": "All Persons aged 15+",
1689     "type": "Categorical",
1690     "role": "Independent",
1691     "topic": "Income",
1692     "subtopic": "Other income",
1693     "values": {
1694         "0": "Niu",
1695         "1": "Yes",
1696         "2": "No"
1697     }
1698 },
1699 "PNSN_VAL": {
1700     "label": "Total combined amount of pension income received from all
           pension sources",
1701     "universe": "PEN_YN = 1",
1702     "type": "Continuous",
1703     "role": "Independent",
1704     "topic": "Income",
1705     "subtopic": "Other income",
1706     "values": {
1707         "0": "None or niu",
1708         "1-9,999,999": "Retirement income"
1709     }
1710 },
1711 "PTOTVAL": {
1712     "label": "Total persons income",
1713     "universe": "All Persons aged 15+",
1714     "type": "Continuous",
1715     "role": "Independent",
1716     "topic": "Income",
1717     "subtopic": "Other income",
1718     "values": {
1719         "0": "None",
1720         "negative amt": "Income (loss)",
1721         "positive amt": "Income"
1722     }

```

```

1723     },
1724     "RESNSS1": {
1725         "label": "What were the reasons (you/name) (was/were) getting
                Social Security Income last year?",
1726         "universe": "SS_YN = 1",
1727         "type": "Categorical",
1728         "role": "Independent",
1729         "topic": "Income",
1730         "subtopic": "Other income",
1731         "values": {
1732             "0": "Niu",
1733             "1": "Retired",
1734             "2": "Disabled (adult or child)",
1735             "3": "Widowed",
1736             "4": "Spouse",
1737             "5": "Surviving child",
1738             "6": "Dependent child",
1739             "7": "On behalf of surviving, dependent, or disabled child(ren)
                ",
1740             "8": "Other (adult or child)"
1741         }
1742     },
1743     "RESNSS2": {
1744         "label": "What were the reasons (you/name) (was/were) getting
                Social Security Income last year?",
1745         "universe": "SS_YN = 1",
1746         "type": "Categorical",
1747         "role": "Independent",
1748         "topic": "Income",
1749         "subtopic": "Other income",
1750         "values": {
1751             "0": "Niu",
1752             "1": "Retired",
1753             "2": "Disabled (adult or child)",
1754             "3": "Widowed",
1755             "4": "Spouse",

```



```

1756         "5": "Surviving child",
1757         "6": "Dependent child",
1758         "7": "On behalf of surviving, dependent, or disabled child(ren)
           ",
1759         "8": "Other (adult or child)"
1760     }
1761 },
1762 "RESNSSI1": {
1763     "label": "What were the reasons (you/name) (was/were) getting
           Supplemental Security Income last year?",
1764     "universe": "SSI_YN = 1",
1765     "type": "Categorical",
1766     "role": "Independent",
1767     "topic": "Income",
1768     "subtopic": "Other income",
1769     "values": {
1770         "0": "Niu",
1771         "1": "Disabled (adult or child)",
1772         "2": "Blind (adult or child)",
1773         "3": "On behalf of a disabled child",
1774         "4": "On behalf of a blind child",
1775         "5": "Other (adult or child)"
1776     }
1777 },
1778 "RESNSSI2": {
1779     "label": "What were the reasons (you/name) (was/were) getting
           Supplemental Security Income last year?",
1780     "universe": "SSI_YN = 1",
1781     "type": "Categorical",
1782     "role": "Independent",
1783     "topic": "Income",
1784     "subtopic": "Other income",
1785     "values": {
1786         "0": "Niu",
1787         "1": "Disabled (adult or child)",
1788         "2": "Blind (adult or child)",

```

```

1789         "3": "On behalf of a disabled child",
1790         "4": "On behalf of a blind child",
1791         "5": "Other (adult or child)"
1792     }
1793 },
1794 "RETCB_VAL": {
1795     "label": "Retirement contributiion, amount",
1796     "universe": "RETCB_YN = 1",
1797     "type": "Continuous",
1798     "role": "Independent",
1799     "topic": "Income",
1800     "subtopic": "Other income",
1801     "values": {
1802         "0": "None or niu",
1803         "1-99999": "Amount contributed"
1804     }
1805 },
1806 "RETCB_YN": {
1807     "label": "Retirement contribution, y/n",
1808     "universe": "All people 15 years and over",
1809     "type": "Categorical",
1810     "role": "Independent",
1811     "topic": "Income",
1812     "subtopic": "Other income",
1813     "values": {
1814         "0": "Niu",
1815         "1": "Yes",
1816         "2": "No"
1817     }
1818 },
1819 "RINT_SC1": {
1820     "label": "Interest income, retirement source 1",
1821     "universe": "RINT_YN = 1",
1822     "type": "Categorical",
1823     "role": "Independent",
1824     "topic": "Income",

```

```

1825     "subtopic": "Other income",
1826     "values": {
1827         "0": "Niu",
1828         "1": "401k account",
1829         "2": "403b account",
1830         "3": "Roth ira",
1831         "4": "Regular ira",
1832         "5": "Keogh plan",
1833         "6": "Sep plan (simplified employee pension)",
1834         "7": "Other type of retirement account"
1835     }
1836 },
1837 "RINT_SC2": {
1838     "label": "Interest income, retirement source 2",
1839     "universe": "RINT_YN = 1",
1840     "type": "Categorical",
1841     "role": "Independent",
1842     "topic": "Income",
1843     "subtopic": "Other income",
1844     "values": {
1845         "0": "Niu",
1846         "1": "401k account",
1847         "2": "403b account",
1848         "3": "Roth ira",
1849         "4": "Regular ira",
1850         "5": "Keogh plan",
1851         "6": "Sep plan (simplified employee pension)",
1852         "7": "Other type of retirement account"
1853     }
1854 },
1855 "RINT_VAL1": {
1856     "label": "Interest income amt, retirement source 1",
1857     "universe": "RINT_SC1 > 0",
1858     "type": "Continuous",
1859     "role": "Independent",
1860     "topic": "Income",

```

```

1861     "subtopic": "Other income",
1862     "values": {
1863         "0": "None or niu",
1864         "1-999999": "Ret interest income"
1865     }
1866 },
1867 "RINT_VAL2": {
1868     "label": "Interest income amt, retirement source 2",
1869     "universe": "RINT_SC2 > 0",
1870     "type": "Continuous",
1871     "role": "Independent",
1872     "topic": "Income",
1873     "subtopic": "Other income",
1874     "values": {
1875         "0": "None or niu",
1876         "1-999999": "Ret interest income"
1877     }
1878 },
1879 "RINT_YN": {
1880     "label": "Interest income - retirement, y/n",
1881     "universe": "All Persons aged 15+",
1882     "type": "Categorical",
1883     "role": "Independent",
1884     "topic": "Income",
1885     "subtopic": "Other income",
1886     "values": {
1887         "0": "Niu",
1888         "1": "Yes",
1889         "2": "No"
1890     }
1891 },
1892 "RNT_VAL": {
1893     "label": "How much did ... receive in income from rent after
           expenses during 20..?",
1894     "universe": "RNT_YN = 1",
1895     "type": "Continuous",

```

```

1896     "role": "Independent",
1897     "topic": "Income",
1898     "subtopic": "Other income",
1899     "values": {
1900         "0": "None or niu",
1901         "-9999-999999": "Rental income"
1902     }
1903 },
1904 "RNT_YN": {
1905     "label": "Did ... own any land, property, rented to others, or
           receive income from royalties, roomers or boarders, or from
           estates or trusts?",
1906     "universe": "All Persons aged 15+",
1907     "type": "Categorical",
1908     "role": "Independent",
1909     "topic": "Income",
1910     "subtopic": "Other income",
1911     "values": {
1912         "0": "Niu",
1913         "1": "Yes",
1914         "2": "No"
1915     }
1916 },
1917 "SRVS_VAL": {
1918     "label": "Total amount of survivor's income received (combined
           amounts in edited sources sur_val1 and sur_val2 plus the
           unedited sources 3 & 4 starting in 1995)",
1919     "universe": "SUR_YN = 1",
1920     "type": "Continuous",
1921     "role": "Independent",
1922     "topic": "Income",
1923     "subtopic": "Other income",
1924     "values": {
1925         "0": "None or niu",
1926         "1-999999": "Income amount"
1927     }

```

```

1928     },
1929     "SS_VAL": {
1930         "label": "How much did ... receive in social security payments
1931             during 20.. ?",
1932         "universe": "SS_YN = 1",
1933         "type": "Continuous",
1934         "role": "Independent",
1935         "topic": "Income",
1936         "subtopic": "Other income",
1937         "values": {
1938             "0": "None or niu",
1939             "1-99999": "Social security"
1940         }
1941     },
1942     "SS_YN": {
1943         "label": "Who received social security payments either for
1944             themselves or as combined payments with other family members?",
1945         "universe": "All Persons aged 15+",
1946         "type": "Categorical",
1947         "role": "Independent",
1948         "topic": "Income",
1949         "subtopic": "Other income",
1950         "values": {
1951             "0": "Niu",
1952             "1": "Yes",
1953             "2": "No"
1954         }
1955     },
1956     "SSI_VAL": {
1957         "label": "How much did ... receive in supplemental security income
1958             during 20..?",
1959         "universe": "SSI_YN = 1",
1960         "type": "Continuous",
1961         "role": "Independent",
1962         "topic": "Income",
1963         "subtopic": "Other income",

```

```

1961     "values": {
1962         "0": "None or niu",
1963         "1-99999": "Supplemental security income"
1964     }
1965 },
1966 "SSI_YN": {
1967     "label": "Did ... received ssi?",
1968     "universe": "All Persons aged 15+",
1969     "type": "Categorical",
1970     "role": "Independent",
1971     "topic": "Income",
1972     "subtopic": "Other income",
1973     "values": {
1974         "0": "Niu",
1975         "1": "Yes",
1976         "2": "No"
1977     }
1978 },
1979 "STRKUC": {
1980     "label": "At any time during 20.. did ... receive any union
           unemployment or strike benefits?",
1981     "universe": "UC_YN = 1",
1982     "type": "Categorical",
1983     "role": "Independent",
1984     "topic": "Income",
1985     "subtopic": "Other income",
1986     "values": {
1987         "0": "Niu",
1988         "1": "Yes",
1989         "2": "No"
1990     }
1991 },
1992 "SUBUC": {
1993     "label": "At any time during 20.. did ... receive any supplemental
           unemployment benefits?",
1994     "universe": "UC_YN = 1",

```

```

1995     "type": "Categorical",
1996     "role": "Independent",
1997     "topic": "Income",
1998     "subtopic": "Other income",
1999     "values": {
2000         "0": "Niu",
2001         "1": "Yes",
2002         "2": "No"
2003     }
2004 },
2005 "SUR_SC1": {
2006     "label": "What was the source of this other widow or survivor
2007         income?",
2008     "universe": "SUR_YN = 1",
2009     "type": "Categorical",
2010     "role": "Independent",
2011     "topic": "Income",
2012     "subtopic": "Other income",
2013     "values": {
2014         "0": "None or niu",
2015         "1": "Company or union survivor pension",
2016         "2": "Federal government",
2017         "3": "Us military retirement survivor pension",
2018         "4": "State or local gov't survivor pension",
2019         "5": "Us railroad retirement survivor pension",
2020         "6": "Worker compensation survivor",
2021         "7": "Black lung",
2022         "8": "Regular payments from estates or trusts",
2023         "9": "Regular payments from annuities or paid-up life insurance
2024         ",
2025         "10": "Other or don't know"
2026     }
2027 },
2028 "SUR_SC2": {
2029     "label": "What was the source of this other widow or survivor
2030         income?",

```



```

2028     "universe": "SUR_YN = 1",
2029     "type": "Categorical",
2030     "role": "Independent",
2031     "topic": "Income",
2032     "subtopic": "Other income",
2033     "values": {
2034         "0": "None or niu",
2035         "1": "Company or union survivor pension",
2036         "2": "Federal government",
2037         "3": "Us military retirement survivor pension",
2038         "4": "State or local gov't survivor pension",
2039         "5": "Us railroad retirement survivor pension",
2040         "6": "Worker compensation survivor",
2041         "7": "Black lung",
2042         "8": "Regular payments from estates or trusts",
2043         "9": "Regular payments from annuities or paid-up life insurance
           ",
2044         "10": "Other or don't know"
2045     }
2046 },
2047 "SUR_VAL1": {
2048     "label": "How much did ... receive (survivor source type) during
           20.. ?",
2049     "universe": "SUR_YN = 1",
2050     "type": "Continuous",
2051     "role": "Independent",
2052     "topic": "Income",
2053     "subtopic": "Other income",
2054     "values": {
2055         "0": "None or niu",
2056         "1-999,999": "Survivor's income"
2057     }
2058 },
2059 "SUR_VAL2": {
2060     "label": "How much did ... receive (source type) during 20.. ?",
2061     "universe": "SUR_YN = 1",

```

```

2062     "type": "Continuous",
2063     "role": "Independent",
2064     "topic": "Income",
2065     "subtopic": "Other income",
2066     "values": {
2067         "0": "None or niu",
2068         "1-999,999": "Survivor's income"
2069     }
2070 },
2071 "SUR_YN": {
2072     "label": "During 20.. did ... receive any survivor benefits such as
           widow's pensions, estates, trusts, insurance annuities, or
           other survivor's income?",
2073     "universe": "All Persons aged 15+",
2074     "type": "Categorical",
2075     "role": "Independent",
2076     "topic": "Income",
2077     "subtopic": "Other income",
2078     "values": {
2079         "0": "Niu",
2080         "1": "Yes",
2081         "2": "No"
2082     }
2083 },
2084 "TRDINT_VAL": {
2085     "label": "Interest amount, exclcuding retirment account interest",
2086     "universe": "INT_YN = 1",
2087     "type": "Continuous",
2088     "role": "Independent",
2089     "topic": "Income",
2090     "subtopic": "Other income",
2091     "values": {
2092         "all": "Dollar value"
2093     }
2094 },
2095 "UC_VAL": {

```

```

2096     "label": "How much did ... receive in unemployment benefits during
2097         20..?",
2098     "universe": "UC_YN = 1",
2099     "type": "Continuous",
2100     "role": "Independent",
2101     "topic": "Income",
2102     "subtopic": "Other income",
2103     "values": {
2104         "0": "None or niu",
2105         "1-99999": "Unemployment compensation"
2106     },
2107     "UC_YN": {
2108         "label": "Any type of unemployment compensation? (Combination of
2109             subuc, strkuc, and uctot_yn)",
2110         "universe": "UC_YN = 1",
2111         "type": "Categorical",
2112         "role": "Independent",
2113         "topic": "Income",
2114         "subtopic": "Other income",
2115         "values": {
2116             "0": "Niu",
2117             "1": "Yes",
2118             "2": "No"
2119         },
2120         "VET_TYP1": {
2121             "label": "What type of veterans payments did .... receive? (
2122                 VET_TYP1- disability compensation?)",
2123             "universe": "VET_YN = 1",
2124             "type": "Categorical",
2125             "role": "Independent",
2126             "topic": "Income",
2127             "subtopic": "Other income",
2128             "values": {

```

```

2129         "1": "Yes",
2130         "2": "No"
2131     }
2132 },
2133 "VET_TYP2": {
2134     "label": "What type of veterans payments did .... receive? (
                VET_TYP2- survivor benefits?)",
2135     "universe": "VET_YN = 1",
2136     "type": "Categorical",
2137     "role": "Independent",
2138     "topic": "Income",
2139     "subtopic": "Other income",
2140     "values": {
2141         "0": "Niu",
2142         "1": "Yes",
2143         "2": "No"
2144     }
2145 },
2146 "VET_TYP3": {
2147     "label": "What type of veterans payments did .... receive? (
                VET_TYP3- veteran's pension?)",
2148     "universe": "VET_YN = 1",
2149     "type": "Categorical",
2150     "role": "Independent",
2151     "topic": "Income",
2152     "subtopic": "Other income",
2153     "values": {
2154         "0": "Niu",
2155         "1": "Yes",
2156         "2": "No"
2157     }
2158 },
2159 "VET_TYP4": {
2160     "label": "What type of veterans payments did .... receive? (
                VET_TYP4- education assistance?)",
2161     "universe": "VET_YN = 1",

```

```

2162     "type": "Categorical",
2163     "role": "Independent",
2164     "topic": "Income",
2165     "subtopic": "Other income",
2166     "values": {
2167         "0": "Niu",
2168         "1": "Yes",
2169         "2": "No"
2170     }
2171 },
2172 "VET_TYP5": {
2173     "label": "What type of veterans payments did .... receive? (
                VET_TYP5- other veteran's payments?)",
2174     "universe": "VET_YN = 1",
2175     "type": "Categorical",
2176     "role": "Independent",
2177     "topic": "Income",
2178     "subtopic": "Other income",
2179     "values": {
2180         "0": "Niu",
2181         "1": "Yes",
2182         "2": "No"
2183     }
2184 },
2185 "VET_VAL": {
2186     "label": "How much did ... receive from veterans' administration
                during 20..?",
2187     "universe": "VET_YN = 1",
2188     "type": "Continuous",
2189     "role": "Independent",
2190     "topic": "Income",
2191     "subtopic": "Other income",
2192     "values": {
2193         "0": "None or niu",
2194         "1-999999": "Veterans' payments"
2195     }

```

```

2196     },
2197     "VET_YN": {
2198         "label": "Did ... receive veterans' payments?",
2199         "universe": "All Persons aged 15+",
2200         "type": "Categorical",
2201         "role": "Independent",
2202         "topic": "Income",
2203         "subtopic": "Other income",
2204         "values": {
2205             "0": "Niu",
2206             "1": "Yes",
2207             "2": "No"
2208         }
2209     },
2210     "WC_TYPE": {
2211         "label": "What was source of these payments?",
2212         "universe": "WC_YN = 1",
2213         "type": "Categorical",
2214         "role": "Independent",
2215         "topic": "Income",
2216         "subtopic": "Other income",
2217         "values": {
2218             "0": "Not in universe",
2219             "1": "State worker's compensation",
2220             "2": "Employer or employers insurance",
2221             "3": "Own insurance",
2222             "4": "Other"
2223         }
2224     },
2225     "WC_VAL": {
2226         "label": "How much compensation did ... receive during 20..?",
2227         "universe": "WC_YN = 1",
2228         "type": "Continuous",
2229         "role": "Independent",
2230         "topic": "Income",
2231         "subtopic": "Other income",

```

```

2232     "values": {
2233         "0": "None or niu",
2234         "1-99999": "Worker's compensation"
2235     }
2236 },
2237 "WC_YN": {
2238     "label": "During 20.. did ... receive any worker's compensation
                payments or other payments as a result of a job related injury
                or illness?",
2239     "universe": "All Persons aged 15+",
2240     "type": "Categorical",
2241     "role": "Independent",
2242     "topic": "Income",
2243     "subtopic": "Other income",
2244     "values": {
2245         "0": "Niu",
2246         "1": "Yes",
2247         "2": "No"
2248     }
2249 },
2250 "PAW_TYP": {
2251     "label": "What type of program did... receive CASH assistance?",
2252     "universe": "PAW_YN = 1",
2253     "type": "Categorical",
2254     "role": "Independent",
2255     "topic": "Income",
2256     "subtopic": "Non-cash benefits",
2257     "values": {
2258         "0": "Niu",
2259         "1": "TANF/AFDC",
2260         "2": "Other",
2261         "3": "Both"
2262     }
2263 },
2264 "PAW_VAL": {

```

```

2265     "label": "How much did ... receive in public assistance or welfare
          during 20..?",
2266     "universe": "PAW_YN = 1",
2267     "type": "Continuous",
2268     "role": "Independent",
2269     "topic": "Income",
2270     "subtopic": "Non-cash benefits",
2271     "values": {
2272         "0": "None or niu",
2273         "1-99999": "Public assistance"
2274     }
2275 },
2276 "PAW_YN": {
2277     "label": "At any time during 20.., even for one month, did...
          receive an CASH assistance from a state or county welfare
          program such as (State program name fill)?",
2278     "universe": "All Persons aged 15+",
2279     "type": "Categorical",
2280     "role": "Independent",
2281     "topic": "Income",
2282     "subtopic": "Non-cash benefits",
2283     "values": {
2284         "0": "Niu",
2285         "1": "Yes",
2286         "2": "No"
2287     }
2288 },
2289 "PENINCL": {
2290     "label": "Was ... included in that plan?",
2291     "universe": "PENPLAN = 1",
2292     "type": "Categorical",
2293     "role": "Independent",
2294     "topic": "Income",
2295     "subtopic": "Non-cash benefits",
2296     "values": {
2297         "0": "Niu",

```



```

2298         "1": "Yes",
2299         "2": "No"
2300     }
2301 },
2302 "PENPLAN": {
2303     "label": "Other than social security did the employer or union that
                ... worked for in 20.. have a pension or other type of
                retirement plan?",
2304     "universe": "WRK_CK = 1",
2305     "type": "Categorical",
2306     "role": "Independent",
2307     "topic": "Income",
2308     "subtopic": "Non-cash benefits",
2309     "values": {
2310         "0": "Niu",
2311         "1": "Yes",
2312         "2": "No"
2313     }
2314 },
2315 "WICYN": {
2316     "label": "Who received WIC?",
2317     "universe": "Adult female",
2318     "type": "Categorical",
2319     "role": "Independent",
2320     "topic": "Income",
2321     "subtopic": "Non-cash benefits",
2322     "values": {
2323         "0": "Niu",
2324         "1": "Received WIC",
2325         "2": "Did not receive WIC"
2326     }
2327 },
2328 "CHCARE_YN": {
2329     "label": "Paid child care was needed for this child?",
2330     "universe": "Persons age 15+ with children",
2331     "type": "Categorical",

```

```

2332     "role": "Independent",
2333     "topic": "Income",
2334     "subtopic": "Supplemental poverty measure",
2335     "values": {
2336         "0": "Niu",
2337         "1": "Yes",
2338         "2": "No"
2339     }
2340 },
2341 "CHELSEW_YN": {
2342     "label": "Does this person have a child living outside the
                household?",
2343     "universe": "All persons aged 15+",
2344     "type": "Categorical",
2345     "role": "Independent",
2346     "topic": "Income",
2347     "subtopic": "Supplemental poverty measure",
2348     "values": {
2349         "0": "Niu",
2350         "1": "Yes",
2351         "2": "No"
2352     }
2353 },
2354 "CHELSEW_YN": {
2355     "label": "Does this person have a child living outside the
                household?",
2356     "universe": "All persons aged 15+",
2357     "type": "Categorical",
2358     "role": "Independent",
2359     "topic": "Income",
2360     "subtopic": "Supplemental poverty measure",
2361     "values": {
2362         "0": "Niu",
2363         "1": "Yes",
2364         "2": "No"
2365     }

```

```

2366 },
2367 "CHSP_VAL": {
2368     "label": "What is the annual amount of child support paid?",
2369     "universe": "CHSP_YN = 1",
2370     "type": "Continuous",
2371     "role": "Independent",
2372     "topic": "Income",
2373     "subtopic": "Supplemental poverty measure",
2374     "values": {
2375         "0": "Niu",
2376         "1-99999": "Amount paid in child support"
2377     }
2378 },
2379 "CHSP_YN": {
2380     "label": "Is this person required to pay child support?",
2381     "universe": "CHELSEW_YN",
2382     "type": "Categorical",
2383     "role": "Independent",
2384     "topic": "Income",
2385     "subtopic": "Supplemental poverty measure",
2386     "values": {
2387         "0": "Niu",
2388         "1": "Yes",
2389         "2": "No"
2390     }
2391 },
2392 "CSP_VAL": {
2393     "label": "How much did ... receive in child support payments?",
2394     "universe": "CHSP_YN = 1",
2395     "type": "Continuous",
2396     "role": "Independent",
2397     "topic": "Income",
2398     "subtopic": "Supplemental poverty measure",
2399     "values": {
2400         "0": "None or niu",
2401         "1-99999": "Child support"

```

```

2402     }
2403 },
2404 "CSP_YN": {
2405     "label": "Did ... receive child support payments?",
2406     "universe": "All Persons aged 15+",
2407     "type": "Categorical",
2408     "role": "Independent",
2409     "topic": "Income",
2410     "subtopic": "Supplemental poverty measure",
2411     "values": {
2412         "0": "Niu",
2413         "1": "Yes",
2414         "2": "No"
2415     }
2416 },
2417 "ACTC_CRD": {
2418     "label": "Additional child tax credit",
2419     "universe": "Tax unit head or dependent filer",
2420     "type": "Continuous",
2421     "role": "Independent",
2422     "topic": "Income",
2423     "subtopic": "Tax model items",
2424     "values": {
2425         "0": "None",
2426         "1-99999": "Dollar amount"
2427     }
2428 },
2429 "AGI": {
2430     "label": "Adjusted gross income",
2431     "universe": "Tax unit head or dependent filer",
2432     "type": "Continuous",
2433     "role": "Independent",
2434     "topic": "Income",
2435     "subtopic": "Tax model items",
2436     "values": {
2437         "0": "None",

```

```

2438         "-9999-99999999": "Dollar amount"
2439     }
2440 },
2441 "CTC_CRD": {
2442     "label": "Child tax credit",
2443     "universe": "Tax unit head or dependent filer",
2444     "type": "Continuous",
2445     "role": "Independent",
2446     "topic": "Income",
2447     "subtopic": "Tax model items",
2448     "values": {
2449         "0": "None",
2450         "1-99999": "Dollar amount"
2451     }
2452 },
2453 "EIT_CRED": {
2454     "label": "Earn income tax credit",
2455     "universe": "Tax unit head or dependent filer",
2456     "type": "Continuous",
2457     "role": "Independent",
2458     "topic": "Income",
2459     "subtopic": "Tax model items",
2460     "values": {
2461         "0": "None",
2462         "1-9999": "Dollar amount"
2463     }
2464 },
2465 "FED_RET": {
2466     "label": "Federal retirement payroll deduction",
2467     "universe": "Tax unit head or dependent filer",
2468     "type": "Continuous",
2469     "role": "Independent",
2470     "topic": "Income",
2471     "subtopic": "Tax model items",
2472     "values": {
2473         "0": "None",

```

```

2474         "1-999999": "Dollar amount"
2475     }
2476 },
2477 "FEDTAX_AC": {
2478     "label": "Federal income tax liability, after all credits",
2479     "universe": "Tax unit head or dependent filer",
2480     "type": "Continuous",
2481     "role": "Independent",
2482     "topic": "Income",
2483     "subtopic": "Tax model items",
2484     "values": {
2485         "0": "None",
2486         "-9999-9999999": "Dollar amount"
2487     }
2488 },
2489 "FEDTAX_BC": {
2490     "label": "Federal income tax liability, before credits",
2491     "universe": "Tax unit head or dependent filer",
2492     "type": "Continuous",
2493     "role": "Independent",
2494     "topic": "Income",
2495     "subtopic": "Tax model items",
2496     "values": {
2497         "0": "None",
2498         "-9999-9999999": "Dollar amount"
2499     }
2500 },
2501 "FICA": {
2502     "label": "Social security retirement payroll deduction",
2503     "universe": "All persons",
2504     "type": "Continuous",
2505     "role": "Independent",
2506     "topic": "Income",
2507     "subtopic": "Tax model items",
2508     "values": {
2509         "0": "None",

```

```

2510         "1-99999": "Dollar amount"
2511     }
2512 },
2513 "FILESTAT": {
2514     "label": "Tax filer status",
2515     "universe": "All persons",
2516     "type": "Categorical",
2517     "role": "Independent",
2518     "topic": "Income",
2519     "subtopic": "Tax model items",
2520     "values": {
2521         "1": "Joint, both<65",
2522         "2": "Joint, one ><65 & one 65+",
2523         "3": "Joint, both 65+",
2524         "4": "Head of household",
2525         "5": "Single",
2526         "6": "Non-filer"
2527     }
2528 },
2529 "MARG_TAX": {
2530     "label": "Marginal tax rate",
2531     "universe": "Tax unit head or dependent filer",
2532     "type": "Continuous",
2533     "role": "Independent",
2534     "topic": "Income",
2535     "subtopic": "Tax model items",
2536     "values": {
2537         "0": "None",
2538         "1-99": "Marginal rate"
2539     }
2540 },
2541 "PRSWKXPNS": {
2542     "label": "Work expenses",
2543     "universe": "A_AGE > 17 or HHDFMX = 1,2,46, or 47",
2544     "type": "Continuous",
2545     "role": "Independent",

```

```

2546     "topic": "Income",
2547     "subtopic": "Tax model items",
2548     "values": {
2549         "0": "None",
2550         "1-1999": "Dollar amount"
2551     }
2552 },
2553 "STATETAX_A": {
2554     "label": "State income tax liability, after all credits",
2555     "universe": "Tax unit head or dependent filer",
2556     "type": "Continuous",
2557     "role": "Independent",
2558     "topic": "Income",
2559     "subtopic": "Tax model items",
2560     "values": {
2561         "0": "None",
2562         "-9999-99999999": "Dollar amount"
2563     }
2564 },
2565 "STATETAX_B": {
2566     "label": "State income tax liability, before credits",
2567     "universe": "Tax unit head or dependent filer",
2568     "type": "Continuous",
2569     "role": "Independent",
2570     "topic": "Income",
2571     "subtopic": "Tax model items",
2572     "values": {
2573         "0": "None",
2574         "-9999-99999999": "Dollar amount"
2575     }
2576 },
2577 "TAX_INC": {
2578     "label": "Taxable income amount",
2579     "universe": "Tax unit head or dependent filer",
2580     "type": "Continuous",
2581     "role": "Independent",

```



```

2582     "topic": "Income",
2583     "subtopic": "Tax model items",
2584     "values": {
2585         "0": "None",
2586         "-9999-99999999": "Dollar amount"
2587     }
2588 },
2589 "PERLIS": {
2590     "label": "Poverty level of persons (Subfamily members have primary
                family recode)",
2591     "universe": "All persons",
2592     "type": "Categorical",
2593     "role": "Independent",
2594     "topic": "Poverty",
2595     "subtopic": "Poverty",
2596     "values": {
2597         "-1": "Not in poverty universe",
2598         "1": "Below poverty level",
2599         "2": "100 - 124 percent of the poverty level",
2600         "3": "125 - 149 percent of the poverty level",
2601         "4": "150 and above the poverty level"
2602     }
2603 },
2604 "POV_UNIV": {
2605     "label": "Poverty universe flag",
2606     "universe": "All persons",
2607     "type": "Categorical",
2608     "role": "Independent",
2609     "topic": "Poverty",
2610     "subtopic": "Poverty",
2611     "values": {
2612         "0": "Not in poverty universe",
2613         "1": "In poverty universe"
2614     }
2615 },
2616 "HEA": {

```

```

2617     "label": "Health status",
2618     "universe": "All persons",
2619     "type": "Categorical",
2620     "role": "Independent",
2621     "topic": "Health insurance",
2622     "subtopic": "Health status",
2623     "values": {
2624         "1": "Excellent",
2625         "2": "Very good",
2626         "3": "Good",
2627         "4": "Fair",
2628         "5": "Poor"
2629     }
2630 },
2631 "SPM_ACTC": {
2632     "label": "SPM units Additional Child Tax Credit",
2633     "universe": "All persons",
2634     "type": "Continuous",
2635     "role": "Independent",
2636     "topic": "Supplemental poverty measure",
2637     "subtopic": "SPM unit characteristics",
2638     "values": {
2639         "0-99999": "Dollar amount"
2640     }
2641 }
2642 }

```

### 3.5.4 Python Modules

The utility module in Code 3.1 is for basic tasks such as creating a directory, backing up existing files before being overwritten, and importing and exporting a dictionary in JSON format. The encoding module in Code 3.2 is used solely during data encoding as its helper, not its main role. The dataset module in Code 3.3 helps importing and exporting dataset in both feather and CSV formats. The first employs LZ4 compression by default to bring a smaller file than the latter. The EDA module in Code 3.4 is primary for cross tabulation analysis. Its result is exported in CSV format, and its chart is saved in SVG, PGF and PDF formats.

Code 3.1: Utility module (module/utility.py)

```

1  import os
2  import time
3  import json
4
5  # Directory
6  def create_dir(dir):
7      try:
8          os.makedirs(dir)
9      except FileExistsError:
10         pass
11
12 # Backup
13 def backup_duplicate(file_dir, filename, format, backup_dir, info):
14     filepath = f"{file_dir}/{filename}.{format}"
15     date = time.strftime("%Y%m%d", time.localtime(time.time()))
16     if os.path.isfile(filepath):
17         backup_subdir = f"{backup_dir}/{date}/{file_dir.replace('../', '')}"
18         "
19         create_dir(backup_subdir)
20         filepath_backup = f"{backup_subdir}/{filename}-backup.{format}"
21         os.replace(filepath, filepath_backup)
22     if info:
23         print(f"{filepath} previously exists")

```

```

23         print(f"Back up to {filepath_backup}")
24     elif info:
25         print(f"{filepath} does not previously exists")
26
27 # Import/export dict/JSON
28 def import_dict(metadata_path):
29     with open(metadata_path) as myfile:
30         indep_contents = myfile.read()
31     return json.loads(indep_contents)
32
33 def export_json(dictfile, jsonfile):
34     with open(jsonfile, 'w', encoding='utf-8') as f:
35         json.dump(dictfile, f, ensure_ascii=False, indent=4)
36
37 def export_txt(string, txtfile):
38     f = open(txtfile, 'w')
39     f.write(string)
40     f.close()

```

Code 3.2: Encoding module (module/metaencode.py)

```

1 import pandas as pd
2
3 def extract_dict_cat(indep_dict):
4     return {attr: info for (attr, info) in indep_dict.items() if indep_dict
5         [attr]['type'] == 'Categorical'}
6
7 def extract_dict_cont(indep_dict):
8     return {attr: info for (attr, info) in indep_dict.items() if indep_dict
9         [attr]['type'] == 'Continuous'}
10
11 def sort_cols(df_indep, indep_dict):
12     sorted_cols = sorted(
13         df_indep.head(),
14         key=lambda attr: indep_dict[attr]['type'],

```

```

13         reverse=True
14     )
15     return df_indep[sorted_cols]
16
17 def indep_info(df_indep, indep_dict):
18     df_info = pd.DataFrame({'variable': df_indep.head().columns})
19     df_info['type'] = df_info['variable'].apply(lambda attr: indep_dict[
20         attr]['type'])
21     minmax = df_indep.agg(['min', 'max']).values.tolist()
22     df_info['min'] = minmax[0]
23     df_info['max'] = minmax[1]
24     del minmax
25     return df_info
26
27 def count_info(df_info):
28     df_count = df_info.groupby('type').count().reset_index()[['type', '
29         variable']]
30     df_count.rename(columns = {'variable': 'count'}, inplace=True)
31     df_count.sort_values('type', ascending=False, inplace=True,
32         ignore_index=True)
33     return df_count

```

Code 3.3: Dataset module (module/dataset.py)

```

1 import os
2 import urllib.request
3 import pandas as pd
4 import pyarrow
5
6 from module.utility import create_dir, backup_duplicate
7
8 # Import
9 def import_dataset(dataset_name, feather_dir, sas_dir='', sas_url=''):
10     filepath_feather = f"{feather_dir}/{dataset_name}.feather"
11

```

```

12     if os.path.isfile(filepath_feather):
13         print(f"{filepath_feather} is found")
14         print(f"{filepath_feather} was previously preprocessed")
15         df0 = pd.read_feather(filepath_feather)
16     else:
17         print(f"{filepath_feather} is not found")
18         if sas_dir == '':
19             raise Exception("SAS data directory is empty")
20         filepath_sas = f"sas_dir/{dataset_name}.sas7bdat"
21         if os.path.isfile(filepath_sas):
22             print(f"{filepath_sas} is found")
23         else:
24             print(f"{filepath_sas} is not found")
25             create_dir('original/data-orig')
26             print(f"{filepath_sas} will be downloaded")
27             print("Download starts")
28             try:
29                 urllib.request.urlretrieve(sas_url, filepath_sas)
30                 print("Download finishes")
31             except:
32                 raise Exception("Download fails")
33             print(f"{filepath_sas} is successfully downloaded")
34         df0 = pd.read_sas(filepath_sas)
35
36     print(f"\nNumber of original data: {len(df0)}")
37     df0 = df0[df0['COV']!=0]
38     print(f"An infant born after calendar year (COV = 0) is excluded")
39     print(f"Number of training data: {len(df0)}")
40     return df0
41
42 # Export
43 def export_dataset(df, file_dir, dataset_name, format, info=True,
44                   backup_dir=''):
45     create_dir(file_dir)
46     if format == 'feather' or format == 'csv':
47         filepath = f"{file_dir}/{dataset_name}.{format}"

```

```

47         if backup_dir != '':
48             backup_duplicate(
49                 file_dir=file_dir, filename=dataset_name,
50                 format=format,
51                 backup_dir=backup_dir, info=info
52             )
53         if format == 'feather':
54             df.to_feather(filepath)
55         else:
56             df.to_csv(filepath, index=False)
57         if info:
58             print(f"The dataframe is successfully exported to {filepath}")
59     else:
60         print(f"Input format {format} is unrecognized")

```

Code 3.4: EDA module (module/eda.py)

```

1  import sys
2  import time
3  import pandas as pd
4  import matplotlib.pyplot as plt
5
6  from module.utility import create_dir, backup_duplicate
7  from module.dataset import export_dataset
8
9  # Variables
10 def describe_var(var_dict, role='independent'):
11     num_cat = 0
12     num_cont = 0
13     for key in var_dict:
14         if var_dict[key]['type'] == 'Categorical':
15             num_cat += 1
16         else:
17             num_cont += 1

```

```

18     print(f"There are {num_cat + num_cont} {role} variables of interest: {
        num_cat} categorical and {num_cont} continuous")
19
20 # Cross Tabulation Analysis
21 def crosstab(df, indep_dict, cont_bins, plot, output_dir, log_filepath,
        backup_dir=''):
22     dir_main = f"{output_dir}/tab-cbins-{cont_bins}"
23
24     for key, val in indep_dict.items():
25         fname_main = f"{key}-cbins-{cont_bins}"
26
27         if val['type'] == "Categorical":
28             crosstb = pd.crosstab(index=df[key].map(lambda x: val['values'
                ][str(x)]), columns=df['code'])
29         else:
30             dat = df[[key, 'code']].copy()
31             dat['bins'] = pd.cut(dat[key], bins=cont_bins)
32             crosstb = pd.crosstab(index=dat['bins'], columns=dat['code'])
33             del dat
34
35         print(key)
36         print(f"Label: {val['label']}")
37         print(f"Universe: {val['universe']}")
38         print(f"Type: {val['type']}")
39         print(f"Topic: {val['topic']}")
40         print(f"Subtopic: {val['subtopic']}")
41         print("\n")
42
43         print(f"Code: Employment-based plan (GRP) | Direct-purchase plan (
        DIR) | Public health insurance (PUB)")
44         print(crosstb)
45         '''
46         dir_crosstb = f"{dir_main}/cross-{cont_bins}"
47         create_dir(dir_crosstb)
48         export_dataset(
49             crosstb,

```



```

50         file_dir=f"{dir_crosstb}/feather", dataset_name=f"{fname_main}-
           cross",
51         format='feather', info=False,
52         backup_dir=backup_dir
53     )
54     export_dataset(
55         crosstb,
56         file_dir=f"{dir_crosstb}/csv", dataset_name=f"{fname_main}-
           cross",
57         format='csv', info=False,
58         backup_dir=backup_dir
59     )
60     '''
61     print("\n")
62
63     if plot:
64         barplot = crosstb.plot.bar()
65         barplot.legend(title='(GRP,DIR,PUB)',
66                        bbox_to_anchor=(1,1.02),
67                        loc='upper left')
68         plt.title(val['label'])
69         plt.xlabel(key)
70         plt.ylabel('Frequency')
71         ls_format = ['svg', 'pgf', 'pdf']
72         for format in ls_format:
73             dir_fig = f"{dir_main}/figures/{format}"
74             figname = f"{key}-cbins-{cont_bins}"
75             figpath = f"{dir_fig}/{figname}.{format}"
76             create_dir(dir_fig)
77             backup_duplicate(
78                 file_dir=dir_fig, filename=figname,
79                 format=format,
80                 backup_dir=backup_dir, info=False
81             )
82             f = open(log_filepath, 'a')
83             temp = sys.stdout

```

```

84         sys.stdout = f
85         count, tries = 0, 4
86         success = False
87         while count < tries:
88             try:
89                 plt.savefig(figpath, bbox_inches='tight')
90                 success = True
91                 break
92             except:
93                 pass
94             count += 1
95         if not success:
96             curtime = time.strftime("%Y-%m-%d %H:%M:%S", time.
97                                     localtime(time.time()))
98             print(f"{curtime} | {key}: {figpath} cannot be saved")
99             sys.stdout = temp
100            f.close()
101
102            #plt.show()
103
104            dftb = crosstb.reset_index().rename_axis(None, axis=1)
105            dftb[dftb.columns[1:]] = dftb[dftb.columns[1:]].astype('uint32')
106            export_dataset(
107                dftb,
108                file_dir=f"{dir_main}/feather", dataset_name=fname_main,
109                format='feather', info=False,
110                backup_dir=backup_dir
111            )
112            export_dataset(
113                dftb,
114                file_dir=f"{dir_main}/csv", dataset_name=fname_main,
115                format='csv', info=False,
116                backup_dir=backup_dir
117            )
118            print("\n-----")

```

### 3.5.5 Python Classes

Pandas DataFrame is a two-dimensional columnwise data structure. Each column must have the same data type. Although it provides by default rich functionality for data manipulation, additional namespaces can be added to pandas objects by registering custom accessors to serve specific purposes. Health insurance dataset in SAS7BDAT file format is imported as a Pandas DataFrame. All columns are numerical, either `int64` or `float64`.

With the `thesis` namespace (Code 3.5), the data type of a column can be of smaller size through the `retype` method, three dependent variables of interest (GRP, DIR and PUB) can be coded to a string of three character literals, either Y (Yes) or N (No), by the `code` method, and these eight different codes are regrouped to five with numerical values assigned by the `recode` method. Since some categorical values do not start from 0 up to a positive integer as required by the box classifier proposed in Chapter 4, they are encoded to be in this format via the `data` namespace (Code 3.6). Any numerical flags representing a continuous NIU (not in universe) value are converted to zero to become more meaningful. A categorical NIU value is already changed by the previous reordering. The `info` namespace (Code 3.7) sets the number of splitting values or cuts as given on a feature appropriately, not exceeding the number of all possible values for a categorical feature.

Code 3.5: ThesisExtension class (cls/ThesisExtension.py)

```

1  import re
2  import pandas as pd
3
4  @pd.api.extensions.register_dataframe_accessor("thesis")
5  class ThesisExtension:
6      def __init__(self, pandas_obj):
7          #self._validate(pandas_obj, list(indep_dict.keys()) + ['COV'] +
              dep_attrs)
8          self.dataset = pandas_obj
9
10     '''
11     @staticmethod
12     def _validate(obj, cols):
13         if any(x not in obj.columns for x in cols):
14             raise AttributeError("Some attributes are missing")

```

```

15     '''
16
17     def select(self, cols):
18         self.dataset.drop(self.dataset.columns.difference(cols), axis=1,
19                             inplace=True)
19
20     def show_type(self, option='short'):
21         if option.lower() == 'full':
22             with pd.option_context('display.max_rows', None, 'display.
23                                     max_columns', None):
24                 print(self.dataset.dtypes)
25         else:
26             print(self.dataset.dtypes)
26
27     @staticmethod
28     def retype(ser):
29         if all(ser.apply(lambda x: isinstance(x, int))):
30             flag_int = True
31         elif all(ser.apply(lambda x: x.is_integer())):
32             flag_int = True
33         else:
34             flag_int = False
35
36         if flag_int:
37             if all(ser.apply(lambda x: x>=0)):
38                 if max(ser) <= 255:
39                     return ser.astype('uint8')
40                 elif max(ser) <= 65535:
41                     return ser.astype('uint16')
42                 else:
43                     return ser.astype('uint32')
44             else:
45                 if min(ser) >= -128 and max(ser) <= 127:
46                     return ser.astype('int8')
47                 elif min(ser) >= -32768 and max(ser) <= 32767:
48                     return ser.astype('int16')

```

```

49         else:
50             return ser.astype('int32')
51     else:
52         return ser.astype('float32')
53
54     def code(self, indep_dict, dep_attrs):
55         self.select(list(indep_dict.keys()) + ['COV'] + dep_attrs)
56         for v in indep_dict.keys():
57             if indep_dict[v]['type'] == 'Categorical':
58                 self.dataset[v] = self.dataset[v].astype('int8').astype('
                    category')
59             else:
60                 self.dataset[v] = self.retype(self.dataset[v])
61         self.dataset['COV'] = self.dataset['COV'].astype('int8').astype('
            category')
62         self.dataset[dep_attrs] = self.dataset[dep_attrs].astype('int8')
63         self.dataset['class_orig'] = 0
64         self.dataset['code_orig'] = ""
65         for v in dep_attrs:
66             self.dataset[v] = self.dataset[v].replace([2.0, 1.0], [False,
                True])
67             self.dataset['class_orig'] = 2*self.dataset['class_orig'] +
                self.dataset[v]
68             self.dataset['code_orig'] = self.dataset['code_orig'] + self.
                dataset[v].replace([True, False], ['Y', 'N'])
69         self.dataset[dep_attrs] = self.dataset[dep_attrs].astype('category'
            )
70         self.dataset['class_orig'] = self.dataset['class_orig'].astype('
            int8').astype('category')
71         self.dataset['code_orig'] = self.dataset['code_orig'].astype('
            category')
72
73     def recode(self):
74         self.dataset['code'] = self.dataset['code_orig'].apply(
75             lambda v: 'NY_' if re.match('(NY)', v)

```

```

76         else 'Y1Y' if re.match(r'^Y(?:\w*Y)', v) # Raw string to
           prevent invalid escape sequence '\w'
77         else v
78     ).astype('category')
79     self.dataset['class'] = self.dataset[['class_orig', 'code']].apply(
80         lambda v: 2 if v['code'] == 'NY_'
81         else 3 if v['code'] == 'YNN'
82         else 4 if v['code'] == 'Y1Y'
83         else v['class_orig'],
84         axis=1
85     ).astype('int8').astype('category')

```

Code 3.6: Data class (cls/Data.py)

```

1  import re
2  import pandas as pd
3  from sklearn.preprocessing import LabelEncoder
4
5  @pd.api.extensions.register_dataframe_accessor("data")
6  class Data:
7      def __init__(self, pandas_obj, indep_dict):
8          self.dataset = pandas_obj
9          self.metadata = indep_dict
10
11      def encodecat(self):
12          cat_change = ""
13          for attr in self.metadata.keys():
14              if self.metadata[attr]['type'] == 'Categorical':
15                  le = LabelEncoder()
16                  le.fit(self.dataset[attr])
17                  self.dataset[attr] = list(le.transform(self.dataset[attr]).
18                                          astype('int8'))
19                  newkeys = list()
20                  unseen = 0
21                  for strval in self.metadata[attr]['values'].keys():

```



```

53             try:
54                 if int(strval) <= 0:
55                     self.metadata[attr]['values'].pop(strval,
56                                                         None)
57             except:
58                 pass
59             if flag:
60                 self.metadata[attr]['values']['0'] = 'NIU'
61         return cont_nonpos[0:-1]

```

Code 3.7: Info class (cls/Info.py)

```

1  import pandas as pd
2
3  # Delete the accessor to avoid warning
4  try:
5      del pd.DataFrame.info
6  except AttributeError:
7      pass
8
9  @pd.api.extensions.register_dataframe_accessor("info")
10 class Info:
11     def __init__(self, pandas_obj):
12         self._validate(pandas_obj, ['id', 'variable', 'type', 'min', 'max'
13                                     ])
14         self.dataset = pandas_obj
15
16     @staticmethod
17     def _validate(obj, cols):
18         if any(x not in obj.columns for x in cols):
19             raise AttributeError("Some attributes are missing")
20
21     def setcut(self, pcont, pcatmax):
22         self.dataset['cut'] = 0

```



```

22         self.dataset.loc[self.dataset['type'] == 'Continuous', 'cut'] =
           pcont
23         self.dataset.loc[self.dataset['type'] == 'Categorical', 'cut'] =
           self.dataset['max'].map(lambda v: min(v, pcatmax))

```

### 3.5.6 Exploratory Data Analysis (EDA)

This dissertation considers health insurance factors from a range of topics and subtopics as shown in Table 3.5. All infants born after calendar year are excluded in this study because they are not in the scope of health insurance coverage. This results in 157,681 relevant survey participants. Code 3.8 performs exploratory data analysis by using the pandas accessor `thesis` in Code 3.5 to compute the cross tabulation between a health factor (independent variable) and a combination of categorical insurance coverage types (dependent variable) as illustrated in Table 3.6. All continuous values of an independent variables are segmented into 10 bins. In addition, it can significantly compress the original dataset of size 237.4 MB in SAS7BDAT format into the feather and CSV formats of size 14.2 MB and 68.1 MB respectively.

Table 3.5: Categories of health insurance factors

| Topic           | Subtopic                   | List of Variables   |
|-----------------|----------------------------|---|
| Demographics    | Individual characteristics | A_AGE, A_EXPRRP, A_FAMTYP, A_HGA, A_MARITL,   |
|                 |                            | A_PFREL, A_SEX, P_STAT, PEAFEVER, PEDISDRS,<br>PEDISEAR, PEDISEYE, PEDISOUT, PEDISPHY, PEDISREM,<br>PRDISFLG, PRCITSH, PRDTRACE |
| Basic CPS items | Edited labor force items   | A_MJIND, A_MJOCC, PEIO1COW, PRDISC, PRUNTYPE  |
|                 | Edited earnings items      | A_GRSWK, A_HRLYWK, A_HRSPAY, PRERELG  |
|                 | Labor force person recodes | A_CIVLF, A_CLSWKR, A_EXPLF, A_LFSR, A_UNCOV,  |
|                 |                            | A_UNMEM, A_UNTYPE, A_USLHRS, A_WKSCH, A_WKSLK,<br>A_WKSTAT, PEHRUSLT, PEMLR, PRCOW1, PRPTREA,<br>PRWKSTAT                       |
| Work experience | General                    | CLWK, EARNER, HRSWK, LJCW, NWLKWK, NWLOOK,  |
|                 |                            | PHMEMPRS, RSNNOTW, WECLW, WEWKRS, WKSWORK,<br>WORKYN, WRK_CK, WTEMP   |

Table 3.5: Categories of health insurance factors (continued)

| Topic  | Subtopic | List of Variables                            |
|--------|----------|--|
| Income | Earnings | ERN_OTR, ERN_SRCE, ERN_VAL, ERN_YN, FRM_VAL, |
|        |          | FRMOTR, FRSE_VAL, FRSE_YN, PEARNVAL, SE_VAL, |
|        |          | SEMP_VAL, SEMP_YN, SEOTR, WAGEOTR, WS_VAL,   |
|        |          | WSAL_VAL, WSAL_YN                            |

Table 3.5: Categories of health insurance factors (continued)

| Topic | Subtopic     | List of Variables   |
|-------|--------------|---|
|       | Other income | ANN_VAL, ANN_YN, CAP_VAL, CAP_YN, DBTN_VAL,<br>DIS_SC1, DIS_SC2, DIS_VAL1, DIS_VAL2, DIS_YN, DIV_VAL,<br>DIV_YN, DSAB_VAL, DST_SC1, DST_SC1_YNG, DST_SC2,<br>DST_SC2_YNG, DST_VAL1, DST_VAL1_YNG, DST_VAL2,<br>DST_VAL2_YNG, DST_YN, DST_YN_YNG, ED_VAL,<br>ED_YN, FIN_VAL, FIN_YN, INT_VAL, INT_YN, OED_TYP1,<br>OED_TYP2, OED_TYP3, OI_OFF, OI_VAL, OI_YN,<br>PEN_SC1, PEN_SC2, PEN_VAL1, PEN_VAL2, PEN_YN,<br>PNSN_VAL, PTOTVAL, RESNSS1, RESNSS2, RESNSSI1,<br>RESNSSI2, RETCB_VAL, RETCB_YN, RINT_SC1, RINT_SC2,<br>RINT_VAL1, RINT_VAL2, RINT_YN, RNT_VAL, RNT_YN,<br>SRVS_VAL, SS_VAL, SS_YN, SSI_VAL, SSI_YN, STRKUC,<br>SUBUC, SUR_SC1, SUR_SC2, SUR_VAL1, SUR_VAL2,<br>SUR_YN, TRDINT_VAL, UC_VAL, UC_YN, VET_TYP1,<br>VET_TYP2, VET_TYP3, VET_TYP4, VET_TYP5, VET_VAL,<br>VET_YN, WC_TYPE, WC_VAL, WC_YN |

Table 3.5: Categories of health insurance factors (continued)

| Topic                        | Subtopic                     | List of Variables   |
|------------------------------|------------------------------|---|
|                              | Non-cash benefits            | PAW_TYP, PAW_VAL, PAW_YN, PENINCL, PENPLAN, WICYN   |
|                              | Supplemental poverty measure | CHCARE_YN, CHELSEW_YN, CHSP_VAL, CHSP_YN, CSP_VAL, CSP_YN   |
|                              | Tax model items              | ACTC_CRD, AGI, CTC_CRD, EIT_CRED, FED_RET, FEDTAX_AC, FEDTAX_BC, FICA, FILESTAT, MARG_TAX, PRSWKXPNS, STATETAX_A, STATETAX_B, TAX_INC |
| Poverty                      | Poverty                      | PERLIS, POV_UNIV  |
| Health insurance             | Health status                | HEA   |
| Supplemental poverty measure | SPM unit characteristics     | SPM_ACTC  |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB)

| Variable                             | Insurance Coverage Type (GRP, DIR, PUB) |       |       |       |        |
|--------------------------------------|---|-------|-------|-------|--------|
|                                      | NNN                                     | NNY   | NY_   | Y1Y   | YNN    |
| A_AGE: Age                           |   |       |       |       |        |
| Universe: All Persons                |   |       |       |       |        |
| (-0.085, 8.5]                        | 1,407                                   | 5,834 | 789   | 628   | 9,795  |
| (8.5, 17.0]                          | 1,557                                   | 6,237 | 1,079 | 770   | 11,822 |
| (17.0, 25.5]                         | 2,238                                   | 2,475 | 1,043 | 414   | 8,017  |
| (25.5, 34.0]                         | 2,635                                   | 2,749 | 1,082 | 594   | 10,611 |
| (34.0, 42.5]                         | 2,271                                   | 2,146 | 976   | 613   | 11,509 |
| (42.5, 51.0]                         | 2,109                                   | 2,171 | 1,157 | 518   | 12,081 |
| (51.0, 59.5]                         | 1,606                                   | 2,403 | 1,223 | 471   | 9,864  |
| (59.5, 68.0]                         | 1,028                                   | 4,854 | 2,313 | 2,090 | 6,097  |
| (68.0, 76.5]                         | 105                                     | 5,404 | 2,602 | 2,044 | 254    |
| (76.5, 85.0]                         | 79                                      | 4,472 | 1,977 | 1,353 | 115    |
| A_EXPRRP: Expanded relationship code |   |       |       |       |        |
| Universe: All Persons                |   |       |       |       |        |
| Reference person with relatives      | 3,693                                   | 8,822 | 4,254 | 3,365 | 21,403 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                           | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|------------------------------------|---|--------|-------|-------|--------|
|                                    | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Reference person without relatives | 1,603                                   | 6,102  | 2,739 | 1,413 | 7,066  |
| Husband                            | 1,049                                   | 2,196  | 1,325 | 1,016 | 7,069  |
| Wife                               | 1,482                                   | 2,898  | 1,984 | 1,426 | 10,471 |
| Own child                          | 4,337                                   | 12,355 | 2,540 | 1,553 | 27,291 |
| Grandchild                         | 377                                     | 1,621  | 137   | 106   | 940    |
| Parent                             | 335                                     | 1,183  | 305   | 174   | 780    |
| Brother/sister                     | 352                                     | 636    | 127   | 50    | 680    |
| Other relative                     | 464                                     | 1,219  | 215   | 106   | 908    |
| Foster child                       | 2                                       | 107    | 2     | 44    | 2      |
| Nonrelative with relatives         | 305                                     | 514    | 101   | 73    | 816    |
| Partner/roommate                   | 803                                     | 780    | 421   | 149   | 2,381  |
| Nonrelative without relatives      | 233                                     | 312    | 91    | 20    | 358    |

A\_FAMTYP: Family type

Universe: All Persons

Primary family

11,310    28,667    10,560    7,564    67,373

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                      | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|-------------------------------|---|--------|-------|-------|--------|
|                               | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Nonfamily householder         | 1,603                                   | 6,102  | 2,739 | 1,413 | 7,066  |
| Related subfamily             | 779                                     | 2,263  | 327   | 232   | 2,169  |
| Unrelated subfamily           | 59                                      | 175    | 32    | 29    | 223    |
| Secondary individual          | 1,284                                   | 1,538  | 583   | 257   | 3,334  |
| A_HGA: Educational attainment |   |        |       |       |        |
| Universe: All Persons         |   |        |       |       |        |
| Children                      | 2,431                                   | 10,167 | 1,488 | 1,160 | 17,629 |
| Less than 1st grade           | 76                                      | 177    | 31    | 19    | 64     |
| 1st,2nd,3rd,or 4th grade      | 170                                     | 390    | 61    | 21    | 115    |
| 5th or 6th grade              | 412                                     | 666    | 105   | 52    | 283    |
| 7th and 8th grade             | 418                                     | 1,035  | 222   | 116   | 794    |
| 9th grade                     | 480                                     | 1,208  | 231   | 126   | 1,381  |
| 10th grade                    | 459                                     | 1,363  | 252   | 169   | 1,694  |
| 11th grade                    | 495                                     | 1,443  | 307   | 172   | 1,814  |
| 12th grade no diploma         | 339                                     | 716    | 159   | 94    | 794    |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|---|---|--------|-------|-------|--------|
|   | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| High school graduate - high school diploma or equivalent    | 4,267                                   | 9,614  | 3,563 | 2,174 | 13,304 |
| Some college but no degree                                  | 2,177                                   | 4,642  | 2,282 | 1,357 | 10,203 |
| Associate degree in college - occupation/vocation program   | 465                                     | 1,044  | 589   | 370   | 2,681  |
| Associate degree in college - academic program              | 610                                     | 1,260  | 719   | 513   | 3,919  |
| Bachelor's degree (for example: BA,AB,BS)                   | 1,580                                   | 3,364  | 2,738 | 1,731 | 15,745 |
| Master's degree (for example: MA,MS,MENG,MED,MSW, MBA)      | 530                                     | 1,221  | 1,041 | 1,017 | 7,264  |
| Professional school degree (for example: MD,DDS,DVM,LLB,JD) | 52                                      | 189    | 202   | 162   | 1,026  |
| Doctorate degree (for example: PHD,EDD)                     | 74                                      | 246    | 251   | 242   | 1,455  |
| A_MARITL: Marital status                                    |   |        |       |       |        |
| Universe: All Persons                                       |   |        |       |       |        |
| Married - civilian spouse present                           | 4,911                                   | 11,026 | 6,899 | 5,333 | 35,669 |
| Married - AF spouse present                                 | 346                                     | 11     | 9     | 0     | 86     |
| Married - spouse absent (exc.separated)                     | 261                                     | 418    | 175   | 97    | 721    |
| Widowed   | 282                                     | 3,671  | 1,344 | 784   | 741    |
| Divorced  | 1,186                                   | 3,834  | 1,402 | 754   | 4,817  |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                             | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--------------------------------------|---|--------|-------|-------|--------|
|                                      | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Separated                            | 356                                     | 723    | 144   | 101   | 758    |
| Never married                        | 7,693                                   | 19,062 | 4,268 | 2,426 | 37,373 |
| A_PFREL: Primary family relationship |   |        |       |       |        |
| Universe: All Persons                |   |        |       |       |        |
| Not in primary family                | 2,946                                   | 7,815  | 3,354 | 1,699 | 10,623 |
| Husband                              | 2,408                                   | 5,385  | 3,324 | 2,794 | 16,972 |
| Wife                                 | 2,501                                   | 4,998  | 3,382 | 2,404 | 17,664 |
| Own child                            | 4,337                                   | 12,355 | 2,540 | 1,553 | 27,291 |
| Other relative                       | 1,528                                   | 4,659  | 784   | 436   | 3,308  |
| Unmarried reference person           | 1,315                                   | 3,533  | 857   | 609   | 4,307  |
| A_SEX: Sex                           |   |        |       |       |        |
| Universe: All Persons                |   |        |       |       |        |
| Male                                 | 7,804                                   | 17,947 | 6,658 | 4,710 | 39,664 |
| Female                               | 7,231                                   | 20,798 | 7,583 | 4,785 | 40,501 |
| P_STAT: Status of person identifier  |   |        |       |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Universe: All Persons   |   |        |        |       |        |
| Civilian 15+  | 12,186                                  | 28,562 | 12,747 | 8,334 | 62,431 |
| Armed forces  | 418                                     | 16     | 6      | 1     | 105    |
| Children 0-14   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| PEAFEVER: Did you ever serve on active duty in the U.S. Armed Forces? |   |        |        |       |        |
| Universe: A_AGE greater than or equal to 17                           |   |        |        |       |        |
| Not in universe   | 3,207                                   | 11,462 | 1,745  | 1,320 | 20,376 |
| Yes   | 674                                     | 3,025  | 1,158  | 1,233 | 2,498  |
| No  | 11,154                                  | 24,258 | 11,338 | 6,942 | 57,291 |
| PEDISDRS: Does...have difficulty dressing or bathing?                 |   |        |        |       |        |
| Universe: PRPERTYP = 2  |   |        |        |       |        |
| Not in universe   | 2,849                                   | 10,183 | 1,494  | 1,161 | 17,734 |
| Yes   | 98                                      | 1,545  | 299    | 233   | 224    |
| No  | 12,088                                  | 27,017 | 12,448 | 8,101 | 62,207 |
| PEDISEAR: Is...deaf or does ...have serious difficulty hearing?       |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Universe: PRPERTYP = 2  |   |        |        |       |        |
| Not in universe   | 2,849                                   | 10,183 | 1,494  | 1,161 | 17,734 |
| Yes   | 153                                     | 2,024  | 809    | 573   | 683    |
| No  | 12,033                                  | 26,538 | 11,938 | 7,761 | 61,748 |
| PEDISEYE: Is...blind or does...have serious difficulty seeing even when wearing glasses?  |   |        |        |       |        |
| Universe: PRPERTYP = 2  |   |        |        |       |        |
| Not in universe   | 2,849                                   | 10,183 | 1,494  | 1,161 | 17,734 |
| Yes   | 110                                     | 1,116  | 280    | 202   | 358    |
| No  | 12,076                                  | 27,446 | 12,467 | 8,132 | 62,073 |
| PEDISOUT: Because of a physical, mental, or emotional condition, does...have difficulty doing errands along such as visiting a doctor's office or shopping? |   |        |        |       |        |
| Universe: PRPERTYP = 2  |   |        |        |       |        |
| Not in universe   | 2,849                                   | 10,183 | 1,494  | 1,161 | 17,734 |
| Yes   | 223                                     | 3,156  | 638    | 513   | 506    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| No   | 11,963                                  | 25,406 | 12,109 | 7,821 | 61,925 |
| PEDISPHY: Does...have serious difficulty Walking or climbing stairs?   |   |        |        |       |        |
| Universe: PRPERTYP = 2   |   |        |        |       |        |
| Not in universe  | 2,849                                   | 10,183 | 1,494  | 1,161 | 17,734 |
| Yes  | 339                                     | 4,767  | 1,210  | 900   | 933    |
| No   | 11,847                                  | 23,795 | 11,537 | 7,434 | 61,498 |
| PEDISREM: Because of a physical, mental, or emotional condition, does...have serious difficulty concentrating, remembering, or making decisions? |   |        |        |       |        |
| Universe: PRPERTYP = 2   |   |        |        |       |        |
| Not in universe  | 2,849                                   | 10,183 | 1,494  | 1,161 | 17,734 |
| Yes  | 292                                     | 2,489  | 519    | 367   | 762    |
| No   | 11,894                                  | 26,073 | 12,228 | 7,967 | 61,669 |
| PRDISFLG: Does this person have any of these disability conditions?  |   |        |        |       |        |
| Universe: PRPERTYP = 2   |   |        |        |       |        |
| Not in universe  | 2,849                                   | 10,183 | 1,494  | 1,161 | 17,734 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Yes                                       | 732                                     | 7,560  | 2,124  | 1,569 | 2,395  |
| No  | 11,454                                  | 21,002 | 10,623 | 6,765 | 60,036 |
| PRCITSH: Citizenship group                |   |        |        |       |        |
| Universe: All persons                     |   |        |        |       |        |
| Native, born in US                        | 11,006                                  | 32,887 | 12,065 | 8,403 | 70,326 |
| Native, born in PR or US outlying area    | 82                                      | 345    | 60     | 49    | 326    |
| Native, born abroad of US parent(s)       | 153                                     | 249    | 92     | 76    | 694    |
| Foreign born, US cit by naturalization    | 1,004                                   | 2,975  | 1,067  | 650   | 4,851  |
| Foreign born, not a US citizen            | 2,790                                   | 2,289  | 957    | 317   | 3,968  |
| PRDTRACE: Race                            |   |        |        |       |        |
| Universe: All persons                     |   |        |        |       |        |
| White only                                | 11,466                                  | 27,682 | 11,885 | 7,517 | 63,366 |
| Black only                                | 1,765                                   | 6,815  | 1,011  | 1,051 | 7,484  |
| American Indian, Alaskan Native only (AI) | 516                                     | 902    | 97     | 85    | 837    |
| Asian only                                | 745                                     | 2,010  | 962    | 561   | 5,947  |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                            | Insurance Coverage Type (GRP, DIR, PUB) |     |     |     |     |
|-------------------------------------|---|-----|-----|-----|-----|
|                                     | NNN                                     | NNY | NY_ | Y1Y | YNN |
| Hawaiian/Pacific Islander only (HP) | 89                                      | 192 | 34  | 41  | 368 |
| White-Black                         | 150                                     | 428 | 70  | 58  | 600 |
| White-AI                            | 131                                     | 351 | 81  | 96  | 490 |
| White-Asian                         | 86                                      | 111 | 52  | 41  | 613 |
| White-HP                            | 17                                      | 50  | 15  | 13  | 112 |
| Black-AI                            | 26                                      | 67  | 5   | 12  | 58  |
| Black-Asian                         | 2                                       | 8   | 9   | 3   | 45  |
| Black-HP                            | 1                                       | 8   | 1   | 4   | 1   |
| AI-Asian                            | 2                                       | 6   | 1   | 0   | 6   |
| AI-HP                               | 0                                       | 4   | 0   | 0   | 4   |
| Asian-HP                            | 5                                       | 17  | 12  | 7   | 72  |
| White-Black-AI                      | 13                                      | 44  | 2   | 3   | 32  |
| White-Black-Asian                   | 12                                      | 8   | 0   | 1   | 34  |
| White-Black-HP                      | 0                                       | 1   | 0   | 0   | 5   |
| White-AI-Asian                      | 2                                       | 3   | 0   | 0   | 7   |
| White-AI-HP                         | 0                                       | 3   | 0   | 0   | 4   |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                   | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--|---|--------|-------|-------|--------|
|  | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| White-Asian-HP                             | 4                                       | 35     | 1     | 2     | 65     |
| Black-AI-Asian                             | 1                                       | 0      | 0     | 0     | 1      |
| White-Black-AI-Asian                       | 0                                       | 0      | 2     | 0     | 5      |
| Other 3 race comb.                         | 1                                       | 0      | 0     | 0     | 3      |
| Other 4 or 5 race comb.                    | 1                                       | 0      | 1     | 0     | 6      |
| A_MJIND: Major industry code               |   |        |       |       |        |
| Universe: A_CLSWKR = 1-7                   |   |        |       |       |        |
| Not in universe, or children               | 6,704                                   | 30,326 | 8,393 | 5,873 | 29,260 |
| Agriculture, forestry,fishing, and hunting | 268                                     | 241    | 309   | 79    | 536    |
| Mining                                     | 44                                      | 21     | 24    | 18    | 445    |
| Construction                               | 1,114                                   | 670    | 511   | 214   | 2,961  |
| Manufacturing                              | 551                                     | 501    | 331   | 346   | 5,528  |
| Wholesale and retail trade                 | 1,124                                   | 1,336  | 770   | 433   | 5,857  |
| Transportation and utilities               | 480                                     | 474    | 276   | 185   | 2,865  |
| Information                                | 80                                      | 117    | 93    | 48    | 978    |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                           | Insurance Coverage Type (GRP, DIR, PUB) |       |       |     |        |
|------------------------------------|---|-------|-------|-----|--------|
|                                    | NNN                                     | NNY   | NY_   | Y1Y | YNN    |
| Financial activities               | 310                                     | 336   | 437   | 233 | 3,752  |
| Professional and business services | 957                                     | 926   | 813   | 414 | 6,036  |
| Educational and health services    | 1,209                                   | 1,607 | 1,088 | 957 | 13,296 |
| Leisure and hospitality            | 1,346                                   | 1,367 | 629   | 278 | 3,561  |
| Other services                     | 589                                     | 615   | 457   | 185 | 1,854  |
| Public administration              | 250                                     | 208   | 110   | 232 | 3,236  |
| Armed forces                       | 9                                       | 0     | 0     | 0   | 0      |

A\_MJOCC: Major occupation recode

Universe: A\_CLSWKR = 1-7

Not in universe or children

Management, business, and financial occupations

Professional and related occupations

Service occupations

Sales and related occupations

Office and administrative support occupations

|       |        |       |       |        |
|-------|--------|-------|-------|--------|
| 6,704 | 30,326 | 8,393 | 5,873 | 29,260 |
| 866   | 821    | 1,144 | 595   | 9,953  |
| 964   | 1,023  | 1,142 | 951   | 14,527 |
| 2,265 | 2,597  | 1,125 | 547   | 6,665  |
| 791   | 1,025  | 687   | 311   | 4,343  |
| 661   | 797    | 589   | 423   | 5,469  |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|---|---|--------|-------|-------|--------|
|   | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Farming, fishing, and forestry occupations        | 177                                     | 123    | 95    | 31    | 246    |
| Construction and extraction occupations           | 948                                     | 536    | 326   | 160   | 2,154  |
| Installation, maintenance, and repair occupations | 327                                     | 215    | 129   | 127   | 1,622  |
| Production occupations                            | 484                                     | 417    | 228   | 194   | 2,728  |
| Transportation and material moving occupations    | 839                                     | 865    | 383   | 283   | 3,198  |
| Armed forces                                      | 9                                       | 0      | 0     | 0     | 0      |
| PEIO1COW: Individual class of worker on first job |   |        |       |       |        |
| Universe: All persons                             |   |        |       |       |        |
| NIU   | 6,704                                   | 30,326 | 8,393 | 5,873 | 29,260 |
| Government-federal                                | 222                                     | 120    | 57    | 138   | 1,708  |
| Government-state                                  | 189                                     | 237    | 151   | 213   | 3,210  |
| Government - local                                | 219                                     | 337    | 196   | 296   | 4,045  |
| Private, for profit                               | 6,214                                   | 5,951  | 3,369 | 2,233 | 34,815 |
| Private, nonprofit                                | 274                                     | 466    | 323   | 343   | 3,933  |
| Self-employed, incorporated                       | 325                                     | 323    | 756   | 152   | 1,484  |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Self-employed, unincorporated                     | 880                                     | 974    | 986    | 246   | 1,703  |
| Without pay                                       | 8                                       | 11     | 10     | 1     | 7      |
| PRDISC: Discouraged worker recode                 |   |        |        |       |        |
| Universe: All persons                             |   |        |        |       |        |
| NIU   | 14,880                                  | 38,437 | 14,165 | 9,452 | 79,861 |
| Discouraged worker                                | 40                                      | 83     | 18     | 4     | 57     |
| Conditionally interested                          | 73                                      | 159    | 34     | 28    | 145    |
| Not available                                     | 42                                      | 66     | 24     | 11    | 102    |
| PRUNTYPE: Individual class of worker on first job |   |        |        |       |        |
| Universe: All persons                             |   |        |        |       |        |
| NIU   | 14,304                                  | 37,763 | 13,967 | 9,302 | 78,459 |
| Job loser /on layoff                              | 252                                     | 341    | 136    | 72    | 797    |
| Other job loser                                   | 127                                     | 130    | 38     | 52    | 329    |
| Temporary job ended                               | 82                                      | 97     | 17     | 14    | 93     |
| Job leaver  | 69                                      | 64     | 14     | 11    | 138    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Re-entrant   | 162                                     | 266    | 62     | 38    | 275    |
| New-entrant  | 39                                      | 84     | 7      | 6     | 74     |
| <p>A_GRSWK: How much does ... usually earn per week at this job before deductions , subject to topcoding, the higher of either the amount of item 25a times Item 25c or the actual item 25d entry will be present</p> <p>Universe: PRERELG=1</p> <p>(-2.885, 288.5]</p> <p>(288.5, 577.0]</p> <p>(577.0, 865.5]</p> <p>(865.5, 1154.0]</p> <p>(1154.0, 1442.5]</p> <p>(1442.5, 1731.0]</p> <p>(1731.0, 2019.5]</p> <p>(2019.5, 2308.0]</p> <p>(2308.0, 2596.5]</p> |   |        |        |       |        |
|  | 14,066                                  | 37,929 | 13,596 | 9,036 | 72,547 |
|  | 412                                     | 407    | 218    | 112   | 1,185  |
|  | 285                                     | 213    | 159    | 122   | 1,652  |
|  | 111                                     | 88     | 102    | 92    | 1,522  |
|  | 64                                      | 47     | 42     | 36    | 979    |
|  | 34                                      | 18     | 33     | 27    | 714    |
|  | 21                                      | 15     | 20     | 16    | 413    |
|  | 10                                      | 9      | 15     | 9     | 314    |
|  | 13                                      | 6      | 20     | 9     | 201    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                       | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (2596.5, 2885.0]                               | 19                                      | 13     | 36     | 36    | 638    |
| A_HRLYWK: Is ... paid by the hour on this job? |   |        |        |       |        |
| Universe: PRERELG=1                            |   |        |        |       |        |
| Not in universe or children and armed forces   | 13,245                                  | 37,057 | 13,165 | 8,715 | 67,548 |
| Yes  | 1,320                                   | 1,289  | 662    | 468   | 6,463  |
| No   | 470                                     | 399    | 414    | 312   | 6,154  |
| A_HRSPAY: How much does ... earn per hour?     |   |        |        |       |        |
| Universe: A_HRLYWK=1                           |   |        |        |       |        |
| (-10.901, 989.1]                               | 14,314                                  | 38,046 | 13,813 | 9,201 | 76,286 |
| (989.1, 1979.2]                                | 563                                     | 582    | 312    | 203   | 2,116  |
| (1979.2, 2969.3]                               | 112                                     | 80     | 69     | 58    | 1,059  |
| (2969.3, 3959.4]                               | 28                                      | 24     | 20     | 19    | 391    |
| (3959.4, 4949.5]                               | 10                                      | 6      | 12     | 5     | 165    |
| (4949.5, 5939.6]                               | 5                                       | 4      | 10     | 6     | 76     |
| (5939.6, 6929.7]                               | 3                                       | 1      | 2      | 2     | 40     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (6929.7, 7919.8]   | 0                                       | 1      | 1      | 1     | 21     |
| (7919.8, 8909.9]   | 0                                       | 0      | 0      | 0     | 7      |
| (8909.9, 9900.0]   | 0                                       | 1      | 2      | 0     | 4      |
| PRERELG: Earnings eligibility flag   |   |        |        |       |        |
| Universe: All persons  |   |        |        |       |        |
| Not earnings eligible  | 13,245                                  | 37,057 | 13,165 | 8,715 | 67,548 |
| Earnings eligible  | 1,790                                   | 1,688  | 1,076  | 780   | 12,617 |
| A_CIVLF: Civilian labor force  |   |        |        |       |        |
| Universe: All persons  |   |        |        |       |        |
| Not in universe or children and Armed Forces                               | 6,798                                   | 30,466 | 8,496  | 5,960 | 29,588 |
| In universe  | 8,237                                   | 8,279  | 5,745  | 3,535 | 50,577 |
| A_CLSWKR: Class of worker  |   |        |        |       |        |
| Universe: PEMLR=1-3 or (PEMLR=4-7 and person worked in the last 12 months) |   |        |        |       |        |
| Not in universe or children and armed forces                               | 6,665                                   | 30,242 | 8,386  | 5,867 | 29,186 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--|---|--------|-------|-------|--------|
|  | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Private  | 6,488                                   | 6,417  | 3,692 | 2,576 | 38,748 |
| Federal government                                 | 222                                     | 120    | 57    | 138   | 1,708  |
| State government                                   | 189                                     | 237    | 151   | 213   | 3,210  |
| Local government                                   | 219                                     | 337    | 196   | 296   | 4,045  |
| Self-employed-incorporated                         | 325                                     | 323    | 756   | 152   | 1,484  |
| Self-employed-not incorporated                     | 880                                     | 974    | 986   | 246   | 1,703  |
| Without pay  | 8                                       | 11     | 10    | 1     | 7      |
| Never worked                                       | 39                                      | 84     | 7     | 6     | 74     |
| A_EXPLF: Experienced labor force employment status |   |        |       |       |        |
| Universe: PEMLR=1-4                                |   |        |       |       |        |
| Not in experienced labor force                     | 6,837                                   | 30,550 | 8,503 | 5,966 | 29,662 |
| Employed   | 7,506                                   | 7,297  | 5,471 | 3,342 | 48,871 |
| Unemployed   | 692                                     | 898    | 267   | 187   | 1,632  |
| A_LFSR: Labor force status recode                  |   |        |       |       |        |
| Universe: All persons                              |   |        |       |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Children or Armed Forces   | 2,849                                   | 10,183 | 1,494  | 1,161 | 17,734 |
| Working  | 7,178                                   | 6,826  | 5,136  | 3,181 | 46,957 |
| With job, not at work  | 328                                     | 471    | 335    | 161   | 1,914  |
| Unemployed, looking for work   | 479                                     | 641    | 138    | 121   | 909    |
| Unemployed, on layoff  | 252                                     | 341    | 136    | 72    | 797    |
| Nilf   | 3,949                                   | 20,283 | 7,002  | 4,799 | 11,854 |
| A_UNCOV: On this job, is ... covered by a union or employee association contract?                        |   |        |        |       |        |
| Universe: A_UNMEM=2  |   |        |        |       |        |
| Not in universe or children and armed forces   | 13,962                                  | 37,715 | 13,483 | 9,016 | 72,936 |
| Yes  | 8                                       | 11     | 8      | 10    | 108    |
| No   | 1,065                                   | 1,019  | 750    | 469   | 7,121  |
| A_UNMEM: On this job, is ... a member of a labor union or of an employee association similar to a union? |   |        |        |       |        |
| Universe: PRRELG=1   |   |        |        |       |        |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Not in universe or children and armed forces                       | 13,909                                  | 37,669 | 13,451 | 8,957 | 71,925 |
| Yes  | 53                                      | 46     | 32     | 59    | 1,011  |
| No   | 1,073                                   | 1,030  | 758    | 479   | 7,229  |
| A_UNTYPE: Reason for unemployment                                  |   |        |        |       |        |
| Universe: A_LFSR=3 or 4  |   |        |        |       |        |
| Not in universe or children and Armed Forces                       | 14,304                                  | 37,763 | 13,967 | 9,302 | 78,459 |
| Job loser - on layoff  | 252                                     | 341    | 136    | 72    | 797    |
| Other job loser  | 209                                     | 227    | 55     | 66    | 422    |
| Job leaver   | 69                                      | 64     | 14     | 11    | 138    |
| Re-entrant   | 162                                     | 266    | 62     | 38    | 275    |
| New entrant  | 39                                      | 84     | 7      | 6     | 74     |
| A_USLHRS: How many hrs per week does ... usually work at this job? |   |        |        |       |        |
| Universe: All persons  |   |        |        |       |        |
| (-4.103, 6.3]  | 8,214                                   | 32,313 | 9,452  | 6,448 | 33,848 |
| (6.3, 16.6]  | 279                                     | 647    | 359    | 198   | 1,392  |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                    | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|---|---|--------|-------|-------|--------|
|   | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| (16.6, 26.9]                                | 641                                     | 1,071  | 691   | 288   | 2,360  |
| (26.9, 37.2]                                | 935                                     | 1,099  | 622   | 362   | 3,750  |
| (37.2, 47.5]                                | 4,268                                   | 3,105  | 2,411 | 1,848 | 32,501 |
| (47.5, 57.8]                                | 436                                     | 291    | 412   | 234   | 4,378  |
| (57.8, 68.1]                                | 186                                     | 149    | 189   | 74    | 1,437  |
| (68.1, 78.4]                                | 45                                      | 46     | 57    | 22    | 289    |
| (78.4, 88.7]                                | 24                                      | 13     | 28    | 16    | 166    |
| (88.7, 99.0]                                | 7                                       | 11     | 20    | 5     | 44     |
| A_WKSCH: Labor force by time worked or lost |   |        |       |       |        |
| Universe: All persons                       |   |        |       |       |        |
| Not in universe                             | 6,798                                   | 30,466 | 8,496 | 5,960 | 29,588 |
| At work                                     | 7,178                                   | 6,826  | 5,136 | 3,181 | 46,957 |
| With job, not at work                       | 328                                     | 471    | 335   | 161   | 1,914  |
| Unemployed, seeks FT                        | 618                                     | 722    | 197   | 136   | 1,316  |
| Unemployed, seeks PT                        | 113                                     | 260    | 77    | 57    | 390    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                          | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|-----------------------------------|---|--------|--------|-------|--------|
|                                   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| A_WKSLK: Duration of unemployment |   |        |        |       |        |
| Universe: PEMLR=3 or 4            |   |        |        |       |        |
| (-0.099, 9.9]                     | 14,748                                  | 38,340 | 14,142 | 9,435 | 79,643 |
| (9.9, 19.8]                       | 118                                     | 150    | 44     | 27    | 237    |
| (19.8, 29.7]                      | 49                                      | 76     | 17     | 12    | 121    |
| (29.7, 39.6]                      | 26                                      | 50     | 9      | 7     | 66     |
| (39.6, 49.5]                      | 10                                      | 11     | 4      | 4     | 16     |
| (49.5, 59.4]                      | 45                                      | 50     | 11     | 5     | 42     |
| (59.4, 69.3]                      | 9                                       | 10     | 3      | 0     | 7      |
| (69.3, 79.2]                      | 4                                       | 2      | 0      | 0     | 1      |
| (79.2, 89.1]                      | 0                                       | 0      | 0      | 0     | 1      |
| (89.1, 99.0]                      | 26                                      | 56     | 11     | 5     | 31     |
| A_WKSTAT: Full/part-time status   |   |        |        |       |        |
| Universe: All persons             |   |        |        |       |        |
| Children or Armed Forces          | 2,849                                   | 10,183 | 1,494  | 1,161 | 17,734 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                       | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--|---|--------|-------|-------|--------|
|  | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Not in labor force                             | 3,949                                   | 20,283 | 7,002 | 4,799 | 11,854 |
| Full-time schedules                            | 5,715                                   | 4,390  | 3,714 | 2,508 | 42,413 |
| Part-time for economic reasons, usually FT     | 267                                     | 217    | 153   | 48    | 670    |
| Part-time for non-economic reasons, usually PT | 1,200                                   | 2,313  | 1,464 | 718   | 5,257  |
| Part-time for economic reasons, usually PT     | 324                                     | 377    | 140   | 68    | 531    |
| Unemployed FT                                  | 618                                     | 722    | 197   | 136   | 1,316  |
| Unemployed PT                                  | 113                                     | 260    | 77    | 57    | 390    |
| PEHRUSLT: Hours usually worked last week       |   |        |       |       |        |
| Universe: All persons                          |   |        |       |       |        |
| (-4.144, 10.4]                                 | 8,336                                   | 32,561 | 9,610 | 6,541 | 34,614 |
| (10.4, 24.8]                                   | 595                                     | 1,159  | 671   | 330   | 2,447  |
| (24.8, 39.2]                                   | 1,147                                   | 1,420  | 805   | 444   | 4,613  |
| (39.2, 53.6]                                   | 4,519                                   | 3,253  | 2,721 | 1,976 | 35,068 |
| (53.6, 68.0]                                   | 333                                     | 257    | 306   | 147   | 2,691  |
| (68.0, 82.4]                                   | 87                                      | 76     | 102   | 42    | 583    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                             | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--------------------------------------|---|--------|-------|-------|--------|
|                                      | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| (82.4, 96.8]                         | 14                                      | 7      | 12    | 8     | 106    |
| (96.8, 111.2]                        | 4                                       | 11     | 13    | 7     | 36     |
| (111.2, 125.6]                       | 0                                       | 0      | 1     | 0     | 7      |
| (125.6, 140.0]                       | 0                                       | 1      | 0     | 0     | 0      |
| PEMLR: Major labor force recode      |   |        |       |       |        |
| Universe: All persons                |   |        |       |       |        |
| NIU                                  | 2,849                                   | 10,183 | 1,494 | 1,161 | 17,734 |
| Employed - at work                   | 7,178                                   | 6,826  | 5,136 | 3,181 | 46,957 |
| Employed - absent                    | 328                                     | 471    | 335   | 161   | 1,914  |
| Unemployed - on layoff               | 252                                     | 341    | 136   | 72    | 797    |
| Unemployed - looking                 | 479                                     | 641    | 138   | 121   | 909    |
| Not in labor force - retired         | 543                                     | 11,004 | 5,087 | 3,754 | 1,768  |
| Not in labor force - disabled        | 437                                     | 4,110  | 405   | 359   | 732    |
| Not in labor force - other           | 2,969                                   | 5,169  | 1,510 | 686   | 9,354  |
| PRCOW1: Class of worker recode-job 1 |   |        |       |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                    | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Universe: All persons                       |   |        |        |       |        |
| NIU   | 6,704                                   | 30,326 | 8,393  | 5,873 | 29,260 |
| Federal govt                                | 222                                     | 120    | 57     | 138   | 1,708  |
| State govt                                  | 189                                     | 237    | 151    | 213   | 3,210  |
| Local govt                                  | 219                                     | 337    | 196    | 296   | 4,045  |
| Private (incl. self-employed incorp.)       | 6,813                                   | 6,740  | 4,448  | 2,728 | 40,232 |
| Self-employed, unincorp.                    | 880                                     | 974    | 986    | 246   | 1,703  |
| Without pay                                 | 8                                       | 11     | 10     | 1     | 7      |
| PRPTREA: Detailed reason for part-time      |   |        |        |       |        |
| Universe: Part time workers                 |   |        |        |       |        |
| NIU   | 12,873                                  | 35,620 | 12,343 | 8,513 | 71,585 |
| Usually FT - slack work/business conditions | 248                                     | 202    | 136    | 45    | 634    |
| Usually FT - seasonal work                  | 13                                      | 6      | 14     | 1     | 17     |
| Usually FT - job started/ended during week  | 6                                       | 9      | 3      | 2     | 19     |
| Usually FT - vacation/personal day          | 90                                      | 87     | 60     | 57    | 970    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                     | Insurance Coverage Type (GRP, DIR, PUB) |     |     |     |       |
|--|---|-----|-----|-----|-------|
|  | NNN                                     | NNY | NY_ | Y1Y | YNN   |
| Usually FT - own illness/injury/medical appt | 109                                     | 124 | 79  | 57  | 669   |
| Usually FT - holiday (religious or legal)    | 5                                       | 7   | 3   | 4   | 40    |
| Usually FT - child care problems             | 4                                       | 5   | 7   | 7   | 52    |
| Usually FT - other fam/pers obligations      | 32                                      | 25  | 20  | 17  | 206   |
| Usually FT - labor dispute                   | 2                                       | 1   | 0   | 0   | 4     |
| Usually FT - weather affected job            | 70                                      | 30  | 10  | 5   | 70    |
| Usually FT - school/training                 | 5                                       | 5   | 1   | 0   | 18    |
| Usually FT - civic/military duty             | 0                                       | 1   | 0   | 0   | 4     |
| Usually FT - other reason                    | 119                                     | 116 | 74  | 44  | 446   |
| Usually PT - slack work/business conditions  | 206                                     | 223 | 95  | 40  | 345   |
| Usually PT - PT could only find PT work      | 133                                     | 177 | 61  | 30  | 233   |
| Usually PT - seasonal work                   | 12                                      | 7   | 5   | 2   | 12    |
| Usually PT - child care problems             | 64                                      | 116 | 40  | 16  | 236   |
| Usually PT - other fam/pers obligations      | 271                                     | 343 | 248 | 111 | 1,221 |
| Usually PT - health/medical limitations      | 51                                      | 199 | 54  | 44  | 123   |
| Usually PT - school/training                 | 303                                     | 450 | 245 | 98  | 1,713 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--|---|--------|-------|-------|--------|
|  | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Usually PT - retired/social security limit on earnings | 52                                      | 440    | 350   | 238   | 228    |
| Usually PT - workweek<35 hours                         | 260                                     | 407    | 251   | 106   | 952    |
| Usually PT - other                                     | 107                                     | 145    | 142   | 58    | 368    |
| PRWKSTAT: Full/part-time work status                   |   |        |       |       |        |
| Universe: All persons                                  |   |        |       |       |        |
| NIU  | 2,849                                   | 10,183 | 1,494 | 1,161 | 17,734 |
| Not in labor force                                     | 3,949                                   | 20,283 | 7,002 | 4,799 | 11,854 |
| FT hours (35+), usually FT                             | 4,995                                   | 3,679  | 3,226 | 2,189 | 38,324 |
| PT for economic reasons, usually FT                    | 267                                     | 217    | 153   | 48    | 670    |
| PT for non-economic reasons, usually FT                | 436                                     | 401    | 254   | 191   | 2,479  |
| Not at work, usually FT                                | 227                                     | 238    | 179   | 105   | 1,389  |
| PT hrs, usually PT for economic reasons                | 324                                     | 377    | 140   | 68    | 531    |
| PT hrs, usually PT for non-economic                    | 1,099                                   | 2,080  | 1,308 | 662   | 4,732  |
| FT hours, usually PT for economic reasons              | 17                                      | 16     | 12    | 1     | 29     |
| FT hours, usually PT for non-economic reasons          | 40                                      | 56     | 43    | 22    | 192    |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                   | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--|---|--------|-------|-------|--------|
|  | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Not at work, usually part-time             | 101                                     | 233    | 156   | 56    | 525    |
| Unemployed FT                              | 618                                     | 722    | 197   | 136   | 1,316  |
| Unemployed PT                              | 113                                     | 260    | 77    | 57    | 390    |
| CLWK: Longest job class of worker (recode) |   |        |       |       |        |
| Universe: All persons aged 15+             |   |        |       |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488 | 1,160 | 17,629 |
| Private                                    | 6,959                                   | 7,099  | 4,733 | 3,023 | 41,294 |
| Government                                 | 1,009                                   | 747    | 446   | 710   | 9,436  |
| Self-employed                              | 849                                     | 992    | 1,008 | 253   | 1,614  |
| Without pay                                | 17                                      | 12     | 15    | 1     | 15     |
| Never worked                               | 3,770                                   | 19,728 | 6,551 | 4,348 | 10,177 |
| EARNER: Earner status recode               |   |        |       |       |        |
| Universe: All persons aged 15+             |   |        |       |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488 | 1,160 | 17,629 |
| Earner                                     | 8,821                                   | 8,842  | 6,188 | 3,986 | 52,346 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|---|---|--------|-------|-------|--------|
|   | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Nonearner   | 3,783                                   | 19,736 | 6,565 | 4,349 | 10,190 |
| HRSWK: In the weeks that ... worked how many hours did ... usually work per week? |   |        |       |       |        |
| Universe: WKSWORK > 0   |   |        |       |       |        |
| (-0.099, 9.9]   | 6,347                                   | 30,317 | 8,296 | 5,648 | 28,472 |
| (9.9, 19.8]   | 354                                     | 837    | 443   | 259   | 1,576  |
| (19.8, 29.7]  | 875                                     | 1,550  | 858   | 390   | 2,922  |
| (29.7, 39.6]  | 1,277                                   | 1,534  | 847   | 486   | 4,780  |
| (39.6, 49.5]  | 5,110                                   | 3,719  | 2,826 | 2,191 | 34,221 |
| (49.5, 59.4]  | 673                                     | 461    | 578   | 336   | 5,584  |
| (59.4, 69.3]  | 276                                     | 228    | 263   | 122   | 1,929  |
| (69.3, 79.2]  | 77                                      | 48     | 74    | 33    | 383    |
| (79.2, 89.1]  | 41                                      | 33     | 33    | 20    | 222    |
| (89.1, 99.0]  | 5                                       | 18     | 23    | 10    | 76     |
| LJCW: Longest job class of worker   |   |        |       |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Universe: WKSWORK > 0  |   |        |        |       |        |
| Niu  | 6,201                                   | 29,895 | 8,039  | 5,508 | 27,806 |
| Private  | 6,640                                   | 6,757  | 3,950  | 2,866 | 40,016 |
| Federal  | 569                                     | 142    | 63     | 152   | 1,842  |
| State  | 208                                     | 249    | 160    | 236   | 3,440  |
| Local  | 232                                     | 356    | 223    | 322   | 4,154  |
| Self employed incorporated, yes  | 319                                     | 342    | 783    | 157   | 1,278  |
| Self employed incorporated, no or farm                                 | 849                                     | 992    | 1,008  | 253   | 1,614  |
| Without pay  | 17                                      | 12     | 15     | 1     | 15     |
| NWLKWK: How may different weeks was ... looking for work or on layoff? |   |        |        |       |        |
| Universe: NWLOOK = 1   |   |        |        |       |        |
| (-0.052, 5.2]  | 14,892                                  | 38,462 | 14,188 | 9,469 | 79,995 |
| (5.2, 10.4]  | 15                                      | 32     | 7      | 6     | 38     |
| (10.4, 15.6]   | 13                                      | 29     | 4      | 0     | 17     |
| (15.6, 20.8]   | 7                                       | 17     | 4      | 2     | 9      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--|---|--------|-------|-------|--------|
|  | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| (20.8, 26.0]   | 14                                      | 22     | 5     | 4     | 23     |
| (26.0, 31.2]   | 3                                       | 7      | 1     | 0     | 2      |
| (31.2, 36.4]   | 3                                       | 7      | 0     | 0     | 1      |
| (36.4, 41.6]   | 6                                       | 17     | 1     | 1     | 5      |
| (41.6, 46.8]   | 4                                       | 3      | 1     | 0     | 1      |
| (46.8, 52.0]   | 78                                      | 149    | 30    | 13    | 74     |
| NWLOOK: Even though ... did not work in 20.. did spend and time trying to find a job or on layoff?<br>Universe: WORKYN = 2                   |   |        |       |       |        |
| Niu  | 11,265                                  | 19,017 | 7,690 | 5,147 | 69,988 |
| Yes  | 176                                     | 340    | 70    | 41    | 236    |
| No   | 3,594                                   | 19,388 | 6,481 | 4,307 | 9,941  |
| PHMEMPRS: For how many employers did ... work in 20..? if more than one at same time, only count it as one employer<br>Universe: WKSWORK > 0 |   |        |       |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|---|---|--------|-------|-------|--------|
|   | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Niu   | 6,201                                   | 29,895 | 8,039 | 5,508 | 27,806 |
| One employer  | 7,684                                   | 7,738  | 5,537 | 3,439 | 47,029 |
| Two employers   | 857                                     | 848    | 535   | 439   | 4,433  |
| 3 or more employers   | 293                                     | 264    | 130   | 109   | 897    |
| RSNNOTW: What was the main reason ... did not work in 20..? |   |        |       |       |        |
| Universe: WORKYN = 2  |   |        |       |       |        |
| Niu   | 11,265                                  | 19,017 | 7,690 | 5,147 | 69,988 |
| Ill or disabled   | 508                                     | 4,721  | 503   | 449   | 681    |
| Retired   | 477                                     | 10,319 | 4,709 | 3,378 | 1,425  |
| Taking care of home   | 1,331                                   | 1,690  | 562   | 231   | 2,816  |
| Going to school   | 1,043                                   | 2,510  | 658   | 254   | 4,901  |
| Could not find work   | 209                                     | 286    | 39    | 21    | 147    |
| Other   | 202                                     | 202    | 80    | 15    | 207    |
| WECLW: Longest job class of worker (persons 15+)            |   |        |       |       |        |
| Universe: All persons aged 15+                              |   |        |       |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                           | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|------------------------------------|---|--------|-------|-------|--------|
|                                    | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Not in universe                    | 2,431                                   | 10,167 | 1,488 | 1,160 | 17,629 |
| Agriculture (Wage and salary)      | 220                                     | 198    | 181   | 60    | 482    |
| Agriculture (Self-employed)        | 51                                      | 58     | 120   | 32    | 106    |
| Agriculture (Unpaid)               | 7                                       | 3      | 2     | 0     | 4      |
| Nonagriculture (Private household) | 100                                     | 138    | 60    | 18    | 133    |
| Nonagriculture (Other private)     | 6,338                                   | 6,452  | 3,776 | 2,801 | 39,483 |
| Nonagriculture (Government)        | 1,006                                   | 742    | 444   | 708   | 9,407  |
| Nonagriculture (Self-employed)     | 1,102                                   | 1,250  | 1,606 | 367   | 2,733  |
| Nonagriculture (Unpaid)            | 10                                      | 9      | 13    | 1     | 11     |
| Nonagriculture (Never worked)      | 3,770                                   | 19,728 | 6,551 | 4,348 | 10,177 |

WEWKRS: Weeks worked recode

Universe: All persons aged 15+

Niu

Full-year worker (Full time)

Full-year worker (Part time)

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                     | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|------------------------------|---|--------|-------|-------|--------|
|                              | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Part-year worker (Full time) | 1,259                                   | 1,434  | 695   | 716   | 4,156  |
| Part-year worker (Part time) | 907                                     | 1,757  | 893   | 491   | 3,308  |
| Part-year worker (Nonworker) | 3,770                                   | 19,728 | 6,551 | 4,348 | 10,177 |

WKSWORK: During 20.. in how many weeks did ... work even for a few hours?  
(include paid vacation and sick leave as work)

Universe: Persons 15+ with WORKYN = 1

|               |       |        |       |       |        |
|---------------|-------|--------|-------|-------|--------|
| (-0.052, 5.2] | 6,329 | 30,179 | 8,164 | 5,588 | 28,130 |
| (5.2, 10.4]   | 147   | 315    | 110   | 98    | 626    |
| (10.4, 15.6]  | 180   | 343    | 147   | 104   | 716    |
| (15.6, 20.8]  | 229   | 363    | 147   | 131   | 748    |
| (20.8, 26.0]  | 318   | 518    | 218   | 197   | 926    |
| (26.0, 31.2]  | 184   | 242    | 117   | 79    | 493    |
| (31.2, 36.4]  | 235   | 266    | 155   | 111   | 733    |
| (36.4, 41.6]  | 300   | 342    | 242   | 163   | 1,138  |
| (41.6, 46.8]  | 267   | 292    | 165   | 126   | 986    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|---|---|--------|-------|-------|--------|
|   | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| (46.8, 52.0]  | 6,846                                   | 5,885  | 4,776 | 2,898 | 45,669 |
| WORKYN: Did ... work at a job or business at any time during 20..?                            |   |        |       |       |        |
| Universe: All persons aged 15+  |   |        |       |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488 | 1,160 | 17,629 |
| Yes   | 8,727                                   | 8,684  | 6,108 | 3,938 | 52,062 |
| No  | 3,877                                   | 19,894 | 6,645 | 4,397 | 10,474 |
| WRK_CK: Worked last year recode, including temporary and part-time                            |   |        |       |       |        |
| Universe: All persons aged 15+  |   |        |       |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488 | 1,160 | 17,629 |
| Yes   | 8,834                                   | 8,850  | 6,202 | 3,987 | 52,359 |
| No  | 3,770                                   | 19,728 | 6,551 | 4,348 | 10,177 |
| WTEMP: Did ... do any temporary, part-time, or seasonal work even for a few days during 20..? |   |        |       |       |        |
| Universe: WORKYN = 2  |   |        |       |       |        |
| Niu   | 11,158                                  | 18,851 | 7,596 | 5,098 | 69,691 |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--|---|--------|-------|-------|--------|
|  | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| Yes  | 107                                     | 166    | 94    | 49    | 297    |
| No   | 3,770                                   | 19,728 | 6,551 | 4,348 | 10,177 |
| ERN_OTR: Wage and salary money earned from other work, Y/N |   |        |       |       |        |
| Universe: All persons aged 15+                             |   |        |       |       |        |
| Niu  | 6,201                                   | 29,895 | 8,039 | 5,508 | 27,806 |
| Yes  | 819                                     | 847    | 635   | 496   | 5,174  |
| No   | 8,015                                   | 8,003  | 5,567 | 3,491 | 47,185 |
| ERN_SRCE: Source of earnings from longest job              |   |        |       |       |        |
| Universe: ERN_YN = 1                                       |   |        |       |       |        |
| Niu  | 6,201                                   | 29,895 | 8,039 | 5,508 | 27,806 |
| Wage and salary  | 7,968                                   | 7,846  | 5,179 | 3,733 | 50,730 |
| Self employment  | 809                                     | 940    | 904   | 224   | 1,529  |
| Farm self employment                                       | 40                                      | 52     | 104   | 29    | 85     |
| Without pay  | 17                                      | 12     | 15    | 1     | 15     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| ERN_VAL: How much did ... earn from this employer before deductions in         |   |        |        |       |        |
| 20..? what was ... net earnings from this business/ farm after expenses during |   |        |        |       |        |
| 20..?  |   |        |        |       |        |
| Universe: ERN_YN = 1   |   |        |        |       |        |
| (-11108.998, 101000.8]   | 14,748                                  | 38,542 | 13,748 | 9,127 | 72,515 |
| (101000.8, 212000.6]   | 239                                     | 156    | 378    | 286   | 6,274  |
| (212000.6, 323000.4]   | 22                                      | 24     | 56     | 54    | 780    |
| (323000.4, 434000.2]   | 9                                       | 11     | 18     | 16    | 236    |
| (434000.2, 545000.0]   | 6                                       | 6      | 13     | 6     | 114    |
| (545000.0, 655999.8]   | 3                                       | 3      | 7      | 0     | 55     |
| (655999.8, 766999.6]   | 1                                       | 0      | 4      | 1     | 23     |
| (766999.6, 877999.4]   | 2                                       | 0      | 4      | 1     | 28     |
| (877999.4, 988999.2]   | 1                                       | 0      | 1      | 1     | 21     |
| (988999.2, 1099999.0]  | 4                                       | 3      | 12     | 3     | 119    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| ERN_YN: Earnings from employer or net earnings from business/ farm after expenses from longest job during 20.. ?<br>Universe: WORKYN=1 or WTEMP=1 |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes   | 8,817                                   | 8,838  | 6,187  | 3,986 | 52,344 |
| No  | 3,787                                   | 19,740 | 6,566  | 4,349 | 10,192 |
| FRM_VAL: Amount of farm self-employment earnings from secondary source<br>Universe: FRMOTR = 1  |   |        |        |       |        |
| (-10288.999, 19000.9]   | 15,028                                  | 38,744 | 14,230 | 9,484 | 80,131 |
| (19000.9, 48000.8]  | 3                                       | 1      | 7      | 3     | 25     |
| (48000.8, 77000.7]  | 3                                       | 0      | 0      | 5     | 7      |
| (77000.7, 106000.6]   | 1                                       | 0      | 4      | 3     | 1      |
| (251000.1, 280000.0]  | 0                                       | 0      | 0      | 0     | 1      |
| FRMOTR: Receiving farm self-employment from secondary source<br>Universe: ERN_OTR = 1   |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Niu   | 14,212                                  | 37,902 | 13,606 | 9,002 | 75,001 |
| Yes   | 86                                      | 56     | 73     | 43    | 478    |
| No  | 737                                     | 787    | 562    | 450   | 4,686  |
| FRSE_VAL: Total amount of farm self-employment earnings |   |        |        |       |        |
| Universe: ERN_YN=1 or FRMOTR=1                          |   |        |        |       |        |
| (-20767.998, 57001.8]                                   | 15,029                                  | 38,739 | 14,206 | 9,483 | 80,136 |
| (57001.8, 134001.6]                                     | 6                                       | 5      | 29     | 10    | 25     |
| (134001.6, 211001.4]                                    | 0                                       | 1      | 2      | 0     | 3      |
| (211001.4, 288001.2]                                    | 0                                       | 0      | 3      | 1     | 1      |
| (442000.8, 519000.6]                                    | 0                                       | 0      | 0      | 1     | 0      |
| (673000.2, 750000.0]                                    | 0                                       | 0      | 1      | 0     | 0      |
| FRSE_YN: Receiving any farm self-employment             |   |        |        |       |        |
| Universe: ERN_YN=1 or FRMOTR=1                          |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes   | 122                                     | 105    | 170    | 70    | 560    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                          | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|-----------------------------------|---|--------|--------|-------|--------|
|                                   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| No                                | 12,482                                  | 28,473 | 12,583 | 8,265 | 61,976 |
| PEARINVAL: Total persons earnings |   |        |        |       |        |
| Universe: All persons aged 15+    |   |        |        |       |        |
| (-12083.998, 198500.8]            | 14,962                                  | 38,669 | 14,069 | 9,370 | 78,229 |
| (198500.8, 407000.6]              | 53                                      | 62     | 126    | 111   | 1,506  |
| (407000.6, 615500.4]              | 11                                      | 11     | 22     | 8     | 220    |
| (615500.4, 824000.2]              | 3                                       | 0      | 10     | 2     | 53     |
| (824000.2, 1032500.0]             | 3                                       | 2      | 5      | 3     | 62     |
| (1032500.0, 1240999.8]            | 3                                       | 1      | 8      | 1     | 93     |
| (1240999.8, 1449499.6]            | 0                                       | 0      | 1      | 0     | 0      |
| (1449499.6, 1657999.4]            | 0                                       | 0      | 0      | 0     | 1      |
| (1866499.2, 2074999.0]            | 0                                       | 0      | 0      | 0     | 1      |

SE\_VAL: Amount of own business self-employment earnings from secondary source

Universe: SEOTR = 1

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable              | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|-----------------------|---|--------|--------|-------|--------|
|                       | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (-10558.999, 46000.9] | 15,027                                  | 38,736 | 14,220 | 9,484 | 80,099 |
| (46000.9, 102000.8]   | 8                                       | 7      | 14     | 6     | 45     |
| (102000.8, 158000.7]  | 0                                       | 2      | 5      | 2     | 6      |
| (158000.7, 214000.6]  | 0                                       | 0      | 0      | 2     | 4      |
| (214000.6, 270000.5]  | 0                                       | 0      | 0      | 1     | 1      |
| (270000.5, 326000.4]  | 0                                       | 0      | 2      | 0     | 5      |
| (326000.4, 382000.3]  | 0                                       | 0      | 0      | 0     | 3      |
| (382000.3, 438000.2]  | 0                                       | 0      | 0      | 0     | 1      |
| (494000.1, 550000.0]  | 0                                       | 0      | 0      | 0     | 1      |

SEMP\_VAL: Total own business self-employment earnings (combined amounts in ern-val, if ern-srce=2, and se-val)

Universe: ERN\_YN=1 or SEOTR=1

|                       |        |        |        |       |        |
|-----------------------|--------|--------|--------|-------|--------|
| (-21117.997, 92001.7] | 14,989 | 38,698 | 14,106 | 9,464 | 79,943 |
| (92001.7, 204001.4]   | 39     | 41     | 111    | 24    | 179    |
| (204001.4, 316001.1]  | 2      | 3      | 15     | 4     | 20     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (316001.1, 428000.8]                                 | 0                                       | 2      | 2      | 2     | 11     |
| (428000.8, 540000.5]                                 | 3                                       | 1      | 2      | 1     | 4      |
| (540000.5, 652000.2]                                 | 0                                       | 0      | 1      | 0     | 2      |
| (652000.2, 763999.9]                                 | 0                                       | 0      | 1      | 0     | 2      |
| (763999.9, 875999.6]                                 | 0                                       | 0      | 1      | 0     | 1      |
| (987999.3, 1099999.0]                                | 2                                       | 0      | 2      | 0     | 3      |
| SEMP_YN: Receiving own business self-employment, y/n |   |        |        |       |        |
| Universe: ERN_YN=1 or SEOTR=1                        |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 942                                     | 1,075  | 1,061  | 320   | 2,577  |
| No   | 11,662                                  | 27,503 | 11,692 | 8,015 | 59,959 |
| SEOTR: Receiving own business self-employment, y/n   |   |        |        |       |        |
| Universe: ERN_YN=1 or SEOTR=1                        |   |        |        |       |        |
| Niu  | 14,214                                  | 37,904 | 13,607 | 9,000 | 74,996 |
| Yes  | 148                                     | 149    | 171    | 101   | 1,077  |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| No  | 673                                     | 692    | 463    | 394   | 4,092  |
| WAGEOTR: Receiving wage and salary earnings from other employers, y/n |   |        |        |       |        |
| Universe: ERN_OTR = 1   |   |        |        |       |        |
| Niu   | 14,218                                  | 37,901 | 13,607 | 9,002 | 74,994 |
| Yes   | 786                                     | 807    | 590    | 471   | 4,927  |
| No  | 31                                      | 37     | 44     | 22    | 244    |
| WS_VAL: Amount of wage and salary earnings from other employers       |   |        |        |       |        |
| Universe: ERN_OTR = 1   |   |        |        |       |        |
| (-1099.999, 109999.9]   | 15,033                                  | 38,738 | 14,235 | 9,491 | 80,092 |
| (109999.9, 219999.8]  | 1                                       | 7      | 5      | 3     | 59     |
| (219999.8, 329999.7]  | 1                                       | 0      | 1      | 1     | 3      |
| (329999.7, 439999.6]  | 0                                       | 0      | 0      | 0     | 5      |
| (439999.6, 549999.5]  | 0                                       | 0      | 0      | 0     | 1      |
| (879999.2, 989999.1]  | 0                                       | 0      | 0      | 0     | 3      |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (989999.1, 1099999.0]   | 0                                       | 0      | 0      | 0     | 2      |
| WSAL_VAL: Total wage and salary earnings (combined amounts in ern-val, if ern-srce=1, and ws-val) |   |        |        |       |        |
| Universe: ERN_YN=1 or WAGEOTR=1   |   |        |        |       |        |
| (-1999.999, 199999.9]   | 14,976                                  | 38,684 | 14,113 | 9,393 | 78,320 |
| (199999.9, 399999.8]  | 38                                      | 44     | 85     | 87    | 1,377  |
| (399999.8, 599999.7]  | 13                                      | 13     | 25     | 9     | 247    |
| (599999.7, 799999.6]  | 3                                       | 1      | 4      | 1     | 56     |
| (799999.6, 999999.5]  | 3                                       | 0      | 4      | 2     | 49     |
| (999999.5, 1199999.4]   | 2                                       | 3      | 10     | 3     | 114    |
| (1199999.4, 1399999.3]  | 0                                       | 0      | 0      | 0     | 1      |
| (1799999.1, 1999999.0]  | 0                                       | 0      | 0      | 0     | 1      |
| WSAL_YN: Receiving wage and salary earnings   |   |        |        |       |        |
| Universe: ERN_YN=1 or WAGEOTR=1   |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                     | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Yes  | 8,025                                   | 7,920  | 5,259  | 3,764 | 50,886 |
| No   | 4,579                                   | 20,658 | 7,494  | 4,571 | 11,650 |
| ANN_VAL: Retirement income, annuities amount |   |        |        |       |        |
| Universe: ANN_YN = 1                         |   |        |        |       |        |
| (-396.0, 39600.0]                            | 15,030                                  | 38,705 | 14,208 | 9,456 | 80,136 |
| (39600.0, 79200.0]                           | 4                                       | 28     | 23     | 34    | 18     |
| (79200.0, 118800.0]                          | 1                                       | 7      | 6      | 3     | 8      |
| (118800.0, 158400.0]                         | 0                                       | 3      | 2      | 0     | 2      |
| (158400.0, 198000.0]                         | 0                                       | 2      | 0      | 1     | 0      |
| (356400.0, 396000.0]                         | 0                                       | 0      | 2      | 1     | 1      |
| ANN_YN: Retirement income, annuities, y/n    |   |        |        |       |        |
| Universe: All Persons aged 15+               |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 26                                      | 634    | 573    | 422   | 219    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| No  | 12,578                                  | 27,944 | 12,180 | 7,913 | 62,317 |
| CAP_VAL: Capital gains value  |   |        |        |       |        |
| Universe: CAP_YN = 1  |   |        |        |       |        |
| (-999.999, 99999.9]   | 15,031                                  | 38,725 | 14,211 | 9,473 | 80,085 |
| (99999.9, 199999.8]   | 2                                       | 13     | 16     | 16    | 35     |
| (199999.8, 299999.7]  | 2                                       | 6      | 6      | 5     | 24     |
| (299999.7, 399999.6]  | 0                                       | 1      | 3      | 0     | 9      |
| (399999.6, 499999.5]  | 0                                       | 0      | 1      | 0     | 3      |
| (499999.5, 599999.4]  | 0                                       | 0      | 1      | 1     | 0      |
| (699999.3, 799999.2]  | 0                                       | 0      | 1      | 0     | 7      |
| (899999.1, 999999.0]  | 0                                       | 0      | 2      | 0     | 2      |
| CAP_YN: Yes/no answer to âDid you receive capital gain from your shares of stock or mutual fund?' |   |        |        |       |        |
| Universe: DIV_YN = 1  |   |        |        |       |        |
| Niu   | 14,044                                  | 36,074 | 11,363 | 7,534 | 66,843 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Yes   | 176                                     | 734    | 958    | 693   | 3,176  |
| No  | 815                                     | 1,937  | 1,920  | 1,268 | 10,146 |
| DBTN_VAL: Total amount of retirement distributions received (dst_val1 + dst_val2) |   |        |        |       |        |
| Universe: DST_VAL1>0 OR DST_VAL2>0  |   |        |        |       |        |
| (-999.999, 99999.9]   | 15,033                                  | 38,711 | 14,203 | 9,460 | 80,139 |
| (99999.9, 199999.8]   | 2                                       | 32     | 35     | 32    | 23     |
| (199999.8, 299999.7]  | 0                                       | 2      | 2      | 1     | 2      |
| (299999.7, 399999.6]  | 0                                       | 0      | 0      | 1     | 0      |
| (399999.6, 499999.5]  | 0                                       | 0      | 1      | 0     | 1      |
| (899999.1, 999999.0]  | 0                                       | 0      | 0      | 1     | 0      |
| DIS_SC1: What was the source of disability income?                                |   |        |        |       |        |
| Universe: DIS_YN=1  |   |        |        |       |        |
| Niu   | 14,947                                  | 38,270 | 14,130 | 9,359 | 79,707 |
| Worker's compensation   | 16                                      | 32     | 11     | 15    | 96     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                 | Insurance Coverage Type (GRP, DIR, PUB) |     |     |     |     |
|--|---|-----|-----|-----|-----|
|  | NNN                                     | NNY | NY_ | Y1Y | YNN |
| Company or union disability              | 10                                      | 48  | 19  | 34  | 123 |
| Federal government disability            | 6                                       | 58  | 9   | 10  | 15  |
| Us military retirement disability        | 18                                      | 45  | 10  | 8   | 12  |
| State or local gov't employee disability | 14                                      | 92  | 21  | 25  | 56  |
| Us railroad retirement disability        | 0                                       | 6   | 2   | 0   | 1   |
| Accident or disability insurance         | 8                                       | 32  | 16  | 17  | 60  |
| Blacklung miners disability              | 0                                       | 0   | 0   | 1   | 0   |
| State temporary sickness                 | 3                                       | 1   | 2   | 1   | 9   |
| Other or don't know                      | 13                                      | 161 | 21  | 25  | 86  |

DIS\_SC2: What was the source of disability income?

Universe: DIS\_YN=1

|  |        |        |        |       |        |
|--|--------|--------|--------|-------|--------|
| Niu                                      | 15,035 | 38,740 | 14,240 | 9,493 | 80,158 |
| Federal government disability            | 0      | 0      | 1      | 0     | 0      |
| Us military retirement disability        | 0      | 1      | 0      | 0     | 0      |
| State or local gov't employee disability | 0      | 2      | 0      | 1     | 3      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Other or don't know  | 0                                       | 2      | 0      | 1     | 4      |
| DIS_VAL1: How much did ... receive (source type) during 20.. ? |   |        |        |       |        |
| Universe: DIS_SC1>0  |   |        |        |       |        |
| (-100.0, 10000.0]  | 14,993                                  | 38,533 | 14,185 | 9,428 | 80,005 |
| (10000.0, 20000.0]   | 26                                      | 144    | 25     | 31    | 78     |
| (20000.0, 30000.0]   | 7                                       | 33     | 16     | 23    | 40     |
| (30000.0, 40000.0]   | 4                                       | 13     | 4      | 4     | 15     |
| (40000.0, 50000.0]   | 3                                       | 10     | 1      | 2     | 11     |
| (50000.0, 60000.0]   | 1                                       | 0      | 0      | 1     | 1      |
| (60000.0, 70000.0]   | 1                                       | 1      | 1      | 0     | 1      |
| (70000.0, 80000.0]   | 0                                       | 1      | 1      | 1     | 4      |
| (80000.0, 90000.0]   | 0                                       | 1      | 0      | 1     | 0      |
| (90000.0, 100000.0]  | 0                                       | 9      | 8      | 4     | 10     |
| DIS_VAL2: How much did ... receive (source type) during 20.. ? |   |        |        |       |        |
| Universe: DIS_SC2>0  |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (-23.672, 2367.2]   | 15,035                                  | 38,740 | 14,240 | 9,493 | 80,158 |
| (4734.4, 7101.6]  | 0                                       | 1      | 0      | 0     | 4      |
| (7101.6, 9468.8]  | 0                                       | 0      | 0      | 0     | 1      |
| (11836.0, 14203.2]  | 0                                       | 0      | 0      | 0     | 1      |
| (14203.2, 16570.4]  | 0                                       | 3      | 1      | 2     | 0      |
| (21304.8, 23672.0]  | 0                                       | 1      | 0      | 0     | 1      |
| DIS_YN: Other than social security did ... receive any income in 20.. as a result of health problems? |   |        |        |       |        |
| Universe: All Persons aged 15+  |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes   | 88                                      | 475    | 111    | 136   | 458    |
| No  | 12,516                                  | 28,103 | 12,642 | 8,199 | 62,078 |
| DIV_VAL: How much did ... receive in dividends from stocks or mutual funds during 20.. ?              |   |        |        |       |        |
| Universe: DIV_YN = 1  |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (-999.999, 99999.9]  | 15,031                                  | 38,730 | 14,217 | 9,476 | 80,108 |
| (99999.9, 199999.8]  | 4                                       | 10     | 14     | 14    | 36     |
| (199999.8, 299999.7]   | 0                                       | 3      | 6      | 3     | 16     |
| (299999.7, 399999.6]   | 0                                       | 2      | 2      | 0     | 2      |
| (699999.3, 799999.2]   | 0                                       | 0      | 0      | 2     | 0      |
| (899999.1, 999999.0]   | 0                                       | 0      | 2      | 0     | 3      |
| DIV_YN: Did ... receive dividends?   |   |        |        |       |        |
| Universe: All Persons aged 15+   |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 583                                     | 1,873  | 2,246  | 1,575 | 8,875  |
| No   | 12,021                                  | 26,705 | 10,507 | 6,760 | 53,661 |
| DSAB_VAL: Total amount of disability income received, combined amounts in edited sources one and two |   |        |        |       |        |
| Universe: DIS_VAL1>0 OR DIS_VAL2>0   |   |        |        |       |        |
| (-100.0, 10000.0]  | 14,993                                  | 38,529 | 14,184 | 9,427 | 80,002 |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable            | Insurance Coverage Type (GRP, DIR, PUB) |     |     |     |     |
|---------------------|---|-----|-----|-----|-----|
|                     | NNN                                     | NNY | NY_ | Y1Y | YNN |
| (10000.0, 20000.0]  | 26                                      | 147 | 25  | 32  | 77  |
| (20000.0, 30000.0]  | 7                                       | 33  | 17  | 23  | 44  |
| (30000.0, 40000.0]  | 4                                       | 14  | 4   | 3   | 15  |
| (40000.0, 50000.0]  | 3                                       | 10  | 1   | 2   | 11  |
| (50000.0, 60000.0]  | 1                                       | 0   | 0   | 2   | 1   |
| (60000.0, 70000.0]  | 1                                       | 1   | 1   | 0   | 1   |
| (70000.0, 80000.0]  | 0                                       | 1   | 1   | 1   | 4   |
| (80000.0, 90000.0]  | 0                                       | 1   | 0   | 1   | 0   |
| (90000.0, 100000.0] | 0                                       | 9   | 8   | 4   | 10  |

DST\_SC1: Retirement income, distribution source 1

Universe: DST\_VAL1 > 0 and a\_age >= 58

|              |        |        |        |       |        |
|--------------|--------|--------|--------|-------|--------|
| Niu          | 14,982 | 37,052 | 12,699 | 8,267 | 79,685 |
| 401k account | 28     | 684    | 568    | 499   | 249    |
| 403b account | 0      | 49     | 39     | 48    | 20     |
| Roth ira     | 2      | 114    | 99     | 60    | 24     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Regular ira  | 17                                      | 739    | 715    | 499   | 115    |
| Keogh plan   | 0                                       | 1      | 3      | 3     | 1      |
| Sep plan (simplified employee pension)                             | 1                                       | 12     | 27     | 18    | 5      |
| Other type of retirement account                                   | 5                                       | 94     | 91     | 101   | 66     |
| DST_SC1_YNG: Retirement Distribution source 1, person under age 58 |   |        |        |       |        |
| Universe: DST_YN_YNG = 1 and a_age < 58                            |   |        |        |       |        |
| Niu  | 14,950                                  | 38,651 | 14,163 | 9,424 | 79,246 |
| 401k account   | 52                                      | 60     | 45     | 47    | 653    |
| 403b account   | 4                                       | 3      | 3      | 4     | 41     |
| Roth ira   | 13                                      | 11     | 5      | 7     | 66     |
| Regular ira  | 11                                      | 15     | 20     | 4     | 107    |
| Sep plan (simplified employee pension)                             | 0                                       | 1      | 1      | 0     | 3      |
| Other type of retirement account                                   | 5                                       | 4      | 4      | 9     | 49     |
| DST_SC2: Retirement income, distribution source 2                  |   |        |        |       |        |
| Universe: DST_VAL2 > 0 and a_age >= 58                             |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Niu  | 15,034                                  | 38,662 | 14,160 | 9,433 | 80,151 |
| 403b account   | 0                                       | 4      | 5      | 5     | 1      |
| Roth ira   | 1                                       | 12     | 12     | 6     | 3      |
| Regular ira  | 0                                       | 51     | 45     | 38    | 9      |
| Keogh plan   | 0                                       | 0      | 1      | 0     | 0      |
| Sep plan (simplified employee pension)                             | 0                                       | 3      | 2      | 3     | 0      |
| Other type of retirement account                                   | 0                                       | 13     | 16     | 10    | 1      |
| DST_SC2_YNG: Retirement Distribution source 2, person under age 58 |   |        |        |       |        |
| Universe: DST_VAL_YNG > 0 and a_age < 58                           |   |        |        |       |        |
| Niu  | 15,031                                  | 38,739 | 14,241 | 9,494 | 80,146 |
| 403b account   | 0                                       | 0      | 0      | 0     | 1      |
| Roth ira   | 2                                       | 2      | 0      | 1     | 9      |
| Regular ira  | 2                                       | 2      | 0      | 0     | 5      |
| Sep plan (simplified employee pension)                             | 0                                       | 2      | 0      | 0     | 3      |
| Other type of retirement account                                   | 0                                       | 0      | 0      | 0     | 1      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| DST_VAL1: Retirement income amount, distribution source 1    |   |        |        |       |        |
| Universe: DST_SC1 = 1  |   |        |        |       |        |
| (-999.999, 99999.9]  | 15,033                                  | 38,711 | 14,207 | 9,463 | 80,139 |
| (99999.9, 199999.8]  | 2                                       | 32     | 31     | 29    | 23     |
| (199999.8, 299999.7]   | 0                                       | 2      | 2      | 1     | 2      |
| (299999.7, 399999.6]   | 0                                       | 0      | 0      | 1     | 0      |
| (399999.6, 499999.5]   | 0                                       | 0      | 1      | 0     | 1      |
| (899999.1, 999999.0]   | 0                                       | 0      | 0      | 1     | 0      |
| DST_VAL1_YNG: Retirement Distribution amount 1, under age 58 |   |        |        |       |        |
| Universe: DST_SC1_YNG = 1                                    |   |        |        |       |        |
| (-999.999, 99999.9]  | 15,033                                  | 38,743 | 14,240 | 9,494 | 80,137 |
| (99999.9, 199999.8]  | 1                                       | 1      | 0      | 1     | 17     |
| (199999.8, 299999.7]   | 0                                       | 1      | 1      | 0     | 6      |
| (299999.7, 399999.6]   | 1                                       | 0      | 0      | 0     | 1      |
| (399999.6, 499999.5]   | 0                                       | 0      | 0      | 0     | 3      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (899999.1, 999999.0]   | 0                                       | 0      | 0      | 0     | 1      |
| DST_VAL2: Retirement income amount, distribution source 2    |   |        |        |       |        |
| Universe: DST_SC2 = 1  |   |        |        |       |        |
| (-75.0, 7500.0]  | 15,034                                  | 38,719 | 14,208 | 9,469 | 80,158 |
| (7500.0, 15000.0]  | 1                                       | 20     | 21     | 15    | 4      |
| (15000.0, 22500.0]   | 0                                       | 0      | 3      | 2     | 0      |
| (22500.0, 30000.0]   | 0                                       | 0      | 1      | 5     | 3      |
| (30000.0, 37500.0]   | 0                                       | 1      | 1      | 0     | 0      |
| (37500.0, 45000.0]   | 0                                       | 0      | 1      | 1     | 0      |
| (45000.0, 52500.0]   | 0                                       | 1      | 0      | 0     | 0      |
| (52500.0, 60000.0]   | 0                                       | 1      | 4      | 1     | 0      |
| (60000.0, 67500.0]   | 0                                       | 2      | 0      | 0     | 0      |
| (67500.0, 75000.0]   | 0                                       | 1      | 2      | 2     | 0      |
| DST_VAL2_YNG: Retirement Distribution amount 2, under age 58 |   |        |        |       |        |
| Universe: DST_SC2_YNG = 1                                    |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (-43.0, 4300.0]  | 15,032                                  | 38,742 | 14,241 | 9,494 | 80,157 |
| (4300.0, 8600.0]   | 2                                       | 1      | 0      | 1     | 4      |
| (8600.0, 12900.0]  | 0                                       | 1      | 0      | 0     | 1      |
| (21500.0, 25800.0]   | 0                                       | 0      | 0      | 0     | 1      |
| (30100.0, 34400.0]   | 0                                       | 1      | 0      | 0     | 2      |
| (38700.0, 43000.0]   | 1                                       | 0      | 0      | 0     | 0      |
| DST_YN: Retirement income distribution y/n                           |   |        |        |       |        |
| Universe: Persons aged 58 and over (a_age >= 58)                     |   |        |        |       |        |
| Niu  | 13,643                                  | 23,641 | 7,180  | 3,933 | 72,508 |
| Yes  | 53                                      | 1,693  | 1,543  | 1,228 | 480    |
| No   | 1,339                                   | 13,411 | 5,518  | 4,334 | 7,177  |
| DST_YN_YNG: Retirement Distribution Reciprocity, person under age 58 |   |        |        |       |        |
| Universe: Persons under age 58 (a_age < 58)                          |   |        |        |       |        |
| Niu  | 3,823                                   | 25,271 | 8,549  | 6,722 | 25,286 |
| Yes  | 85                                      | 94     | 78     | 71    | 919    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| No  | 11,127                                  | 13,380 | 5,614  | 2,702 | 53,960 |
| ED_VAL: Total amount of educational assistance received (combined amounts<br>in pell grant and other educational) assistance during 20.. ?<br>Universe: ED_YN = 1 |   |        |        |       |        |
| (-99,999, 9999.9]   | 14,940                                  | 38,640 | 14,141 | 9,451 | 79,622 |
| (9999.9, 19999.8]   | 62                                      | 73     | 50     | 21    | 289    |
| (19999.8, 29999.7]  | 20                                      | 17     | 26     | 10    | 141    |
| (29999.7, 39999.6]  | 7                                       | 8      | 9      | 9     | 59     |
| (39999.6, 49999.5]  | 2                                       | 2      | 2      | 1     | 28     |
| (49999.5, 59999.4]  | 4                                       | 2      | 5      | 2     | 16     |
| (59999.4, 69999.3]  | 0                                       | 1      | 4      | 0     | 3      |
| (69999.3, 79999.2]  | 0                                       | 0      | 0      | 0     | 2      |
| (79999.2, 89999.1]  | 0                                       | 2      | 2      | 0     | 3      |
| (89999.1, 99999.0]  | 0                                       | 0      | 2      | 1     | 2      |
| ED_YN: Did ... receive educational assistance?  |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Universe: All Persons aged 15+   |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 430                                     | 611    | 303    | 159   | 1,946  |
| No   | 12,174                                  | 27,967 | 12,450 | 8,176 | 60,590 |
| FIN_VAL: How much did ... receive in financial assistance income during 20.. |   |        |        |       |        |
| ?  |   |        |        |       |        |
| Universe: FIN_YN = 1   |   |        |        |       |        |
| (-500.0, 50000.0]  | 15,033                                  | 38,742 | 14,238 | 9,491 | 80,147 |
| (50000.0, 100000.0]  | 2                                       | 3      | 3      | 4     | 15     |
| (100000.0, 150000.0]   | 0                                       | 0      | 0      | 0     | 2      |
| (450000.0, 500000.0]   | 0                                       | 0      | 0      | 0     | 1      |
| FIN_YN: Did ... receive financial assistance?                                |   |        |        |       |        |
| Universe: All Persons aged 15+   |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 166                                     | 321    | 141    | 75    | 406    |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| No   | 12,438                                  | 28,257 | 12,612 | 8,260 | 62,130 |
| INT_VAL: Edited total combined interest income     |   |        |        |       |        |
| Universe: INT_YN = 1                               |   |        |        |       |        |
| (-280.0, 28000.0]                                  | 14,979                                  | 38,527 | 13,944 | 9,220 | 78,544 |
| (28000.0, 56000.0]                                 | 31                                      | 126    | 164    | 145   | 937    |
| (56000.0, 84000.0]                                 | 16                                      | 41     | 60     | 46    | 281    |
| (84000.0, 112000.0]                                | 7                                       | 45     | 66     | 73    | 354    |
| (112000.0, 140000.0]                               | 1                                       | 4      | 7      | 10    | 35     |
| (140000.0, 168000.0]                               | 1                                       | 1      | 0      | 0     | 11     |
| (168000.0, 196000.0]                               | 0                                       | 0      | 0      | 1     | 1      |
| (196000.0, 224000.0]                               | 0                                       | 1      | 0      | 0     | 1      |
| (252000.0, 280000.0]                               | 0                                       | 0      | 0      | 0     | 1      |
| INT_YN: Edited total combined interest income, y/n |   |        |        |       |        |
| Universe: All Persons aged 15+                     |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Yes  | 3,950                                   | 9,847  | 7,759  | 5,700 | 40,283 |
| No   | 8,654                                   | 18,731 | 4,994  | 2,635 | 22,253 |
| OED_TYP1: Source 1 other than gi bill received (OED_TYP1- source of other government assistance)     |   |        |        |       |        |
| Universe: ED_YN = 1  |   |        |        |       |        |
| Niu  | 14,584                                  | 38,089 | 13,928 | 9,331 | 78,173 |
| Yes  | 102                                     | 144    | 62     | 44    | 321    |
| No   | 349                                     | 512    | 251    | 120   | 1,671  |
| OED_TYP2: Source 2 other than gi bill received (OED_TYP2- scholarships, grants etc. from the school) |   |        |        |       |        |
| Universe: ED_YN = 1  |   |        |        |       |        |
| Niu  | 14,584                                  | 38,089 | 13,928 | 9,331 | 78,173 |
| Yes  | 146                                     | 211    | 153    | 61    | 986    |
| No   | 305                                     | 445    | 160    | 103   | 1,006  |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| OED_TYP3: Source other than gi bill received (OED_TYP3- other assistance<br>(employers friends, etc.)<br>Universe: ED_YN = 1 |   |        |        |       |        |
| Niu  | 14,584                                  | 38,089 | 13,928 | 9,331 | 78,173 |
| Yes  | 51                                      | 51     | 41     | 26    | 375    |
| No   | 400                                     | 605    | 272    | 138   | 1,617  |
| OI_OFF: Other income sources<br>Universe: OI_YN = 1  |   |        |        |       |        |
| Niu  | 14,824                                  | 38,368 | 14,077 | 9,332 | 79,115 |
| Social security  | 1                                       | 2      | 1      | 0     | 3      |
| Private pensions   | 0                                       | 5      | 3      | 3     | 5      |
| Afdc   | 6                                       | 6      | 3      | 0     | 13     |
| Other public assistance  | 0                                       | 2      | 0      | 1     | 5      |
| Dividends  | 0                                       | 1      | 0      | 0     | 0      |
| Rents or royalties   | 2                                       | 1      | 3      | 0     | 7      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| State disability payments (worker's comp)                                     | 1                                       | 1      | 0      | 1     | 1      |
| Disability payments (own insurance)   | 0                                       | 1      | 0      | 0     | 4      |
| Annuities or paid up insurance policies                                       | 1                                       | 1      | 1      | 0     | 2      |
| Anything else   | 192                                     | 330    | 137    | 150   | 969    |
| Alimony   | 8                                       | 27     | 16     | 8     | 41     |
| OI_VAL: How much did ... receive in other incomes                             |   |        |        |       |        |
| Universe: OI_YN = 1   |   |        |        |       |        |
| (-950.0, 95000.0]   | 15,033                                  | 38,744 | 14,240 | 9,488 | 80,149 |
| (95000.0, 190000.0]   | 2                                       | 0      | 1      | 5     | 12     |
| (190000.0, 285000.0]  | 0                                       | 0      | 0      | 1     | 0      |
| (285000.0, 380000.0]  | 0                                       | 1      | 0      | 0     | 1      |
| (380000.0, 475000.0]  | 0                                       | 0      | 0      | 1     | 1      |
| (475000.0, 570000.0]  | 0                                       | 0      | 0      | 0     | 1      |
| (855000.0, 950000.0]  | 0                                       | 0      | 0      | 0     | 1      |
| OI_YN: Did ... receive cash income not already covered from any other source? |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                     | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Universe: All Persons aged 15+               |   |        |        |       |        |
| None or niu                                  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 211                                     | 377    | 164    | 163   | 1,050  |
| No   | 12,393                                  | 28,201 | 12,589 | 8,172 | 61,486 |
| PEN_SC1: Retirement income, pension source 1 |   |        |        |       |        |
| Universe: PEN_YN = 1                         |   |        |        |       |        |
| Niu  | 14,862                                  | 36,035 | 12,394 | 7,307 | 79,002 |
| Company pension                              | 48                                      | 1,416  | 1,039  | 872   | 419    |
| Union pension                                | 15                                      | 264    | 176    | 183   | 94     |
| Federal government pension                   | 22                                      | 173    | 76     | 262   | 130    |
| State government pension                     | 21                                      | 524    | 397    | 643   | 336    |
| Local government pension                     | 10                                      | 162    | 84     | 168   | 129    |
| Us military pension                          | 56                                      | 118    | 15     | 15    | 35     |
| Us railroad retirement                       | 0                                       | 10     | 6      | 8     | 2      |
| Other  | 1                                       | 43     | 54     | 37    | 18     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| PEN_SC2: Retirement income, pension source 2         |   |        |        |       |        |
| Universe: PEN_VAL2 > 0                               |   |        |        |       |        |
| Niu  | 15,028                                  | 38,634 | 14,198 | 9,420 | 80,137 |
| Union pension  | 1                                       | 21     | 16     | 20    | 4      |
| Federal government pension                           | 0                                       | 8      | 3      | 6     | 1      |
| State government pension                             | 1                                       | 17     | 9      | 29    | 8      |
| Local government pension                             | 0                                       | 9      | 4      | 6     | 6      |
| Us military pension                                  | 5                                       | 49     | 5      | 11    | 7      |
| Us railroad retirement                               | 0                                       | 1      | 0      | 0     | 0      |
| Other  | 0                                       | 6      | 6      | 3     | 2      |
| PEN_VAL1: Retirement income amount, pension source 1 |   |        |        |       |        |
| Universe: PEN_SC1 > 0                                |   |        |        |       |        |
| (-999.999, 99999.9]                                  | 15,031                                  | 38,709 | 14,220 | 9,454 | 80,129 |
| (99999.9, 199999.8]                                  | 4                                       | 21     | 16     | 33    | 27     |
| (199999.8, 299999.7]                                 | 0                                       | 3      | 1      | 3     | 3      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (299999.7, 399999.6]                                 | 0                                       | 3      | 1      | 1     | 1      |
| (399999.6, 499999.5]                                 | 0                                       | 3      | 1      | 0     | 2      |
| (599999.4, 699999.3]                                 | 0                                       | 2      | 0      | 0     | 0      |
| (699999.3, 799999.2]                                 | 0                                       | 1      | 0      | 0     | 0      |
| (899999.1, 999999.0]                                 | 0                                       | 3      | 2      | 4     | 3      |
| PEN_VAL2: Retirement income amount, pension source 2 |   |        |        |       |        |
| Universe: PEN_SC2 > 0                                |   |        |        |       |        |
| (-360.0, 36000.0]                                    | 15,033                                  | 38,737 | 14,239 | 9,485 | 80,158 |
| (36000.0, 72000.0]                                   | 1                                       | 6      | 1      | 7     | 6      |
| (72000.0, 108000.0]                                  | 1                                       | 1      | 1      | 2     | 1      |
| (108000.0, 144000.0]                                 | 0                                       | 0      | 0      | 1     | 0      |
| (324000.0, 360000.0]                                 | 0                                       | 1      | 0      | 0     | 0      |

PEN\_YN: Retirement income, pension y/n

Universe: All Persons aged 15+

Niu

2,431    10,167    1,488    1,160    17,629

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Yes   | 173                                     | 2,710  | 1,847  | 2,188 | 1,163  |
| No  | 12,431                                  | 25,868 | 10,906 | 6,147 | 61,373 |
| PNSN_VAL: Total combined amount of pension income received from all pension sources |   |        |        |       |        |
| Universe: PEN_YN = 1  |   |        |        |       |        |
| (-999.999, 99999.9]   | 15,030                                  | 38,707 | 14,219 | 9,451 | 80,125 |
| (99999.9, 199999.8]   | 5                                       | 22     | 17     | 36    | 31     |
| (199999.8, 299999.7]  | 0                                       | 3      | 1      | 3     | 3      |
| (299999.7, 399999.6]  | 0                                       | 4      | 1      | 1     | 1      |
| (399999.6, 499999.5]  | 0                                       | 3      | 1      | 0     | 2      |
| (599999.4, 699999.3]  | 0                                       | 2      | 0      | 0     | 0      |
| (699999.3, 799999.2]  | 0                                       | 1      | 0      | 0     | 0      |
| (899999.1, 999999.0]  | 0                                       | 3      | 2      | 4     | 3      |
| PTOTVAL: Total persons income   |   |        |        |       |        |
| Universe: All Persons aged 15+  |   |        |        |       |        |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable               | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|------------------------|---|--------|--------|-------|--------|
|                        | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (-12094.703, 199571.3] | 14,933                                  | 38,563 | 13,963 | 9,239 | 77,720 |
| (199571.3, 409141.6]   | 78                                      | 150    | 209    | 217   | 1,918  |
| (409141.6, 618711.9]   | 13                                      | 21     | 35     | 24    | 282    |
| (618711.9, 828282.2]   | 5                                       | 5      | 14     | 3     | 74     |
| (828282.2, 1037852.5]  | 3                                       | 4      | 4      | 7     | 60     |
| (1037852.5, 1247422.8] | 3                                       | 2      | 13     | 5     | 100    |
| (1247422.8, 1456993.1] | 0                                       | 0      | 2      | 0     | 8      |
| (1456993.1, 1666563.4] | 0                                       | 0      | 0      | 0     | 1      |
| (1876133.7, 2085704.0] | 0                                       | 0      | 1      | 0     | 2      |

RESNSSI: What were the reasons (you/name) (was/were) getting Social

Security Income last year?

Universe: SS\_YN = 1

Niu

Retired

Disabled (adult or child)

|        |        |       |       |        |
|--------|--------|-------|-------|--------|
| 14,638 | 25,268 | 8,599 | 5,024 | 78,937 |
| 195    | 10,639 | 5,128 | 3,924 | 693    |
| 138    | 2,272  | 280   | 266   | 293    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Widowed  | 25                                      | 208    | 93     | 57    | 51     |
| Spouse   | 4                                       | 89     | 39     | 45    | 9      |
| Surviving child  | 16                                      | 54     | 11     | 18    | 77     |
| Dependent child  | 9                                       | 59     | 12     | 7     | 36     |
| On behalf of surviving, dependent, or disabled child(ren)                                      | 8                                       | 61     | 6      | 10    | 51     |
| Other (adult or child)   | 2                                       | 95     | 73     | 144   | 18     |
| RESNSS2: What were the reasons (you/name) (was/were) getting Social Security Income last year? |   |        |        |       |        |
| Universe: SS_YN = 1  |   |        |        |       |        |
| Niu  | 15,018                                  | 38,345 | 14,129 | 9,409 | 80,099 |
| Disabled (adult or child)  | 2                                       | 164    | 28     | 20    | 7      |
| Widowed  | 0                                       | 103    | 50     | 31    | 3      |
| Spouse   | 3                                       | 20     | 4      | 4     | 3      |
| Surviving child  | 0                                       | 5      | 2      | 0     | 3      |
| Dependent child  | 0                                       | 4      | 0      | 0     | 2      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| On behalf of surviving, dependent, or disabled child(ren)  | 11                                      | 89     | 22     | 21    | 47     |
| Other (adult or child)   | 1                                       | 15     | 6      | 10    | 1      |
| RESNSSI1: What were the reasons (you/name) (was/were) getting Supplemental Security Income last year?<br>Universe: SSI_YN = 1<br>Niu | 14,976                                  | 36,504 | 14,140 | 9,303 | 80,055 |
| Disabled (adult or child)  | 39                                      | 1,992  | 77     | 159   | 66     |
| Blind (adult or child)   | 0                                       | 25     | 2      | 1     | 2      |
| On behalf of a disabled child  | 16                                      | 58     | 6      | 10    | 25     |
| On behalf of a blind child   | 0                                       | 2      | 0      | 0     | 1      |
| Other (adult or child)   | 4                                       | 164    | 16     | 22    | 16     |
| RESNSSI2: What were the reasons (you/name) (was/were) getting Supplemental Security Income last year?<br>Universe: SSI_YN = 1<br>Niu | 15,031                                  | 38,715 | 14,240 | 9,493 | 80,162 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Blind (adult or child)                     | 0                                       | 5      | 0      | 0     | 0      |
| On behalf of a disabled child              | 2                                       | 14     | 0      | 1     | 1      |
| Other (adult or child)                     | 2                                       | 11     | 1      | 1     | 2      |
| RETCB_VAL: Retirement contribution, amount |   |        |        |       |        |
| Universe: RETCB_YN = 1                     |   |        |        |       |        |
| (-32.0, 3200.0]                            | 14,564                                  | 38,456 | 13,704 | 8,916 | 67,888 |
| (3200.0, 6400.0]                           | 256                                     | 114    | 243    | 252   | 5,011  |
| (6400.0, 9600.0]                           | 63                                      | 60     | 116    | 117   | 2,102  |
| (9600.0, 12800.0]                          | 62                                      | 47     | 52     | 56    | 1,625  |
| (12800.0, 16000.0]                         | 31                                      | 18     | 22     | 30    | 945    |
| (16000.0, 19200.0]                         | 37                                      | 10     | 50     | 46    | 1,617  |
| (19200.0, 22400.0]                         | 10                                      | 17     | 18     | 23    | 279    |
| (22400.0, 25600.0]                         | 12                                      | 20     | 32     | 48    | 632    |
| (25600.0, 28800.0]                         | 0                                       | 0      | 0      | 2     | 22     |
| (28800.0, 32000.0]                         | 0                                       | 3      | 4      | 5     | 44     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                       | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| RETCB_YN: Retirement contribution, y/n         |   |        |        |       |        |
| Universe: All people 15 years and over         |   |        |        |       |        |
| Niu  | 13,470                                  | 34,901 | 10,249 | 6,228 | 53,437 |
| Yes  | 1,034                                   | 793    | 1,070  | 1,247 | 21,810 |
| No   | 531                                     | 3,051  | 2,922  | 2,020 | 4,918  |
| RINT_SC1: Interest income, retirement source 1 |   |        |        |       |        |
| Universe: RINT_YN = 1                          |   |        |        |       |        |
| Niu  | 13,470                                  | 34,901 | 10,249 | 6,228 | 53,437 |
| 401k account                                   | 973                                     | 1,925  | 1,791  | 1,791 | 19,885 |
| 403b account                                   | 60                                      | 121    | 118    | 188   | 2,112  |
| Roth ira                                       | 216                                     | 421    | 583    | 292   | 1,465  |
| Regular ira                                    | 163                                     | 1,063  | 1,207  | 711   | 1,239  |
| Keogh plan                                     | 0                                       | 5      | 11     | 4     | 23     |
| Sep plan (simplified employee pension)         | 19                                      | 49     | 98     | 43    | 305    |
| Other type of retirement account               | 134                                     | 260    | 184    | 238   | 1,699  |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| RINT_SC2: Interest income, retirement source 2      |   |        |        |       |        |
| Universe: RINT_YN = 1                               |   |        |        |       |        |
| Niu   | 14,818                                  | 38,284 | 13,614 | 8,981 | 75,781 |
| 403b account  | 10                                      | 27     | 23     | 34    | 351    |
| Roth ira  | 92                                      | 113    | 154    | 163   | 2,018  |
| Regular ira   | 65                                      | 255    | 342    | 228   | 1,284  |
| Keogh plan  | 0                                       | 1      | 6      | 0     | 10     |
| Sep plan (simplified employee pension)              | 7                                       | 16     | 48     | 18    | 162    |
| Other type of retirement account                    | 43                                      | 49     | 54     | 71    | 559    |
| RINT_VAL1: Interest income amt, retirement source 1 |   |        |        |       |        |
| Universe: RINT_SC1 > 0                              |   |        |        |       |        |
| (-100.0, 10000.0]                                   | 14,936                                  | 38,372 | 13,795 | 9,102 | 77,436 |
| (10000.0, 20000.0]                                  | 51                                      | 173    | 178    | 147   | 1,160  |
| (20000.0, 30000.0]                                  | 17                                      | 60     | 86     | 68    | 496    |
| (30000.0, 40000.0]                                  | 9                                       | 45     | 56     | 40    | 274    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (40000.0, 50000.0]                                  | 6                                       | 28     | 43     | 46    | 287    |
| (50000.0, 60000.0]                                  | 3                                       | 5      | 16     | 7     | 85     |
| (60000.0, 70000.0]                                  | 3                                       | 9      | 12     | 10    | 75     |
| (70000.0, 80000.0]                                  | 5                                       | 13     | 9      | 17    | 71     |
| (80000.0, 90000.0]                                  | 0                                       | 2      | 6      | 4     | 26     |
| (90000.0, 100000.0]                                 | 5                                       | 38     | 40     | 54    | 255    |
| RINT_VAL2: Interest income amt, retirement source 2 |   |        |        |       |        |
| Universe: RINT_SC2 > 0                              |   |        |        |       |        |
| (-100.0, 10000.0]                                   | 15,015                                  | 38,701 | 14,182 | 9,431 | 79,816 |
| (10000.0, 20000.0]                                  | 9                                       | 14     | 22     | 25    | 140    |
| (20000.0, 30000.0]                                  | 0                                       | 13     | 14     | 16    | 44     |
| (30000.0, 40000.0]                                  | 2                                       | 2      | 2      | 4     | 39     |
| (40000.0, 50000.0]                                  | 3                                       | 6      | 7      | 3     | 15     |
| (50000.0, 60000.0]                                  | 2                                       | 2      | 1      | 3     | 11     |
| (60000.0, 70000.0]                                  | 1                                       | 0      | 1      | 1     | 14     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (70000.0, 80000.0]  | 0                                       | 2      | 2      | 3     | 12     |
| (80000.0, 90000.0]  | 0                                       | 0      | 1      | 0     | 9      |
| (90000.0, 100000.0]   | 3                                       | 5      | 9      | 9     | 65     |
| RNT_YN: Interest income - retirement, y/n                                   |   |        |        |       |        |
| Universe: All Persons aged 15+  |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes   | 1,565                                   | 3,844  | 3,992  | 3,267 | 26,728 |
| No  | 11,039                                  | 24,734 | 8,761  | 5,068 | 35,808 |
| RNT_VAL: How much did ... receive in income from rent after expenses during |   |        |        |       |        |
| 20..?   |   |        |        |       |        |
| Universe: RNT_YN = 1  |   |        |        |       |        |
| (-11008.998, 91000.8]   | 15,031                                  | 38,718 | 14,217 | 9,473 | 80,117 |
| (91000.8, 192000.6]   | 2                                       | 25     | 18     | 20    | 26     |
| (192000.6, 293000.4]  | 0                                       | 1      | 1      | 0     | 10     |
| (293000.4, 394000.2]  | 1                                       | 1      | 1      | 0     | 6      |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (394000.2, 495000.0]   | 0                                       | 0      | 1      | 1     | 2      |
| (495000.0, 595999.8]   | 0                                       | 0      | 0      | 0     | 1      |
| (595999.8, 696999.6]   | 1                                       | 0      | 0      | 0     | 1      |
| (898999.2, 999999.0]   | 0                                       | 0      | 3      | 1     | 2      |
| RNT_YN: Did ... own any land, property, rented to others, or receive income from royalties, roomers or boarders, or from estates or trusts?                      |   |        |        |       |        |
| Universe: All Persons aged 15+   |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 290                                     | 918    | 1,088  | 677   | 2,802  |
| No   | 12,314                                  | 27,660 | 11,665 | 7,658 | 59,734 |
| SRVS_VAL: Total amount of survivor's income received (combined amounts in edited sources sur_val1 and sur_val2 plus the unedited sources 3 & 4 starting in 1995) |   |        |        |       |        |
| Universe: SUR_YN = 1   |   |        |        |       |        |
| (-200.0, 20000.0]  | 15,022                                  | 38,674 | 14,181 | 9,420 | 80,073 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable             | Insurance Coverage Type (GRP, DIR, PUB) |     |     |     |     |
|----------------------|---|-----|-----|-----|-----|
|                      | NNN                                     | NNY | NY_ | Y1Y | YNN |
| (20000.0, 40000.0]   | 7                                       | 39  | 39  | 48  | 47  |
| (40000.0, 60000.0]   | 4                                       | 18  | 8   | 14  | 13  |
| (60000.0, 80000.0]   | 0                                       | 1   | 3   | 0   | 8   |
| (80000.0, 100000.0]  | 2                                       | 11  | 8   | 13  | 20  |
| (100000.0, 120000.0] | 0                                       | 1   | 1   | 0   | 1   |
| (120000.0, 140000.0] | 0                                       | 1   | 1   | 0   | 1   |
| (140000.0, 160000.0] | 0                                       | 0   | 0   | 0   | 1   |
| (180000.0, 200000.0] | 0                                       | 0   | 0   | 0   | 1   |

SS\_VAL: How much did ... receive in social security payments during 20.. ?

Universe: SS\_YN = 1

|                    |        |        |       |       |        |
|--------------------|--------|--------|-------|-------|--------|
| (-80.0, 8000.0]    | 14,729 | 27,315 | 9,197 | 5,611 | 79,192 |
| (8000.0, 16000.0]  | 185    | 5,828  | 1,913 | 1,388 | 471    |
| (16000.0, 24000.0] | 91     | 3,923  | 2,002 | 1,553 | 335    |
| (24000.0, 32000.0] | 20     | 1,192  | 846   | 695   | 113    |
| (32000.0, 40000.0] | 2      | 203    | 146   | 140   | 21     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (40000.0, 48000.0]  | 8                                       | 279    | 136    | 107   | 30     |
| (48000.0, 56000.0]  | 0                                       | 3      | 1      | 0     | 0      |
| (56000.0, 64000.0]  | 0                                       | 0      | 0      | 1     | 1      |
| (72000.0, 80000.0]  | 0                                       | 2      | 0      | 0     | 2      |
| SS_YN: Who received social security payments either for themselves or as combined payments with other family members? |   |        |        |       |        |
| Universe: All Persons aged 15+  |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes   | 397                                     | 13,477 | 5,642  | 4,471 | 1,228  |
| No  | 12,207                                  | 15,101 | 7,111  | 3,864 | 61,308 |
| SSI_VAL: How much did ... receive in supplemental security income during 20..?  |   |        |        |       |        |
| Universe: SSI_YN = 1  |   |        |        |       |        |
| (-50.0, 5000.0]   | 14,990                                  | 37,145 | 14,170 | 9,351 | 80,087 |
| (5000.0, 10000.0]   | 35                                      | 1,032  | 35     | 77    | 47     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (10000.0, 15000.0]   | 3                                       | 388    | 21     | 44    | 21     |
| (15000.0, 20000.0]   | 1                                       | 107    | 7      | 10    | 4      |
| (20000.0, 25000.0]   | 2                                       | 41     | 3      | 9     | 3      |
| (25000.0, 30000.0]   | 3                                       | 31     | 5      | 4     | 3      |
| (45000.0, 50000.0]   | 1                                       | 1      | 0      | 0     | 0      |
| SSI_YN: Did ... received ssi?  |   |        |        |       |        |
| Universe: All Persons aged 15+   |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 59                                      | 2,241  | 101    | 192   | 110    |
| No   | 12,545                                  | 26,337 | 12,652 | 8,143 | 62,426 |
| STRKUC: At any time during 20.. did ... receive any union unemployment or strike benefits? |   |        |        |       |        |
| Universe: UC_YN = 1  |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 4                                       | 10     | 3      | 4     | 27     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| No   | 12,600                                  | 28,568 | 12,750 | 8,331 | 62,509 |
| SUBUC: At any time during 20.. did ... receive any supplemental unemployment benefits? |   |        |        |       |        |
| Universe: UC_YN = 1  |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 11                                      | 28     | 9      | 8     | 47     |
| No   | 12,593                                  | 28,550 | 12,744 | 8,327 | 62,489 |
| SUR_SC1: What was the source of this other widow or survivor income?                   |   |        |        |       |        |
| Universe: SUR_YN = 1   |   |        |        |       |        |
| None or niu  | 14,986                                  | 38,246 | 13,934 | 9,233 | 79,856 |
| Company or union survivor pension  | 10                                      | 206    | 134    | 106   | 44     |
| Federal government   | 7                                       | 49     | 25     | 41    | 26     |
| Us military retirement survivor pension  | 2                                       | 48     | 10     | 10    | 9      |
| State or local gov't survivor pension  | 3                                       | 44     | 34     | 39    | 19     |
| Us railroad retirement survivor pension  | 2                                       | 14     | 6      | 3     | 5      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Worker compensation survivor   | 0                                       | 2      | 0      | 3     | 3      |
| Black lung   | 0                                       | 1      | 0      | 0     | 1      |
| Regular payments from estates or trusts                              | 8                                       | 40     | 34     | 17    | 79     |
| Regular payments from annuities or paid-up life insurance            | 6                                       | 29     | 30     | 15    | 42     |
| Other or don't know  | 11                                      | 66     | 34     | 28    | 81     |
| SUR_SC2: What was the source of this other widow or survivor income? |   |        |        |       |        |
| Universe: SUR_YN = 1   |   |        |        |       |        |
| None or niu  | 15,034                                  | 38,731 | 14,233 | 9,490 | 80,152 |
| Federal government   | 0                                       | 2      | 0      | 0     | 0      |
| Us military retirement survivor pension                              | 1                                       | 2      | 0      | 1     | 0      |
| State or local gov't survivor pension                                | 0                                       | 2      | 3      | 1     | 7      |
| Worker compensation survivor   | 0                                       | 1      | 0      | 0     | 0      |
| Black lung   | 0                                       | 0      | 0      | 1     | 0      |
| Regular payments from estates or trusts                              | 0                                       | 0      | 1      | 0     | 1      |
| Regular payments from annuities or paid-up life insurance            | 0                                       | 5      | 1      | 2     | 0      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Other or don't know   | 0                                       | 2      | 3      | 0     | 5      |
| SUR_VAL1: How much did ... receive (survivor source type) during 20.. ? |   |        |        |       |        |
| Universe: SUR_YN = 1  |   |        |        |       |        |
| (-100.0, 10000.0]   | 15,009                                  | 38,539 | 14,106 | 9,366 | 80,014 |
| (10000.0, 20000.0]  | 13                                      | 137    | 78     | 56    | 61     |
| (20000.0, 30000.0]  | 6                                       | 35     | 25     | 36    | 32     |
| (30000.0, 40000.0]  | 1                                       | 5      | 14     | 11    | 15     |
| (40000.0, 50000.0]  | 3                                       | 14     | 5      | 10    | 6      |
| (50000.0, 60000.0]  | 1                                       | 3      | 3      | 4     | 8      |
| (60000.0, 70000.0]  | 0                                       | 0      | 1      | 1     | 7      |
| (70000.0, 80000.0]  | 0                                       | 1      | 2      | 0     | 1      |
| (90000.0, 100000.0]   | 2                                       | 11     | 7      | 11    | 21     |
| SUR_VAL2: How much did ... receive (source type) during 20.. ?          |   |        |        |       |        |
| Universe: SUR_YN = 1  |   |        |        |       |        |
| (-100.0, 10000.0]   | 15,035                                  | 38,741 | 14,237 | 9,493 | 80,160 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (10000.0, 20000.0]  | 0                                       | 1      | 1      | 1     | 0      |
| (20000.0, 30000.0]  | 0                                       | 0      | 0      | 0     | 1      |
| (30000.0, 40000.0]  | 0                                       | 1      | 0      | 0     | 0      |
| (60000.0, 70000.0]  | 0                                       | 1      | 1      | 1     | 0      |
| (90000.0, 100000.0]   | 0                                       | 1      | 2      | 0     | 4      |
| SUR_YN: During 20.. did ... receive any survivor benefits such as widow's pensions, estates, trusts, insurance annuities, or other survivor's income? |   |        |        |       |        |
| Universe: All Persons aged 15+  |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes   | 49                                      | 499    | 307    | 262   | 309    |
| No  | 12,555                                  | 28,079 | 12,446 | 8,073 | 62,227 |
| TRDINT_VAL: Interest amount, excluding retirement account interest  |   |        |        |       |        |
| Universe: INT_YN = 1  |   |        |        |       |        |
| (-99.999, 9999.9]   | 15,018                                  | 38,629 | 14,089 | 9,398 | 79,874 |
| (9999.9, 19999.8]   | 8                                       | 69     | 87     | 53    | 147    |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable           | Insurance Coverage Type (GRP, DIR, PUB) |     |     |     |     |
|--------------------|---|-----|-----|-----|-----|
|                    | NNN                                     | NNY | NY_ | Y1Y | YNN |
| (19999.8, 29999.7] | 3                                       | 21  | 23  | 14  | 64  |
| (29999.7, 39999.6] | 2                                       | 8   | 16  | 8   | 24  |
| (39999.6, 49999.5] | 0                                       | 5   | 4   | 2   | 9   |
| (49999.5, 59999.4] | 1                                       | 6   | 6   | 4   | 14  |
| (59999.4, 69999.3] | 1                                       | 1   | 1   | 2   | 11  |
| (69999.3, 79999.2] | 1                                       | 1   | 3   | 4   | 7   |
| (79999.2, 89999.1] | 1                                       | 0   | 1   | 2   | 3   |
| (89999.1, 99999.0] | 0                                       | 5   | 11  | 8   | 12  |

UC\_VAL: How much did ... receive in unemployment benefits during 20..?

Universe: UC\_YN = 1

|                    |        |        |        |       |        |
|--------------------|--------|--------|--------|-------|--------|
| (-99.999, 9999.9]  | 15,013 | 38,710 | 14,224 | 9,465 | 80,074 |
| (9999.9, 19999.8]  | 21     | 26     | 13     | 26    | 79     |
| (19999.8, 29999.7] | 1      | 6      | 0      | 1     | 5      |
| (29999.7, 39999.6] | 0      | 1      | 0      | 1     | 0      |
| (39999.6, 49999.5] | 0      | 1      | 1      | 0     | 4      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (49999.5, 59999.4]   | 0                                       | 1      | 3      | 2     | 1      |
| (69999.3, 79999.2]   | 0                                       | 0      | 0      | 0     | 1      |
| (89999.1, 99999.0]   | 0                                       | 0      | 0      | 0     | 1      |
| UC_YN: Any type of unemployment compensation? (Combination of subuc, strkuc, and uctot_yn)     |   |        |        |       |        |
| Universe: UC_YN = 1  |   |        |        |       |        |
| Niu  | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes  | 180                                     | 305    | 119    | 154   | 805    |
| No   | 12,424                                  | 28,273 | 12,634 | 8,181 | 61,731 |
| VET_TYP1: What type of veterans payments did .... receive? (VET_TYP1-disability compensation?) |   |        |        |       |        |
| Universe: VET_YN = 1   |   |        |        |       |        |
| Niu  | 14,764                                  | 37,749 | 14,043 | 9,176 | 79,766 |
| Yes  | 203                                     | 675    | 131    | 264   | 322    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| No  | 68                                      | 321    | 67     | 55    | 77     |
| VET_TYP2: What type of veterans payments did .... receive? (VET_TYP2-survivor benefits?)    |   |        |        |       |        |
| Universe: VET_YN = 1  |   |        |        |       |        |
| Niu   | 14,764                                  | 37,749 | 14,043 | 9,176 | 79,766 |
| Yes   | 4                                       | 80     | 16     | 14    | 5      |
| No  | 267                                     | 916    | 182    | 305   | 394    |
| VET_TYP3: What type of veterans payments did .... receive? (VET_TYP3-veteran's pension?)    |   |        |        |       |        |
| Universe: VET_YN = 1  |   |        |        |       |        |
| Niu   | 14,764                                  | 37,749 | 14,043 | 9,176 | 79,766 |
| Yes   | 76                                      | 245    | 41     | 42    | 48     |
| No  | 195                                     | 751    | 157    | 277   | 351    |
| VET_TYP4: What type of veterans payments did .... receive? (VET_TYP4-education assistance?) |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Universe: VET_YN = 1  |   |        |        |       |        |
| Niu   | 14,764                                  | 37,749 | 14,043 | 9,176 | 79,766 |
| Yes   | 14                                      | 18     | 3      | 7     | 24     |
| No  | 257                                     | 978    | 195    | 312   | 375    |
| VET_TYP5: What type of veterans payments did .... receive? (VET_TYP5-<br>other veteran's payments?) |   |        |        |       |        |
| Universe: VET_YN = 1  |   |        |        |       |        |
| Niu   | 14,764                                  | 37,749 | 14,043 | 9,176 | 79,766 |
| Yes   | 8                                       | 33     | 11     | 7     | 12     |
| No  | 263                                     | 963    | 187    | 312   | 387    |
| VET_VAL: How much did ... receive from veterans' administration during<br>20..?                     |   |        |        |       |        |
| Universe: VET_YN = 1  |   |        |        |       |        |
| (-100.0, 10000.0]   | 14,845                                  | 38,124 | 14,132 | 9,317 | 79,960 |
| (10000.0, 20000.0]  | 61                                      | 292    | 49     | 77    | 98     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                    | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (20000.0, 30000.0]                          | 67                                      | 121    | 20     | 42    | 59     |
| (30000.0, 40000.0]                          | 23                                      | 134    | 24     | 34    | 25     |
| (40000.0, 50000.0]                          | 18                                      | 55     | 9      | 19    | 16     |
| (50000.0, 60000.0]                          | 3                                       | 8      | 2      | 2     | 1      |
| (60000.0, 70000.0]                          | 7                                       | 3      | 1      | 2     | 0      |
| (70000.0, 80000.0]                          | 4                                       | 0      | 1      | 0     | 0      |
| (80000.0, 90000.0]                          | 4                                       | 2      | 2      | 0     | 3      |
| (90000.0, 100000.0]                         | 3                                       | 6      | 1      | 2     | 3      |
| VET_YN: Did ... receive veterans' payments? |   |        |        |       |        |
| Universe: All Persons aged 15+              |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes   | 271                                     | 996    | 198    | 319   | 399    |
| No  | 12,333                                  | 27,582 | 12,555 | 8,016 | 62,137 |
| WC_TYPE: What was source of these payments? |   |        |        |       |        |
| Universe: WC_YN = 1                         |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Not in universe  | 14,980                                  | 38,653 | 14,204 | 9,447 | 79,891 |
| State worker's compensation                                | 15                                      | 40     | 14     | 15    | 74     |
| Employer or employers insurance                            | 39                                      | 42     | 23     | 30    | 187    |
| Own insurance  | 0                                       | 1      | 0      | 0     | 5      |
| Other  | 1                                       | 9      | 0      | 3     | 8      |
| WC_VAL: How much compensation did ... receive during 20..? |   |        |        |       |        |
| Universe: WC_YN = 1  |   |        |        |       |        |
| (-99.999, 9999.9]  | 15,009                                  | 38,712 | 14,227 | 9,467 | 80,086 |
| (9999.9, 19999.8]  | 17                                      | 18     | 6      | 19    | 44     |
| (19999.8, 29999.7]   | 5                                       | 8      | 2      | 2     | 15     |
| (29999.7, 39999.6]   | 1                                       | 6      | 5      | 6     | 12     |
| (39999.6, 49999.5]   | 0                                       | 0      | 0      | 0     | 3      |
| (49999.5, 59999.4]   | 1                                       | 0      | 0      | 1     | 0      |
| (59999.4, 69999.3]   | 0                                       | 1      | 0      | 0     | 3      |
| (89999.1, 99999.0]   | 2                                       | 0      | 1      | 0     | 2      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| WC_YN: During 20.. did ... receive any worker's compensation payments or other payments as a result of a job related injury or illness? |   |        |        |       |        |
| Universe: All Persons aged 15+  |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes   | 55                                      | 92     | 37     | 48    | 274    |
| No  | 12,549                                  | 28,486 | 12,716 | 8,287 | 62,262 |
| PAW_TYP: What type of program did... receive CASH assistance?   |   |        |        |       |        |
| Universe: PAW_YN = 1  |   |        |        |       |        |
| Niu   | 15,011                                  | 38,275 | 14,214 | 9,382 | 80,127 |
| TANF/AFDC   | 14                                      | 327    | 13     | 51    | 16     |
| Other   | 8                                       | 130    | 14     | 60    | 21     |
| Both  | 2                                       | 13     | 0      | 2     | 1      |
| PAW_VAL: How much did ... receive in public assistance or welfare during 20..?  |   |        |        |       |        |
| Universe: PAW_YN = 1  |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable           | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--------------------|---|--------|--------|-------|--------|
|                    | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (-25.0, 2500.0]    | 15,018                                  | 38,508 | 14,228 | 9,445 | 80,143 |
| (2500.0, 5000.0]   | 6                                       | 115    | 7      | 28    | 8      |
| (5000.0, 7500.0]   | 5                                       | 53     | 4      | 5     | 6      |
| (7500.0, 10000.0]  | 2                                       | 42     | 1      | 8     | 3      |
| (10000.0, 12500.0] | 3                                       | 17     | 0      | 5     | 4      |
| (12500.0, 15000.0] | 1                                       | 6      | 0      | 0     | 0      |
| (15000.0, 17500.0] | 0                                       | 1      | 0      | 1     | 0      |
| (17500.0, 20000.0] | 0                                       | 0      | 0      | 2     | 1      |
| (20000.0, 22500.0] | 0                                       | 2      | 0      | 0     | 0      |
| (22500.0, 25000.0] | 0                                       | 1      | 1      | 1     | 0      |

PAW\_YN: At any time during 20..., even for one month, did... receive an CASH assistance from a state or county welfare program such as (State program name fill)?

Universe: All Persons aged 15+

Niu 2,431 10,167 1,488 1,160 17,629



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Yes  | 24                                      | 470    | 27     | 113   | 38     |
| No   | 12,580                                  | 28,108 | 12,726 | 8,222 | 62,498 |
| PENINCL: Was ... included in that plan?  |   |        |        |       |        |
| Universe: PENPLAN = 1  |   |        |        |       |        |
| Niu  | 12,999                                  | 36,775 | 12,935 | 7,709 | 54,529 |
| Yes  | 1,334                                   | 996    | 775    | 1,381 | 21,824 |
| No   | 702                                     | 974    | 531    | 405   | 3,812  |
| PENPLAN: Other than social security did the employer or union that ... worked for in 20.. have a pension or other type of retirement plan? |   |        |        |       |        |
| Universe: WRK_CK = 1   |   |        |        |       |        |
| Niu  | 6,201                                   | 29,895 | 8,039  | 5,508 | 27,806 |
| Yes  | 2,036                                   | 1,970  | 1,306  | 1,786 | 25,636 |
| No   | 6,798                                   | 6,880  | 4,896  | 2,201 | 26,723 |
| WICYN: Who received WIC?   |   |        |        |       |        |
| Universe: Adult female   |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Niu   | 10,363                                  | 30,214 | 11,865 | 8,177 | 56,383 |
| Received WIC  | 207                                     | 717    | 59     | 110   | 390    |
| Did not receive WIC   | 4,465                                   | 7,814  | 2,317  | 1,208 | 23,392 |
| CHCARE_YN: Paid child care was needed for this child?                   |   |        |        |       |        |
| Universe: Persons age 15+ with children                                 |   |        |        |       |        |
| Niu   | 12,604                                  | 28,578 | 12,753 | 8,335 | 62,536 |
| Yes   | 361                                     | 1,381  | 252    | 233   | 4,405  |
| No  | 2,070                                   | 8,786  | 1,236  | 927   | 13,224 |
| CHELSEW_YN: Does this person have a child living outside the household? |   |        |        |       |        |
| Universe: All persons aged 15+  |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes   | 386                                     | 443    | 163    | 129   | 1,438  |
| No  | 12,218                                  | 28,135 | 12,590 | 8,206 | 61,098 |
| CHSP_VAL: What is the annual amount of child support paid?              |   |        |        |       |        |
| Universe: CHSP_YN = 1   |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (-99.999, 9999.9]  | 15,003                                  | 38,723 | 14,222 | 9,484 | 79,970 |
| (9999.9, 19999.8]  | 26                                      | 19     | 14     | 7     | 141    |
| (19999.8, 29999.7]   | 4                                       | 1      | 1      | 2     | 41     |
| (29999.7, 39999.6]   | 1                                       | 1      | 4      | 0     | 5      |
| (39999.6, 49999.5]   | 1                                       | 0      | 0      | 1     | 2      |
| (49999.5, 59999.4]   | 0                                       | 0      | 0      | 1     | 1      |
| (59999.4, 69999.3]   | 0                                       | 1      | 0      | 0     | 1      |
| (69999.3, 79999.2]   | 0                                       | 0      | 0      | 0     | 1      |
| (89999.1, 99999.0]   | 0                                       | 0      | 0      | 0     | 3      |
| CHSP_YN: Is this person required to pay child support?       |   |        |        |       |        |
| Universe: CHELSEW_YN   |   |        |        |       |        |
| Niu  | 14,649                                  | 38,302 | 14,078 | 9,366 | 78,727 |
| Yes  | 194                                     | 136    | 70     | 41    | 681    |
| No   | 192                                     | 307    | 93     | 88    | 757    |
| CSP_VAL: How much did ... receive in child support payments? |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Universe: CHSP_YN = 1                           |   |        |        |       |        |
| (-99.999, 9999.9]                               | 15,010                                  | 38,682 | 14,215 | 9,484 | 79,977 |
| (9999.9, 19999.8]                               | 19                                      | 48     | 18     | 8     | 148    |
| (19999.8, 29999.7]                              | 5                                       | 10     | 5      | 1     | 23     |
| (29999.7, 39999.6]                              | 0                                       | 4      | 1      | 1     | 11     |
| (39999.6, 49999.5]                              | 1                                       | 0      | 1      | 1     | 2      |
| (49999.5, 59999.4]                              | 0                                       | 0      | 0      | 0     | 1      |
| (69999.3, 79999.2]                              | 0                                       | 0      | 1      | 0     | 0      |
| (89999.1, 99999.0]                              | 0                                       | 1      | 0      | 0     | 3      |
| CSP_YN: Did ... receive child support payments? |   |        |        |       |        |
| Universe: All Persons aged 15+                  |   |        |        |       |        |
| Niu   | 2,431                                   | 10,167 | 1,488  | 1,160 | 17,629 |
| Yes   | 201                                     | 560    | 112    | 136   | 1,080  |
| No  | 12,403                                  | 28,018 | 12,641 | 8,199 | 61,456 |
| ACTC_CRD: Additional child tax credit           |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Universe: Tax unit head or dependent filer |   |        |        |       |        |
| (-11.1, 1110.0]                            | 13,939                                  | 37,125 | 13,926 | 9,144 | 78,392 |
| (1110.0, 2220.0]                           | 534                                     | 804    | 153    | 168   | 833    |
| (2220.0, 3330.0]                           | 359                                     | 525    | 102    | 119   | 560    |
| (3330.0, 4440.0]                           | 153                                     | 215    | 45     | 42    | 256    |
| (4440.0, 5550.0]                           | 27                                      | 33     | 5      | 12    | 59     |
| (5550.0, 6660.0]                           | 17                                      | 29     | 8      | 8     | 41     |
| (6660.0, 7770.0]                           | 3                                       | 8      | 2      | 1     | 15     |
| (7770.0, 8880.0]                           | 2                                       | 4      | 0      | 0     | 4      |
| (8880.0, 9990.0]                           | 1                                       | 2      | 0      | 1     | 4      |
| (9990.0, 11100.0]                          | 0                                       | 0      | 0      | 0     | 1      |
| AGI: Adjusted gross income                 |   |        |        |       |        |
| Universe: Tax unit head or dependent filer |   |        |        |       |        |
| (-12341.073, 224208.3]                     | 14,924                                  | 38,542 | 13,917 | 9,179 | 77,141 |
| (224208.3, 458415.6]                       | 89                                      | 171    | 256    | 278   | 2,438  |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (458415.6, 692622.9]                       | 14                                      | 21     | 33     | 21    | 325    |
| (692622.9, 926830.2]                       | 4                                       | 5      | 16     | 4     | 98     |
| (926830.2, 1161037.5]                      | 4                                       | 5      | 11     | 9     | 87     |
| (1161037.5, 1395244.8]                     | 0                                       | 0      | 4      | 2     | 56     |
| (1395244.8, 1629452.1]                     | 0                                       | 1      | 1      | 2     | 7      |
| (1629452.1, 1863659.4]                     | 0                                       | 0      | 1      | 0     | 1      |
| (1863659.4, 2097866.7]                     | 0                                       | 0      | 1      | 0     | 6      |
| (2097866.7, 2332074.0]                     | 0                                       | 0      | 1      | 0     | 6      |
| CTC_CRD: Child tax credit                  |   |        |        |       |        |
| Universe: Tax unit head or dependent filer |   |        |        |       |        |
| (-18.0, 1800.0]                            | 13,956                                  | 38,047 | 13,477 | 8,913 | 69,728 |
| (1800.0, 3600.0]                           | 646                                     | 462    | 418    | 331   | 5,280  |
| (3600.0, 5400.0]                           | 327                                     | 186    | 250    | 182   | 3,845  |
| (5400.0, 7200.0]                           | 73                                      | 41     | 78     | 52    | 1,015  |
| (7200.0, 9000.0]                           | 26                                      | 8      | 15     | 15    | 236    |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (9000.0, 10800.0]                          | 5                                       | 1      | 2      | 2     | 40     |
| (10800.0, 12600.0]                         | 2                                       | 0      | 0      | 0     | 17     |
| (12600.0, 14400.0]                         | 0                                       | 0      | 0      | 0     | 2      |
| (14400.0, 16200.0]                         | 0                                       | 0      | 1      | 0     | 0      |
| (16200.0, 18000.0]                         | 0                                       | 0      | 0      | 0     | 2      |
| EIT_CRED: Earn income tax credit           |   |        |        |       |        |
| Universe: Tax unit head or dependent filer |   |        |        |       |        |
| (-6.557, 655.7]                            | 13,787                                  | 36,710 | 13,872 | 9,134 | 78,356 |
| (655.7, 1311.4]                            | 106                                     | 159    | 45     | 40    | 348    |
| (1311.4, 1967.1]                           | 127                                     | 149    | 72     | 55    | 330    |
| (1967.1, 2622.8]                           | 153                                     | 229    | 44     | 46    | 281    |
| (2622.8, 3278.5]                           | 135                                     | 248    | 45     | 54    | 207    |
| (3278.5, 3934.2]                           | 263                                     | 420    | 62     | 60    | 266    |
| (3934.2, 4589.9]                           | 92                                      | 184    | 36     | 24    | 120    |
| (4589.9, 5245.6]                           | 88                                      | 152    | 20     | 26    | 86     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (5245.6, 5901.3]   | 168                                     | 306    | 28     | 39    | 117    |
| (5901.3, 6557.0]   | 116                                     | 188    | 17     | 17    | 54     |
| FED_RET: Federal retirement payroll deduction              |   |        |        |       |        |
| Universe: Tax unit head or dependent filer                 |   |        |        |       |        |
| (-16.9, 1690.0]  | 15,032                                  | 38,744 | 14,241 | 9,491 | 80,153 |
| (1690.0, 3380.0]   | 0                                       | 0      | 0      | 0     | 2      |
| (3380.0, 5070.0]   | 1                                       | 1      | 0      | 0     | 2      |
| (5070.0, 6760.0]   | 2                                       | 0      | 0      | 1     | 4      |
| (6760.0, 8450.0]   | 0                                       | 0      | 0      | 0     | 1      |
| (8450.0, 10140.0]  | 0                                       | 0      | 0      | 2     | 2      |
| (10140.0, 11830.0]   | 0                                       | 0      | 0      | 0     | 1      |
| (15210.0, 16900.0]   | 0                                       | 0      | 0      | 1     | 0      |
| FEDTAX_AC: Federal income tax liability, after all credits |   |        |        |       |        |
| Universe: Tax unit head or dependent filer                 |   |        |        |       |        |
| (-10797.046, 69805.6]                                      | 15,001                                  | 38,684 | 14,139 | 9,415 | 79,276 |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (69805.6, 149610.2]                                     | 22                                      | 49     | 66     | 62    | 605    |
| (149610.2, 229414.8]                                    | 8                                       | 5      | 18     | 6     | 94     |
| (229414.8, 309219.4]                                    | 2                                       | 3      | 7      | 4     | 62     |
| (309219.4, 389024.0]                                    | 2                                       | 3      | 7      | 6     | 91     |
| (389024.0, 468828.6]                                    | 0                                       | 1      | 1      | 2     | 23     |
| (468828.6, 548633.2]                                    | 0                                       | 0      | 2      | 0     | 4      |
| (628437.8, 708242.4]                                    | 0                                       | 0      | 1      | 0     | 6      |
| (708242.4, 788047.0]                                    | 0                                       | 0      | 0      | 0     | 4      |
| FEDTAX_BC: Federal income tax liability, before credits |   |        |        |       |        |
| Universe: Tax unit head or dependent filer              |   |        |        |       |        |
| (-788.047, 78804.7]                                     | 15,006                                  | 38,696 | 14,150 | 9,434 | 79,411 |
| (78804.7, 157609.4]                                     | 18                                      | 37     | 59     | 43    | 473    |
| (157609.4, 236414.1]                                    | 7                                       | 5      | 14     | 6     | 96     |
| (236414.1, 315218.8]                                    | 2                                       | 3      | 7      | 4     | 62     |
| (315218.8, 394023.5]                                    | 2                                       | 3      | 7      | 6     | 90     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (394023.5, 472828.2]                               | 0                                       | 1      | 1      | 2     | 19     |
| (472828.2, 551632.9]                               | 0                                       | 0      | 2      | 0     | 4      |
| (630437.6, 709242.3]                               | 0                                       | 0      | 1      | 0     | 6      |
| (709242.3, 788047.0]                               | 0                                       | 0      | 0      | 0     | 4      |
| FICA: Social security retirement payroll deduction |   |        |        |       |        |
| Universe: All persons                              |   |        |        |       |        |
| (-55.449, 5544.9]                                  | 14,080                                  | 38,087 | 12,928 | 8,678 | 63,814 |
| (5544.9, 11089.8]                                  | 821                                     | 521    | 979    | 661   | 14,090 |
| (11089.8, 16634.7]                                 | 98                                      | 99     | 209    | 123   | 1,751  |
| (16634.7, 22179.6]                                 | 23                                      | 29     | 85     | 19    | 287    |
| (22179.6, 27724.5]                                 | 6                                       | 5      | 21     | 9     | 78     |
| (27724.5, 33269.4]                                 | 5                                       | 4      | 13     | 5     | 134    |
| (33269.4, 38814.3]                                 | 0                                       | 0      | 4      | 0     | 6      |
| (38814.3, 44359.2]                                 | 1                                       | 0      | 2      | 0     | 1      |
| (44359.2, 49904.1]                                 | 1                                       | 0      | 0      | 0     | 3      |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                   | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--|---|--------|-------|-------|--------|
|  | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| (49904.1, 55449.0]                         | 0                                       | 0      | 0     | 0     | 1      |
| FILESTAT: Tax filer status                 |   |        |       |       |        |
| Universe: All persons                      |   |        |       |       |        |
| Joint, both <65                            | 4,721                                   | 3,600  | 2,931 | 1,621 | 33,473 |
| Joint, one ><65 & one 65+                  | 235                                     | 1,045  | 692   | 782   | 1,812  |
| Joint, both 65+                            | 67                                      | 3,661  | 2,693 | 2,660 | 271    |
| Head of household                          | 764                                     | 1,485  | 350   | 299   | 3,024  |
| Single                                     | 4,246                                   | 5,595  | 3,652 | 1,956 | 17,561 |
| Non-filer                                  | 5,002                                   | 23,359 | 3,923 | 2,177 | 24,024 |
| MARG_TAX: Marginal tax rate                |   |        |       |       |        |
| Universe: Tax unit head or dependent filer |   |        |       |       |        |
| (-0.037, 3.7]                              | 9,196                                   | 31,832 | 8,644 | 5,356 | 45,074 |
| (7.4, 11.1]                                | 1,801                                   | 2,645  | 1,229 | 717   | 3,139  |
| (11.1, 14.8]                               | 3,127                                   | 2,994  | 2,557 | 1,813 | 14,677 |
| (18.5, 22.2]                               | 687                                     | 920    | 1,267 | 1,088 | 11,655 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable                                       | Insurance Coverage Type (GRP, DIR, PUB) |        |       |       |        |
|--|---|--------|-------|-------|--------|
|  | NNN                                     | NNY    | NY_   | Y1Y   | YNN    |
| (22.2, 25.9]                                   | 174                                     | 259    | 404   | 403   | 4,335  |
| (29.6, 33.3]                                   | 15                                      | 39     | 53    | 62    | 523    |
| (33.3, 37.0]                                   | 35                                      | 56     | 87    | 56    | 762    |
| PRSWKXPNS: Work expenses                       |   |        |       |       |        |
| Universe: A_AGE > 17 or HHDFMX = 1,2,46, or 47 |   |        |       |       |        |
| (-2.065, 206.5]                                | 6,481                                   | 30,475 | 8,279 | 5,658 | 29,096 |
| (206.5, 413.0]                                 | 131                                     | 275    | 104   | 94    | 470    |
| (413.0, 619.5]                                 | 175                                     | 312    | 141   | 101   | 591    |
| (619.5, 826.0]                                 | 210                                     | 347    | 136   | 124   | 670    |
| (826.0, 1032.5]                                | 131                                     | 225    | 119   | 86    | 416    |
| (1032.5, 1239.0]                               | 352                                     | 504    | 210   | 178   | 879    |
| (1239.0, 1445.5]                               | 228                                     | 252    | 155   | 108   | 696    |
| (1445.5, 1652.0]                               | 292                                     | 336    | 238   | 161   | 1,100  |
| (1652.0, 1858.5]                               | 265                                     | 284    | 167   | 124   | 969    |
| (1858.5, 2065.0]                               | 6,770                                   | 5,735  | 4,692 | 2,861 | 45,278 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| STATETAX_A: State income tax liability, after all credits |   |        |        |       |        |
| Universe: Tax unit head or dependent filer                |   |        |        |       |        |
| (-6490.585, 19727.5]                                      | 15,009                                  | 38,704 | 14,157 | 9,429 | 79,338 |
| (19727.5, 45686.0]  | 20                                      | 37     | 63     | 54    | 637    |
| (45686.0, 71644.5]  | 6                                       | 3      | 15     | 6     | 113    |
| (71644.5, 97603.0]  | 0                                       | 0      | 2      | 6     | 35     |
| (97603.0, 123561.5]                                       | 0                                       | 1      | 4      | 0     | 25     |
| (123561.5, 149520.0]                                      | 0                                       | 0      | 0      | 0     | 10     |
| (149520.0, 175478.5]                                      | 0                                       | 0      | 0      | 0     | 1      |
| (175478.5, 201437.0]                                      | 0                                       | 0      | 0      | 0     | 3      |
| (201437.0, 227395.5]                                      | 0                                       | 0      | 0      | 0     | 2      |
| (227395.5, 253354.0]                                      | 0                                       | 0      | 0      | 0     | 1      |
| STATETAX_B: State income tax liability, before credits    |   |        |        |       |        |
| Universe: Tax unit head or dependent filer                |   |        |        |       |        |
| (-253.354, 25335.4]                                       | 15,017                                  | 38,718 | 14,185 | 9,458 | 79,632 |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable             | Insurance Coverage Type (GRP, DIR, PUB) |     |     |     |     |
|----------------------|---|-----|-----|-----|-----|
|                      | NNN                                     | NNY | NY_ | Y1Y | YNN |
| (25335.4, 50670.8]   | 12                                      | 23  | 38  | 28  | 377 |
| (50670.8, 76006.2]   | 6                                       | 3   | 12  | 4   | 83  |
| (76006.2, 101341.6]  | 0                                       | 0   | 2   | 5   | 39  |
| (101341.6, 126677.0] | 0                                       | 1   | 4   | 0   | 18  |
| (126677.0, 152012.4] | 0                                       | 0   | 0   | 0   | 9   |
| (152012.4, 177347.8] | 0                                       | 0   | 0   | 0   | 1   |
| (177347.8, 202683.2] | 0                                       | 0   | 0   | 0   | 3   |
| (202683.2, 228018.6] | 0                                       | 0   | 0   | 0   | 2   |
| (228018.6, 253354.0] | 0                                       | 0   | 0   | 0   | 1   |

TAX\_INC: Taxable income amount

Universe: Tax unit head or dependent filer

|                       |        |        |        |       |        |
|-----------------------|--------|--------|--------|-------|--------|
| (-2298.214, 229821.4] | 14,968 | 38,607 | 14,027 | 9,280 | 78,079 |
| (229821.4, 459642.8]  | 49     | 112    | 153    | 185   | 1,604  |
| (459642.8, 689464.2]  | 11     | 17     | 34     | 14    | 250    |
| (689464.2, 919285.6]  | 5      | 4      | 10     | 4     | 78     |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable   | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|--|---|--------|--------|-------|--------|
|  | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| (919285.6, 1149107.0]  | 2                                       | 4      | 11     | 9     | 93     |
| (1149107.0, 1378928.4]   | 0                                       | 1      | 3      | 3     | 45     |
| (1378928.4, 1608749.8]   | 0                                       | 0      | 2      | 0     | 4      |
| (1608749.8, 1838571.2]   | 0                                       | 0      | 0      | 0     | 1      |
| (1838571.2, 2068392.6]   | 0                                       | 0      | 0      | 0     | 6      |
| (2068392.6, 2298214.0]   | 0                                       | 0      | 1      | 0     | 5      |
| PERLIS: Poverty level of persons (Subfamily members have primary family<br>recode) |   |        |        |       |        |
| Universe: All persons  |   |        |        |       |        |
| Not in poverty universe  | 29                                      | 173    | 9      | 37    | 46     |
| Below poverty level  | 2,650                                   | 10,405 | 1,038  | 549   | 1,873  |
| 100 - 124 percent of the poverty level   | 872                                     | 3,558  | 448    | 302   | 898    |
| 125 - 149 percent of the poverty level   | 968                                     | 3,113  | 506    | 303   | 1,240  |
| 150 and above the poverty level  | 10,516                                  | 21,496 | 12,240 | 8,304 | 76,108 |
| POV_UNIV: Poverty universe flag  |   |        |        |       |        |

Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable  | Insurance Coverage Type (GRP, DIR, PUB) |        |        |       |        |
|---|---|--------|--------|-------|--------|
|   | NNN                                     | NNY    | NY_    | Y1Y   | YNN    |
| Universe: All persons                           |   |        |        |       |        |
| Not in poverty universe                         | 29                                      | 173    | 9      | 37    | 46     |
| In poverty universe                             | 15,006                                  | 38,572 | 14,232 | 9,458 | 80,119 |
| HEA: Health status                              |   |        |        |       |        |
| Universe: All persons                           |   |        |        |       |        |
| Excellent                                       | 4,703                                   | 8,539  | 4,173  | 2,207 | 32,776 |
| Very good                                       | 4,895                                   | 9,678  | 4,540  | 3,038 | 29,492 |
| Good  | 4,164                                   | 11,856 | 3,859  | 2,899 | 15,028 |
| Fair  | 1,039                                   | 6,158  | 1,247  | 1,007 | 2,439  |
| Poor  | 234                                     | 2,514  | 422    | 344   | 430    |
| SPM_ACTC: SPM units Additional Child Tax Credit |   |        |        |       |        |
| Universe: All persons                           |   |        |        |       |        |
| (-11.1, 1110.0]                                 | 11,509                                  | 28,742 | 13,080 | 8,266 | 72,935 |
| (1110.0, 2220.0]                                | 1,538                                   | 3,848  | 513    | 507   | 3,105  |
| (2220.0, 3330.0]                                | 1,172                                   | 3,423  | 362    | 420   | 2,227  |



Table 3.6: Number of survey participants by health factors and five insurance coverage combinations of enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) (continued)

| Variable          | Insurance Coverage Type (GRP, DIR, PUB) |       |     |     |       |
|-------------------|---|-------|-----|-----|-------|
|                   | NNN                                     | NNY   | NY_ | Y1Y | YNN   |
| (3330.0, 4440.0]  | 583                                     | 1,834 | 215 | 176 | 1,141 |
| (4440.0, 5550.0]  | 111                                     | 393   | 26  | 55  | 337   |
| (5550.0, 6660.0]  | 74                                      | 314   | 36  | 56  | 233   |
| (6660.0, 7770.0]  | 25                                      | 111   | 9   | 2   | 116   |
| (7770.0, 8880.0]  | 11                                      | 41    | 0   | 1   | 43    |
| (8880.0, 9990.0]  | 9                                       | 32    | 0   | 12  | 15    |
| (9990.0, 11100.0] | 3                                       | 7     | 0   | 0   | 13    |

Code 3.8: Exploratory data analysis (describe.py)

```
1  import os
2  import pandas as pd
3  import warnings
4
5  from module.utility import create_dir, import_dict
6  from module.eda import *
7  from module.dataset import *
8  from cls.ThesisExtension import *
9
10 texlive_binpath = '/usr/local/texlive/2024/bin/x86_64-linux'
11 os.environ['PATH'] += os.pathsep + texlive_binpath
12
13 pd.set_option('display.max_columns', None)
14 pd.set_option('display.width', 1000)
15 warnings.filterwarnings('ignore')
16
17 # Given Information
18 dataset_name = "pppub20"
19
20 # Predefined Directories
21 meta_dir = "../../../Data/Original/metadata"
22 feather_dir = "../../../Data/Original/feather"
23 csv_dir = "../../../Data/Original/csv"
24
25 output_dir = f"../../../Outputs/Main/EDA/{dataset_name}"
26 log_dir = f"../../../Logs/preprocessing"
27 log_filepath = f"{log_dir}/describe.log"
28
29 backup_dir = "../../../Backups"
30
31 create_dir(log_dir)
32
```

```

33 # Data Preparation
34 indep_dict = import_dict(metadata_path=f"{meta_dir}/meta-indep.json")
35 dep_attrs = ['GRP', 'DIR', 'PUB']
36 print()
37 describe_var(indep_dict)
38 print()
39 df = import_dataset(dataset_name=dataset_name, feather_dir=feather_dir)
40 print()
41 dep_features = ['class_orig', 'code_orig', 'code', 'class']
42 acpt_types = {'category', 'int16', 'int32', 'int8', 'uint16', 'uint32', 'uint8'}
43 preprocess = True
44
45 if all(feats in df.columns for feat in dep_features):
46     col_types = set()
47     for col in df.columns:
48         col_types.add(str(df[col].dtype))
49     if col_types == acpt_types:
50         preprocess = False
51
52 if preprocess:
53     df.thesis.code(indep_dict, dep_attrs)
54     df.thesis.recode()
55
56 filepath_feather = f"{feather_dir}/{dataset_name}.feather"
57 filepath_csv = f"{csv_dir}/{dataset_name}.csv"
58
59 if not os.path.isfile(filepath_feather):
60     export_dataset(df, file_dir='data/feather', dataset_name=dataset_name,
61                    format='feather')
62
63 if not os.path.isfile(filepath_csv):
64     dfther = pd.read_feather(filepath_feather)
65     export_dataset(dfther, file_dir='data/csv', dataset_name=dataset_name,
66                    format='csv')

```

```

66 # Univariate Data Analysis
67 df.thesis.show_type(option='full')
68 print()
69 df[['GRP', 'DIR', 'PUB', 'class_orig', 'code_orig', 'code', 'class']].
    drop_duplicates().sort_values('class').reset_index(drop=True)
70 print(f"Code: Employment-based plan (GRP) | Direct-purchase plan (DIR) |
    Public health insurance (PUB)")
71 print(df.groupby('code').size())
72 print('\n'*2)
73
74 # Cross Tabulation Analysis
75 print("-----")
76 crosstab(df=df, indep_dict=indep_dict, cont_bins=10, plot=True, output_dir
    =output_dir, log_filepath=log_filepath, backup_dir=backup_dir)

```

### 3.5.7 Data Encoding

Code 3.9 encodes the input dataset in the correct format, zero for a continuous NIU (not in universe) value and 0 up to a positive integer for a categorical value, by instantiating the Data class defined in Code 3.6. The state of this instance is maintained by two attached attributes **dataset**, a pandas DataFrame extended by the **data** accessor, and **metadata**, a Python list. The nonstatic methods **encodecat** and **encodecont** for encoding categorical and continuous features change the object into multiple states. This dissertation excessively uses the shallow copies of attributes by calling the method **copy** to protect the originals. Unlike a deep copy, a shallow copy inserts reference to an original object to the extent possible.

Code 3.9: Data encoding (convert.py)

```

1 import os
2 import pandas as pd
3 import pyarrow
4
5 from module.utility import create_dir, import_dict, export_json,
    export_txt
6 from module.metaencode import *

```

```

7  from cls.Data import *
8
9  # Given Information
10 dataset_inname = "pppub20"
11 dataset_encname = f"{dataset_inname}enc"
12 dataset_procname = "proc20"
13
14 # Predefined Directories
15 meta_indir = "../.../Data/Original/metadata"
16 meta_extra_indir = f"{meta_indir}/extra"
17 feather_indir = "../.../Data/Original/feather"
18 csv_indir = "../.../Data/Original/csv"
19
20 meta_encdir = "../.../Data/Encoded/metadata"
21 meta_extra_encdir = f"{meta_encdir}/extra"
22 feather_encdir = "../.../Data/Encoded/feather"
23 csv_encdir = "../.../Data/Encoded/csv"
24 info_encdir = "../.../Data/Encoded/info"
25
26 csv_procdir = "../.../Data/Processed/csv"
27
28 create_dir(meta_extra_indir)
29 create_dir(feather_indir)
30 create_dir(csv_indir)
31 create_dir(meta_extra_encdir)
32 create_dir(feather_encdir)
33 create_dir(csv_encdir)
34 create_dir(info_encdir)
35 create_dir(csv_procdir)
36
37 # Metadata
38 indep_dict = import_dict(metadata_path=f"{meta_indir}/meta-indep.json")
39 export_json(extract_dict_cat(indep_dict), f"{meta_extra_indir}/meta-indep-
    cat.json")
40 export_json(extract_dict_cont(indep_dict), f"{meta_extra_indir}/meta-indep-
    cont.json")

```

```

41
42 # Imported Dataset
43 if os.path.isfile(f"{feather_indir}/{dataset_inname}.feather"):
44     df = pd.read_feather(f"{feather_indir}/{dataset_inname}.feather")
45     if not os.path.isfile(f"{csv_indir}/{dataset_inname}.csv"):
46         df.to_csv(f"{csv_indir}/{dataset_inname}.csv", index=False)
47 else:
48     df = pd.read_csv(f"{csv_indir}/{dataset_inname}.csv")
49
50 # Encoded Dataset and Dictionary
51 data_obj = Data(df.copy(), indep_dict.copy())
52 cat_var_change = data_obj.encodecat()
53 cont_var_nonpos = data_obj.encodecont()
54 df_enc = data_obj.dataset
55 indep_dict_enc = data_obj.metadata
56
57 # Processed Dataset
58 dep_attrs = ['GRP', 'DIR', 'PUB']
59 class_attrs = ['class_orig', 'code_orig', 'code', 'class']
60 df_proc_enc = df_enc.drop(columns=['COV']+dep_attrs+class_attrs)
61 df_proc_enc = sort_cols(df_proc_enc, indep_dict_enc).join(df_enc['class'])
62 df_proc_info = indep_info(df_proc_enc.loc[:, df_proc_enc.columns != 'class'],
63                             indep_dict_enc)
64
65 df_count_info = count_info(df_proc_info)
66
67 # Exported Results
68 df_enc.to_feather(f"{feather_encdir}/{dataset_encname}.feather")
69 df_enc.to_csv(f"{csv_encdir}/{dataset_encname}.csv", index=False)
70 export_json(
71     indep_dict_enc,
72     f"{meta_encdir}/meta-indep-{dataset_encname}.json"
73 )
74 export_json(
75     extract_dict_cat(indep_dict_enc),
76     f"{meta_extra_encdir}/meta-indep-cat-{dataset_encname}.json"
77 )

```

```

76
77 df_proc_enc.to_csv(f"{csv_procdir}/{dataset_procname}.csv", header=True,
    index=False)
78
79 df_proc_info.index = df_proc_info.index + 1
80 df_proc_info.to_csv(f"{info_encdir}/{dataset_encname}-info.csv",
    index_label="id")
81 df_count_info.to_csv(f"{info_encdir}/{dataset_encname}-countinfo.csv",
    header=True, index=False)
82
83 export_txt(cat_var_change, f"{meta_extra_encdir}/catchchange-{
    dataset_encname}.txt")
84 export_txt(cont_var_nonpos, f"{meta_extra_encdir}/contnonpos-{
    dataset_encname}.txt")

```

### 3.5.8 Sampling using SelectKBest

Because the classifier proposed in Chapter 4 is exponentially expensive, certain features are preselected by evaluating their scores against a target variable. Code 3.10 considers 3, 4 and 8 highest scores based on the mutual information for a discrete target. In addition, 100 out of 157,681 survey participants are sampled of equal class size by calling two methods `groupby` and `sample`. Due to its random nature, the sampling result changes in each call. The use of the model is illustrated in Chapter 5 with only three preselected features.

Code 3.10: SelectKBest (selectkbest.py)

```

1 import pandas as pd
2 from functools import partial
3 from sklearn.feature_selection import mutual_info_classif, SelectKBest
4
5 from module.utility import create_dir
6
7 sel_num_ls = [3, 4, 8]
8 train_eachclass_num = 20
9

```

```

10 data_filepath = "../../../Data/Processed/csv/proc20.csv"
11 info_filepath = "../../../Data/Encoded/info/pppub20enc-info.csv"
12
13 data_selname = "selproc20"
14 train_name = "seltrain20"
15 test_name = "seltest20"
16
17 # Predefined Directories
18 sample_dir = "../../../Samples/random"
19 sel_dir = f"{sample_dir}/{data_selname}"
20
21 data_dir = f"{sel_dir}/data"
22 info_dir = f"{sel_dir}/info"
23 feat_dir = f"{sel_dir}/features"
24 score_dir = f"{sel_dir}/scores"
25 train_dir = f"{sel_dir}/train"
26 test_dir = f"{sel_dir}/test"
27
28 create_dir(data_dir)
29 create_dir(info_dir)
30 create_dir(feat_dir)
31 create_dir(score_dir)
32 create_dir(train_dir)
33 create_dir(test_dir)
34
35 # Univariate Feature Selection
36 def feat_select(df_indata, df_info, sel_num):
37     discrete_feat_idx = df_info.index[df_info['type']=='Categorical']
38     score_func = partial(mutual_info_classif, discrete_features=
39         discrete_feat_idx)
39     feat_selector = SelectKBest(score_func, k=sel_num)
40     feat_selector.fit(df_indata.drop('class', axis=1), df_indata['class'])
41
42     df_scores = pd.DataFrame()
43     df_scores["Attribute"] = df_indata.drop('class', axis=1).columns
44     df_scores['Type'] = df_info['type']

```



```

45     df_scores["Support"] = feat_selector.get_support()
46     df_scores["F Score"] = feat_selector.scores_
47     df_scores["P Value"] = feat_selector.pvalues_
48
49     df_selffeat = df_scores[df_scores['Support']].drop('Support', axis=1).
        reset_index(drop=True)
50     df_seldata = df_indata[df_selffeat['Attribute']].join(df_indata['class'
        ])
51
52     minmax = df_seldata.loc[:, df_seldata.columns != 'class'].agg(['min', '
        max']).values.tolist()
53     df_selffeat['Min'] = minmax[0]
54     df_selffeat['Max'] = minmax[1]
55     del minmax
56
57     return df_seldata, df_selffeat, df_scores
58
59 # Implementation
60 df_indata = pd.read_csv(data_filepath)
61 df_info = pd.read_csv(info_filepath)
62
63 print(f"\n{df_indata.head()}\n")
64 print(f"{df_info.head()}\n")
65
66 for sel_num in sel_num_ls:
67
68     # Univariate feature selection
69     df_seldata, df_selffeat, df_scores = feat_select(df_indata=df_indata,
        df_info=df_info, sel_num=sel_num)
70
71     # Display results (selected features)
72     print(f"Select {sel_num} features:\n")
73     print(f"{df_selffeat}\n")
74
75     # Train-test split
76     df_seltrain = df_seldata.groupby('class', group_keys=False).apply(

```

```

77         lambda x: x.sample(train_eachclass_num)
78     )
79     df_seltest = df_seldata.drop(df_seltrain.index)
80
81     # Exported results
82     df_seldata.to_csv(f"{data_dir}/{data_selname}num{sel_num}.csv", header=
        True, index=False)
83
84     df_selfeat.to_csv(f"{feat_dir}/fnum{sel_num}.csv", header=True, index=
        False)
85     df_scores.to_csv(f"{score_dir}/snum{sel_num}.csv", header=True, index=
        False)
86
87     df_selfeat.index = df_selfeat.index + 1
88     df_selinfo = df_selfeat.drop(['F Score', 'P Value'], axis=1)
89     df_selinfo.columns = ['variable', 'type', 'min', 'max']
90     df_selinfo.to_csv(f"{info_dir}/{data_selname}num{sel_num}info.csv",
        index_label='id')
91
92     df_seltrain.to_csv(f"{train_dir}/{train_name}num{sel_num}each{
        train_eachclass_num}.csv", header=True, index=False)
93     df_seltest.to_csv(f"{test_dir}/{test_name}num{sel_num}exc{
        train_eachclass_num}.csv", header=True, index=False)

```

### 3.5.9 Setting Number of Variable Splits

Provided that two and three splits or cuts are of interest, Code 3.11 determines an appropriate number of splits on an individual feature in the health insurance dataset of all noninfant survey participants with full features and previously preselected 3, 4 and 8 features. For example, in the case of three splits, up to two splits are allowed on the feature SS\_YN representing the answer, including NIU (not in universe), to the yes/no question regarding social security payments. The column of these numbers is inserted into the DataFrame as an additional information directly through the pandas accessor `info` in Code 3.7 without explicit class instantiation.

Code 3.11: Setting number of variable splits (setcut.py)

```

1  import pandas as pd
2
3  from module.utility import create_dir
4  from cls.Info import *
5
6  # Given Information
7  pcut_ls = [2, 3]
8  info_ls = []
9  info_ls.append({
10     'indir': "../.../Data/Encoded/info",
11     'infile': "pppub20enc-info.csv",
12     'outdir': "../.../Samples/proc20/cuts"
13 })
14 extra_infile_ls = [
15     "selproc20num3info.csv",
16     "selproc20num4info.csv",
17     "selproc20num8info.csv"
18 ]
19 for file in extra_infile_ls:
20     info_ls.append({
21         'indir': "../.../Samples/selproc20/info",
22         'infile': file,
23         'outdir': "../.../Samples/selproc20/cuts"
24     })
25 print(f"\n{info_ls}\n")
26
27 # Implementation
28 for dc in info_ls:
29     for pcut in pcut_ls:
30
31         # Import
32         inpath = f"{dc['indir']}/{dc['infile']}"

```

```

33     df = pd.read_csv(inpath)
34
35     # Set cuts
36     pcont, pcatmax = pcut, pcut
37     df.info.setcut(pcont, pcatmax)
38
39     # Set output path
40     infilename = dc['infile'].replace('.csv', '').replace('info', '').
        replace('-', '')
41     cutfilename = f"{infilename}co{pcont}ca{pcatmax}cutinfo"
42     outpath = f"{dc['outdir']}/{cutfilename}.csv"
43
44     # Display results
45     print(f"Input: {inpath}")
46     print(f"NUmber of features: {len(df)}")
47     print(f"Number of continuous cuts: {pcont}")
48     print(f"Number of maximum categorical cuts: {pcatmax}")
49     print(f"Output: {outpath}\n")
50     print(f"{df.head()}\n")
51
52     # Export
53     create_dir(dc['outdir'])
54     df.to_csv(outpath, header=True, index=False)

```

# CHAPTER IV

## PROPOSED CLASSIFIER

### 4.1 Proposed Model for Selecting Continuous Factors

Suppose a training dataset of dimension  $\tilde{d}$  excluding its target variable has  $N$  instances, and every feature  $1 \leq \tilde{j} \leq \tilde{d}$  is continuous. Each training instance  $\tilde{x}^i = (\tilde{x}_{\tilde{j}}^i)_{1 \leq \tilde{j} \leq \tilde{d}} \in \mathbb{R}^{\tilde{d}}$  where  $1 \leq i \leq N$  has an integer class label between 0 and  $n$ . Let  $y_k^i$  specify whether a training instance  $\tilde{x}^i$  is in class  $k$  for  $0 \leq k \leq n$ . Assume that at most  $1 \leq d \leq \tilde{d}$  contributing factors are considered. It follows that a reduced instance  $x^i = (x_j^i)_{1 \leq j \leq d} \in \mathbb{R}^d$  is a partial selection of the components of the original instance  $\tilde{x}^i$ :

$$\begin{aligned} x_j^i &= \sum_{\tilde{j}=1}^{\tilde{d}} c_{j,\tilde{j}} \tilde{x}_{\tilde{j}}^i \\ \sum_{\tilde{j}=1}^{\tilde{d}} c_{j,\tilde{j}} &\leq 1 \\ \sum_{\tilde{j}=1}^{\tilde{d}} c_{j,\tilde{j}} &\leq 1 \\ c_{j,\tilde{j}} &\in \{0, 1\}. \end{aligned}$$

An original feature  $\tilde{j}$  is selected and considered significant when

$$\sum_{\tilde{j}=1}^{\tilde{d}} c_{j,\tilde{j}} = 1$$

and it becomes a new feature  $j$ , uniquely, for  $c_{j,\tilde{j}} = 1$ .

Every selected, rearranged feature  $1 \leq j \leq d$  is assumed to have  $p_j \geq 0$  splitting values:  $b_{j,1} \leq \dots \leq b_{j,p_j}$ . Two endpoints are assumed:  $b_{j,0} = -M$  and  $b_{j,p_j+1} = M$  for sufficiently large positive  $M$  such as  $\max\{|x_j^i|\}$ . All splitting points along each new axis forms  $B = (p_1 + 1) \cdots (p_d + 1)$  decision boxes. A box  $S_\beta$  is defined in the following manner:

$$S_\beta = \prod_{j=1}^d \sum_{q=0}^{p_j} \beta_{j,q} [b_{j,q}, b_{j,q+1}]$$

where  $b_{j,0}$  and  $b_{j,p_j+1}$  are sufficiently small negative and large positive,

$$\begin{aligned}\beta &= \sum_{j=1}^d \left[ \prod_{j_0=0}^{j-1} (p_{j_0} + 1) \right] \left[ \sum_{q=0}^{p_j} q \beta_{j,q} \right] \\ \sum_{q=0}^{p_j} \beta_{j,q} &= 1 \\ \beta_{j,q} &\in \{0, 1\}\end{aligned}$$

and  $p_0 = 1$ .

Each  $x_j^i \in \mathbb{R}$  is in an open interval  $(b_{j,q}, b_{j,q+1})$  for some  $0 \leq q \leq p_j$ , and its existence is indicated by a boolean variable  $\alpha_{j,q}^i$ :

$$\begin{aligned}\sum_{j=1}^d c_{j,j} \tilde{x}_j^i &= x_j^i \in \sum_{q=0}^{p_j} \alpha_{j,q}^i [b_{j,q} + m_j, b_{j,q+1} - m_j] = \sum_{q=0}^{p_j} [l_{j,q}^i, r_{j,q}^i] \\ \sum_{q=0}^{p_j} \alpha_{j,q}^i &= 1 \\ \alpha_{j,q}^i &\in \{0, 1\}\end{aligned}$$

for sufficiently small positive  $m_j$  such as

$$m_j = \frac{1}{2} \min\{|x_j^{i_1} - x_j^{i_2}| : x_j^{i_1} \neq x_j^{i_2}\}$$

and for some  $l_{j,q}^i$  and  $r_{j,q}^i$ . Both terms are introduced to linearize the nonlinear products  $\alpha_{j,q}^i(b_{j,q} + m_j)$  and  $\alpha_{j,q}^i(b_{j,q+1} - m_j)$  respectively. Proven constructively, Theorem 4.1 ensures the linearizability.

**Theorem 4.1.** Two intervals  $\alpha_{j,q}^i[b_{j,q} + m_j, b_{j,q+1} - m_j]$  and  $[l_{j,q}^i, r_{j,q}^i]$  are identical only when

$$\begin{aligned}l_{j,q}^i &\in [-M, b_{j,q} + m_j] + M(1 - \alpha_{j,q}^i) \\ l_{j,q}^i &\in [b_{j,q} + m_j, M] - M(1 - \alpha_{j,q}^i) \\ r_{j,q}^i &\in [-M, b_{j,q+1} - m_j] + M(1 - \alpha_{j,q}^i) \\ r_{j,q}^i &\in [b_{j,q+1} - m_j, M] - M(1 - \alpha_{j,q}^i).\end{aligned}$$

*Proof.* It suffices to show that  $l_{j,q}^i = \alpha_{j,q}^i(b_{j,q} + m_j)$  under the given constraints because substitution  $b_{j,q}$  and  $m_j$  with  $b_{j,q+1}$  and  $-m_j$  results in the expression for  $r_{j,q}^i$ . The equivalent condition for the nonlinear product is given by for sufficiently large positive  $M_1$ ,  $M_2$ ,  $M_3$  and  $M_4$

$$l_{j,q}^i = \begin{cases} 0, & \text{for } \alpha_{j,q}^i = 0 \\ b_{j,q} + m_j, & \text{for } \alpha_{j,q}^i = 1 \end{cases}$$

$$\in \begin{cases} [-M_1, 0] \cap [0, M_2], & \text{for } \alpha_{j,q}^i = 0 \\ [b_{j,q} + m_j, M_3] \cap [-M_4, b_{j,q} + m_j], & \text{for } \alpha_{j,q}^i = 1. \end{cases}$$

Consider how each interval changes when  $\alpha_{j,q}^i$  moves from 0 to 1:

$$[b_{j,q} + m_j, M_3] = [-M_1, 0] + [b_{j,q} + m_j + M_1, M_3]$$

$$[-M_4, b_{j,q} + m_j] = [0, M_2] + [-M_4, b_{j,q} + m_j - M_2].$$

Hence the translations are given by  $(1 - \alpha_{j,q}^i)[b_{j,q} + m_j + M_1, M_3]$  and  $(1 - \alpha_{j,q}^i)[-M_4, b_{j,q} + m_j - M_2]$ . To remove all nonlinear terms, choose  $M_1$  and  $M_2$  such that  $b_{j,q} + m_j + M_1$  and  $b_{j,q} + m_j - M_2$  are constant. One example of such the ordered tuple  $(M_1, M_2, M_3, M_4)$  is  $(M - b_{j,q} - m_j, M + b_{j,q} + m_j, M, M)$ .  $\square$

Governed by a boolean variable  $\gamma_\beta^i$ , an instance  $x^i \in \mathbb{R}^d$  is also located in one of these boxes labeled by  $0 \leq \beta \leq B - 1$ :

$$\sum_{j=1}^d \left[ \prod_{j_0=0}^{j-1} (p_{j_0} + 1) \right] \left[ \sum_{q=0}^{p_j} q \alpha_{j,q}^i \right] = \sum_{\beta=0}^{B-1} \beta \gamma_\beta^i$$

$$\sum_{\beta=0}^{B-1} \gamma_\beta^i = 1$$

$$\gamma_\beta^i \in \{0, 1\}.$$

By majority voting, a decision box  $\beta$  therefore predicts exactly one class label from the following set

$$\Theta_\beta = \operatorname{argmax}_{0 \leq k \leq n} \left\{ \sum_{i=1}^N y_k^i \gamma_\beta^i \right\}.$$

In total, there are

$$N - \sum_{\beta=0}^{B-1} \max_{0 \leq k \leq n} \left\{ \sum_{i=1}^N y_k^i \gamma_\beta^i \right\} = N + \sum_{\beta=0}^{B-1} \min_{0 \leq k \leq n} \left\{ - \sum_{i=1}^N y_k^i \gamma_\beta^i \right\}$$

misclassified instances.

**Theorem 4.2.** The optimal value of the program

$$\begin{aligned}
& \text{minimize} && h_\beta \\
& \text{subject to} && h_\beta + \sum_{i=1}^N y_k^i \gamma_\beta^i + N z_{\beta,k} \geq 0, \\
& && \sum_{k=0}^n z_{\beta,k} = n, \\
& && z_{\beta,k} \in \{0, 1\}
\end{aligned}$$

is given by

$$\min_{0 \leq k \leq n} \left\{ - \sum_{i=1}^N y_k^i \gamma_\beta^i \right\}.$$

*Proof.* Let  $\mathcal{P}$  be the original problem. It can be partitioned into  $n + 1$  subproblems, each of which  $\mathcal{P}_{k_0}$  for  $0 \leq k_0 \leq n$  has the following restriction:

$$z_{\beta,k} = \begin{cases} 0, & \text{for } k = k_0 \\ 1, & \text{for } k \neq k_0. \end{cases}$$

For each subproblem  $\mathcal{P}_{k_0}$ ,

$$h_\beta \geq - \sum_{i=1}^N y_{k_0}^i \gamma_\beta^i = 0 - \sum_{i=1}^N y_{k_0}^i \gamma_\beta^i \geq - \sum_{i=1}^N y_k^i \gamma_\beta^i - N z_{\beta,k}$$

and this implies

$$\min(\mathcal{P}_{k_0}) = - \sum_{i=1}^N y_{k_0}^i \gamma_\beta^i.$$

Hence

$$\min(\mathcal{P}) = \min_{0 \leq k_0 \leq n} (\min(\mathcal{P}_{k_0})) = \min_{0 \leq k_0 \leq n} \left\{ - \sum_{i=1}^N y_{k_0}^i \gamma_\beta^i \right\}.$$

□

By Theorems 4.1 and 4.2, the selection model for continuous dataset is given by

$$\begin{aligned}
& \text{minimize} && \sum_{\beta=0}^{B-1} h_\beta \\
& \text{subject to} && \sum_{\tilde{j}=1}^{\tilde{d}} c_{j,\tilde{j}} \leq 1, \\
& && \sum_{j=1}^d c_{j,\tilde{j}} \leq 1, \\
& && b_{j,q+1} - b_{j,q} \geq 0,
\end{aligned}$$



$$\begin{aligned}
& \sum_{j=1}^d \tilde{x}_{j,\tilde{j}}^i c_{j,\tilde{j}} - \sum_{q=0}^{p_j} l_{j,q}^i \geq 0, \\
& \sum_{j=1}^d \tilde{x}_{j,\tilde{j}}^i c_{j,\tilde{j}} - \sum_{q=0}^{p_j} r_{j,q}^i \leq 0, \\
& l_{j,q}^i + M\alpha_{j,q}^i \geq 0, \\
& l_{j,q}^i - M\alpha_{j,q}^i \leq 0, \\
& l_{j,q}^i - b_{j,q} + M\alpha_{j,q}^i \leq M + m_j, \\
& l_{j,q}^i - b_{j,q} - M\alpha_{j,q}^i \geq -M + m_j, \\
& r_{j,q}^i + M\alpha_{j,q}^i \geq 0, \\
& r_{j,q}^i - M\alpha_{j,q}^i \leq 0, \\
& r_{j,q}^i - b_{j,q+1} + M\alpha_{j,q}^i \leq M - m_j, \\
& r_{j,q}^i - b_{j,q+1} - M\alpha_{j,q}^i \geq -M - m_j, \\
& \sum_{j=1}^d \left[ \prod_{j_0=0}^{j-1} (p_{j_0} + 1) \right] \left[ \sum_{q=0}^{p_j} q\alpha_{j,q}^i \right] - \sum_{\beta=0}^{B-1} \beta\gamma_{\beta}^i = 0, \\
& \sum_{q=0}^{p_j} \alpha_{j,q}^i = 1, \\
& \sum_{\beta=0}^{B-1} \gamma_{\beta}^i = 1, \\
& h_{\beta} + \sum_{i=1}^N y_k^i \gamma_{\beta}^i + Nz_{\beta,k} \geq 0, \\
& \sum_{k=0}^n z_{\beta,k} = n, \\
& l_{j,q}^i, r_{j,q}^i, b_{j,q}, h_{\beta} \in \mathbb{R}, \\
& c_{j,\tilde{j}}, \alpha_{j,q}^i, \gamma_{\beta}^i, z_{\beta,k} \in \{0, 1\}
\end{aligned}$$

where the artificial splitting values  $b_{j,0}$  and  $b_{j,p_j+1}$  are also treated as decision variables, and it produces a training accuracy of

$$1 + \frac{\sum_{\beta=0}^{B-1} h_{\beta}^*}{N} \leq 1.$$

## 4.2 Selection of Mixed-Type Features

More generally, a training instance  $\tilde{x}^i \in \mathbb{R}^{\tilde{d}}$  has a mixed-type component  $\tilde{x}_j^i \in \mathbb{R}$  in feature  $\tilde{j}$ . The index sets of continuous and categorical features are denoted by  $\tilde{\mathcal{C}}_{\text{cont}}$  and  $\tilde{\mathcal{C}}_{\text{cat}}$  where

$$\tilde{\mathcal{C}}_{\text{cont}} \cup \tilde{\mathcal{C}}_{\text{cat}} = \{1, 2, \dots, \tilde{d}\}.$$

The continuous features are initially selected, whereas all categorical features are kept. The latter will be subsequently selected. The sets  $\mathcal{C}_{\text{cont}}$  and  $\mathcal{C}_{\text{cat}}$  represent new continuous and intermediate categorical components respectively where

$$\begin{aligned} |\mathcal{C}_{\text{cont}}| &\leq |\tilde{\mathcal{C}}_{\text{cont}}| \\ |\mathcal{C}_{\text{cat}}| &= |\tilde{\mathcal{C}}_{\text{cat}}| \\ \mathcal{C}_{\text{cont}} \cup \mathcal{C}_{\text{cat}} &= \{1, 2, \dots, d\}. \end{aligned}$$

These conditions above can be satisfied specifically, as illustrated on the health insurance dataset in Chapter 5, when  $\mathcal{C}_{\text{cont}} \subseteq \tilde{\mathcal{C}}_{\text{cont}}$  and  $\mathcal{C}_{\text{cat}} = \tilde{\mathcal{C}}_{\text{cat}}$ , for instance. In the case of continuous data type, the constraints of feature selection become

$$\begin{aligned} x_j^i &= \sum_{\tilde{j} \in \tilde{\mathcal{C}}_{\text{cont}}} c_{j,\tilde{j}} \tilde{x}_{\tilde{j}}^i, & j \in \mathcal{C}_{\text{cont}} \\ \sum_{\tilde{j} \in \tilde{\mathcal{C}}_{\text{cont}}} c_{j,\tilde{j}} &\leq 1, & j \in \mathcal{C}_{\text{cont}} \\ \sum_{j \in \mathcal{C}_{\text{cont}}} c_{j,\tilde{j}} &\leq 1, & \tilde{j} \in \tilde{\mathcal{C}}_{\text{cont}} \\ c_{j,\tilde{j}} &\in \{0, 1\}, & (j, \tilde{j}) \in \mathcal{C}_{\text{cont}} \times \tilde{\mathcal{C}}_{\text{cont}}. \end{aligned}$$

Since at most  $|\mathcal{C}_{\text{cont}}|$  out of  $|\tilde{\mathcal{C}}_{\text{cont}}|$  continuous features are selected, the following condition holds:

$$\sum_{(j,\tilde{j}) \in \mathcal{C}_{\text{cont}} \times \tilde{\mathcal{C}}_{\text{cont}}} c_{j,\tilde{j}} \leq |\mathcal{C}_{\text{cont}}|.$$

A selected, rearranged component  $x_j^i \in \mathbb{R}$  for a feature  $1 \leq j \leq d$  is now either continuous or categorical. A continuous feature  $j \in \mathcal{C}_{\text{cont}}$  is similarly assumed to have  $p_j$  splitting points, namely  $b_{j,q} \in \mathbb{R}$  where  $1 \leq q \leq p_j$ . Usually,  $p_j$  is assumed to be constant across all new continuous features because the new explicit order of this selection is unknown before optimization. A categorical feature  $j \in \mathcal{C}_{\text{cat}}$  comprises finite discrete values which are also assumed to form  $p_j + 1$  new small groups labeled with  $0 \leq u_j \leq p_j$ .

A box  $0 \leq \beta \leq B - 1$  along a categorical feature, as opposed to a continuous feature, lacks continuity because its entry is simply a singleton. Algebraically, it is represented by a set

$$S_\beta = \prod_{j \in \mathcal{C}_{\text{cont}}} \sum_{q=0}^{p_j} \beta_{j,q} [b_{j,q}, b_{j,q+1}] \times \prod_{j \in \mathcal{C}_{\text{cat}}} \{u_j\}$$

where

$$\begin{aligned} \beta &= \sum_{j \in \mathcal{C}_{\text{cont}}} \left[ \prod_{0 \leq j_0 < j} (p_{j_0} + 1) \right] \left[ \sum_{q=0}^{p_j} q \beta_{j,q} \right] \\ &\quad + \sum_{j \in \mathcal{C}_{\text{cat}}} \left[ \prod_{0 \leq j_0 < j} (p_{j_0} + 1) \right] u_j \\ \sum_{q=0}^{p_j} \beta_{j,q} &= 1, & j \in \mathcal{C}_{\text{cont}} \\ \beta_{j,q} &\in \{0, 1\}, & j \in \mathcal{C}_{\text{cont}} \\ u_j &\in \{0, 1, \dots, p_j\}, & j \in \mathcal{C}_{\text{cat}} \end{aligned}$$

and  $p_0 = 0$ . The existence of  $b_{j,0}$  and  $b_{j,p_j+1}$  where  $j \in \mathcal{C}_{\text{cat}}$  is shown in the previous section. Numerically, each box can also be identified by the unique combination of binary  $(\beta_{j,q})_{j \in \mathcal{C}_{\text{cont}}}$  and integer  $(u_j)_{j \in \mathcal{C}_{\text{cat}}}$ .

For a categorical feature  $j \in \mathcal{C}_{\text{cat}}$ , an original categorical label  $x_j^i \in \mathbb{R}$  is reassigned to a new integer group label  $0 \leq v_{j,x_j^i} \leq p_j$ . As a result, the following conditions must hold:

$$\begin{aligned} \sum_{\beta=0}^{B-1} \beta \gamma_\beta^i &= \sum_{j \in \mathcal{C}_{\text{cont}}} \left[ \prod_{0 \leq j_0 < j} (p_{j_0} + 1) \right] \left[ \sum_{q=0}^{p_j} q \alpha_{j,q}^i \right] \\ &\quad + \sum_{j \in \mathcal{C}_{\text{cat}}} \left[ \prod_{0 \leq j_0 < j} (p_{j_0} + 1) \right] v_{j,x_j^i} \\ \sum_{q=0}^{p_j} \alpha_{j,q}^i &= 1, & j \in \mathcal{C}_{\text{cont}} \\ \sum_{\beta=0}^{B-1} \gamma_\beta^i &= 1, \\ \beta_{j,q} &\in \{0, 1\}, & j \in \mathcal{C}_{\text{cont}} \\ v_{j,x_j^i} &\in \{0, 1, \dots, p_j\}, & j \in \mathcal{C}_{\text{cat}}. \end{aligned}$$

A boolean variable  $f_j \in \{0, 1\}$  is defined to determine whether a categorical feature  $j$  is significant. All categorical labels of an insignificant feature are grouped together. Its necessary, though insufficient, condition can be obtained:

$$-M f_j \leq v_{j,x_j^i} \leq M f_j.$$

If at most  $d_{\text{cat}}$  out of  $|\mathcal{C}_{\text{cat}}|$  categorical features are of interest, the following condition holds:

$$\sum_{j \in \mathcal{C}_{\text{cat}}} f_j \leq d_{\text{cat}}.$$

There are at most  $|\mathcal{C}_{\text{cont}}| + d_{\text{cat}} \leq d \leq \tilde{d}$  contributing factors,  $|\mathcal{C}_{\text{cont}}| \leq |\tilde{\mathcal{C}}_{\text{cont}}|$  of which are continuous and  $d_{\text{cat}} \leq |\mathcal{C}_{\text{cat}}| = |\tilde{\mathcal{C}}_{\text{cat}}|$  categorical:

$$\sum_{(j, \tilde{j}) \in \mathcal{C}_{\text{cont}} \times \tilde{\mathcal{C}}_{\text{cont}}} c_{j, \tilde{j}} + \sum_{j \in \mathcal{C}_{\text{cat}}} f_j \leq d.$$

A continuous feature  $\tilde{j} \in \tilde{\mathcal{C}}_{\text{cont}}$  is deemed significant when

$$\sum_{j \in \mathcal{C}_{\text{cont}}} c_{j, \tilde{j}} = 1,$$

and for an original categorical feature  $\tilde{j} \in \tilde{\mathcal{C}}_{\text{cat}}$  corresponding to  $j \in \mathcal{C}_{\text{cat}}$  a new group label  $v_{j, x_j^i}$  is nonconstant across all training instances  $x^i$ .

The final selection model is proposed:

$$\text{minimize} \quad \sum_{\beta=0}^{B-1} h_{\beta}$$

subject to

$$\begin{aligned} \sum_{\tilde{j} \in \tilde{\mathcal{C}}_{\text{cont}}} c_{j, \tilde{j}} &\leq 1, & j \in \mathcal{C}_{\text{cont}}, \\ \sum_{j \in \mathcal{C}_{\text{cont}}} c_{j, \tilde{j}} &\leq 1, & j \in \tilde{\mathcal{C}}_{\text{cont}}, \\ b_{j, q+1} - b_{j, q} &\geq 0, & j \in \mathcal{C}_{\text{cont}}, \\ \sum_{\tilde{j} \in \tilde{\mathcal{C}}_{\text{cont}}} \tilde{x}_j^i c_{j, \tilde{j}} - \sum_{q=0}^{p_j} l_{j, q}^i &\geq 0, & j \in \mathcal{C}_{\text{cont}}, \\ \sum_{\tilde{j} \in \tilde{\mathcal{C}}_{\text{cont}}} \tilde{x}_j^i c_{j, \tilde{j}} - \sum_{q=0}^{p_j} r_{j, q}^i &\leq 0, & j \in \mathcal{C}_{\text{cont}}, \\ l_{j, q}^i + M \alpha_{j, q}^i &\geq 0, & j \in \mathcal{C}_{\text{cont}}, \\ l_{j, q}^i - M \alpha_{j, q}^i &\leq 0, & j \in \mathcal{C}_{\text{cont}}, \\ l_{j, q}^i - b_{j, q} + M \alpha_{j, q}^i &\leq M + m_j, & j \in \mathcal{C}_{\text{cont}}, \\ l_{j, q}^i - b_{j, q} - M \alpha_{j, q}^i &\geq -M + m_j, & j \in \mathcal{C}_{\text{cont}}, \\ r_{j, q}^i + M \alpha_{j, q}^i &\geq 0, & j \in \mathcal{C}_{\text{cont}}, \\ r_{j, q}^i - M \alpha_{j, q}^i &\leq 0, & j \in \mathcal{C}_{\text{cont}}, \\ r_{j, q}^i - b_{j, q+1} + M \alpha_{j, q}^i &\leq M - m_j, & j \in \mathcal{C}_{\text{cont}}, \\ r_{j, q}^i - b_{j, q+1} - M \alpha_{j, q}^i &\geq -M - m_j, & j \in \mathcal{C}_{\text{cont}}, \end{aligned}$$

$$\begin{aligned}
& \sum_{j \in \mathcal{C}_{\text{cont}}} \left[ \prod_{0 \leq j_0 < j} (p_{j_0} + 1) \right] \left[ \sum_{q=0}^{p_j} q \alpha_{j,q}^i \right] \\
& + \sum_{j \in \mathcal{C}_{\text{cat}}} \left[ \prod_{0 \leq j_0 < j} (p_{j_0} + 1) \right] v_{j,x_j^i} \\
& - \sum_{\beta=0}^{B-1} \beta \gamma_{\beta}^i = 0, \\
& \sum_{q=0}^{p_j} \alpha_{j,q}^i = 1, \quad j \in \mathcal{C}_{\text{cont}}, \\
& v_{j,x_j^i} + M f_j \geq 0, \quad j \in \mathcal{C}_{\text{cat}}, \\
& v_{j,x_j^i} - M f_j \leq 0, \quad j \in \mathcal{C}_{\text{cat}}, \\
& \sum_{(j,\tilde{j}) \in \mathcal{C}_{\text{cont}} \times \tilde{\mathcal{C}}_{\text{cont}}} c_{j,\tilde{j}} + \sum_{j \in \mathcal{C}_{\text{cat}}} f_j \leq d, \\
& \sum_{\beta=0}^{B-1} \gamma_{\beta}^i = 1, \\
& h_{\beta} + \sum_{i=1}^N y_k^i \gamma_{\beta}^i + N z_{\beta,k} \geq 0, \\
& \sum_{k=0}^n z_{\beta,k} = n, \\
& l_{j,q}^i, r_{j,q}^i, b_{j,q} \in \mathbb{R}, \quad j \in \mathcal{C}_{\text{cont}}, \\
& h_{\beta} \in \mathbb{R}, \\
& c_{j,\tilde{j}} \in \{0, 1\}, \quad (j, \tilde{j}) \in \mathcal{C}_{\text{cont}} \times \tilde{\mathcal{C}}_{\text{cont}}, \\
& \alpha_{j,q}^i \in \{0, 1\}, \quad j \in \mathcal{C}_{\text{cont}}, \\
& f_j \in \{0, 1\}, \quad j \in \mathcal{C}_{\text{cat}}, \\
& v_{j,x_j^i} \in \{0, 1, \dots, p_j\}, \quad j \in \mathcal{C}_{\text{cat}}, \\
& \alpha_{j,q}^i, \gamma_{\beta}^i, z_{\beta,k} \in \{0, 1\}.
\end{aligned}$$

### 4.3 CPLEX OPL Modeling

The proposed classifier heavily relies on 0-1 mixed integer programming (MIP). The CPLEX optimizer (version 22.1.1) is used to solve for the classifier including its splitting values and the set of predicted class labels in each decision box. Although achieving higher performance, manual adjustment of internal optimization procedures such as a node selection during branching and a combination of multiple techniques in cut generation is beyond the scope of this dissertation. The MIP problem is very large, and its information is stored in a huge tree data structure. Multiple lock-free nodes can be executed simultaneously in parallel by utilizing all available CPU cores. CPLEX uses in-memory computation.

When a central memory is consumed more than its upper limit which is 2048 MB by default, some nodes are transferred from the in-memory set to node files which are also in memory and compressed by default. Optionally, they can be flushed to disk, in either uncompressed or compressed form, where speed is sacrificed for more storage space. As more solutions are explored, the branch-and-cut tree grows larger. When its size exceeds its upper limit, which is set at  $10^{75}$  MB by default, the optimization process terminates. The solver also stops when a memory is exhausted or a disk is fully occupied depending on whether node files are stored in memory or on disk. CPLEX parameters related to this dissertation is included in Table 4.1.

Table 4.1: Relevant CPLEX parameters

| Parameter                      | Description   |
|--------------------------------|---|
| <code>cplex.intsollim</code>   | MIP solution number limit   |
| <code>cplex.tilim</code>       | Time limit per optimizer call (in seconds)  |
| <code>cplex.threads</code>     | Parallel threads (default: 0 implying up to 32 threads)   |
| <code>cplex.workmem</code>     | Working memory before compression and swap (in MB) (default: 2048)  |
| <code>cplex.treelim</code>     | Uncompressed tree limit (in MB) (default: $10^{75}$ )   |
| <code>cplex.nodefileind</code> | Node storage file switch<br>0: No node file<br>1: Node file in memory and compressed (default)<br>2: Node file on disk<br>3: Node file on disk and compressed |
| <code>cplex.status</code>      | Solution status code<br>1: Optimal for simplex and barrier methods  |

Table 4.1: Relevant CPLEX parameters (continued)

| Parameter | Description  |
|-----------|--|
|           | 11: Time limit exceeded                                    |
|           | 101: Optimal for MIP model                                 |
|           | 102: Optimal within predefined MIP gap tolerance           |
|           | 104: Limit on mixed integer solutions                      |
|           | 111: Tree memory limit exceeded and integer solution found |
|           | 112: Tree memory limit exceeded and no integer solution    |

Two following classification files are written in Optimization Programming Language (OPL), supported by default. Code 4.1 is the main execution of the classification model in Code 4.2. Two data structures are employed: an array and a tuple. Once the first is declared, its size is unchanged. The latter is used as a secondary option only when a combination of indexes cannot perfectly fit in an array format. As illustrated in Chapter 5, only three features are considered: A\_AGE, PEMLR and SS\_YN. Three splits are assumed except two for SS\_YN representing both whether social security payments are paid and whether a survey participant is in the universe of this question. Two most significant factors are of interest. The cardinality of a new continuous component  $|\mathcal{C}_{\text{cont}}|$  is assumed to be the minimum of its given counterpart  $|\tilde{\mathcal{C}}_{\text{cont}}| = 1$  and an upper bound on the number of significant features  $d = 2$ . The continuous feature selection can be partially concluded by the condition  $c_{j,\tilde{j}}^* = 1$ . The sufficiently small positive number  $m_0$  is set to be 0.01. The execution time is limited up to 24 hours or one day. Code 4.1 records every MIP solution, feasible but not necessarily optimal, thereby calling a CPLEX solver multiple times. After the working memory exceeds 2 GB, some nodes are transferred to disk in compressed form. The uncompressed tree size is limited to 200 GB.

Code 4.1: Main OPL model

```

1  /*****
2   * OPL 22.1.1.0 Model
3   * Author: songkomkrit
4   * Creation Date: Nov 4, 2024 at 12:24:05 AM
5   *****/
6

```

```

7  /*****
8  * NOTES
9  * pl.bc.solutionValue[thisOplModel.mPairs.find(1,0)]
10 *****/
11
12 /*****
13 * Class Labels
14 * Input file: 0, 1, 2, ..., n
15 * Algorithm: 0, 1, 2, ..., n
16 * Output file: 0, 1, 2, ..., n
17 *****/
18
19 /*****
20 * INPUTS
21 *****/
22 int mdimold = 3; // dimension    // 4 or 184 or 8 or 4
23 int mdimcontold = 1; // continuous dimension // 2 or 66 or 3 or 2
24 //int mdimcat = 2; // categorical dimension // 2 or 118 or 5 or 2
25 int mN = 100; // number of instances // 8 or 157681 or 100 or 100
26 int mn = 4; // the value of n = (number of classes) - 1 // 1 or 4 or 4
27
28 int mseltol = 2; // given number of total selected cont/cat dimensions (at
    most)
29
30 // Initialized UB on number of selected continuous dimensions
31 int mselcont = mdimcontold;
32 execute {
33     if (mselcont > mseltol)
34         mselcont = mseltol;
35 }
36
37 int mexcccont = mdimcontold - mselcont; // computed LB on number of
    excluded continuous dimensions
38 int mdim = mdimold - mexcccont;
39 int mdimcont = mselcont;
40

```



```

41 range mDS = 1..mdim;
42 range mDSCONTOLD = 1..mdimcontold; // old continuous
43 range mDSCONT = 1..mselcont; // new continuous
44 range mDSCAT = mdimcont+1..mdim; // shifted categorical
45 range mIS = 1..mN;
46 float mxcontold[mIS][mDSCONTOLD]; // x along continuous dimensions
47 int mxcat[mIS][mDSCAT]; // x along categorical dimensions
48 int my[mIS];
49 int mmaxlab[mDSCAT]; // maximum labels for categorical dimensions
50 float mM[mDS]; // big-M for all new/shifted dimensions (continuous and
    categorical)
51 float mm[mDSCONT]; // small-m for continuous dimensions
52 int mp[mDS]; // number of cuts along axes
53 int mcoef[mDS];
54
55 /*****
56  * TUPLES
57  *****/
58 tuple ContPairType { // index for continuous cut
59     int j;
60     int q;
61 };
62
63 {ContPairType} mContPairs = {<j, q> | j in mDSCONT, q in 0..mp[j]+1};
64
65 tuple ContTripleType { // index for continuous cut of each individual
    instance
66     int i;
67     int j;
68     int q;
69 };
70
71 {ContTripleType} mContTriples = {<i, j, q> | i in mIS, j in mDSCONT, q in
    0..mp[j]};
72
73 tuple CatPairType { // index for categorical group

```

```

74     int j;
75     int l;
76 };
77
78 {CatPairType} mCatPairs = {<j, l> | j in mDSCAT, l in 0..mmaxlab[j]};
79
80 tuple tuplePred {
81     key int b;
82     sorted {int} label;
83 }
84 sorted {tuplePred} mpred;
85 {int} memptyset = {};
86
87 /*****
88  * OUTSIDE EXECUTION
89  *****/
90 execute {
91     thisOplModel.settings.run_engineLog = "tmp/current-engine.log"; //
        temporary engine log
92 }
93
94 /*****
95  * MAIN EXECUTION
96  *****/
97 main {
98     var ftime = Opl.round((new Date()).getTime()/1000) % 100000; // first
        timestamp (in seconds)
99
100    // Input/variable filenames
101    var infilename = "input/seltrain20num3each20.csv"; // input filename
102    var varfilename = "input/selproc20num3co3ca3cutinfo.csv"; // variable
        filename (6 columns)
103
104    // Prefix of all output files
105    var prefixout = "output/" + ftime + "-";
106    prefixout += infilename.split("/")[1].split(".")[0] + "-";

```

```

107
108     // Inputs
109     //var M0 = 500;    // big-M (float)
110     var m0 = 0.01;    // small-m (float)
111     var pcont0 = 3;    // max number of cuts along continuous axis (integer)
112
113     // Customization
114     var timelimit = 1; // whether set total time limits (1 = limit / 0 =
                        // none)
115     var limit = 1;    // whether customize performance settings (1 =
                        // customize / 0 = none)
116     var perf = 1;    // whether set limits (1 = limit / 0 = none)
117
118     // Custom time limit parameter
119     if (timelimit == 1)
120         var acctimelimmin = 24*60; // accumulated time limit (in minutes)
121
122     // Cplex limit parameters (excluding time limit)
123     if (limit == 1) {
124         var intsollim = 1; // MIP solution number limit (in each iteration)
125     }
126
127     // Cplex performance parameters
128     if (perf == 1) {
129         var threads = 0; // parallel threads (default: 0 = at most 32
                        // threads)
130         var workmemgb = 2; // working memory before compression and swap (
                        // in GB) (default: 2 GB) (only marginally improved efficiency)
131         var trelimgb = 200; // uncompressed tree memory limit (in GB) (
                        // default: around 1e+72 GB)
132
133         /* Node storage file switch
134         * 0 = No node file
135         * 1 = Node file in memory and compressed (default)
136         * 2 = Node file on disk
137         * 3 = Node file on disk and compressed

```

```

138      */
139      var nodefileind = 3;
140
141      /* Note on directory for temporary working files
142      * cplex.workdir = ...;
143      * CPLEX Error 1422: Could not open file for writing
144      */
145
146      // Calculation
147      var workmem = 1024*workmemgb; // working memory before compression
          and swap (in MB) (default: 2048 MB)
148      var trelim = 1024*trelimgb; // uncompressed tree memory limit (in
          MB) (default: 1e+75 MB)
149  }
150
151  // Postfixes
152  var cpostfixname = "mfullaltseltol-" + thisOplModel.mseltol; // common
          postfix name
153  if (timelimit == 1)
154      cpostfixname += "-t-" + acctimelimmin + ".csv";
155  else
156      cpostfixname += ".csv";
157  var postfixerror = "-" + cpostfixname; // postfix of error file
158  var postfixout = "-pcont-" + pcont0 + "-" + cpostfixname; // postfix of
          all other output files
159
160  // Output filenames
161  var outerrorname = prefixout + "export-error" + postfixerror;
162  var outinstancename = prefixout + "export-predict-instance" +
          postfixout;
163  var outcutcontname = prefixout + "export-cutcont-full" + postfixout;
164  var outcutcatname = prefixout + "export-cutcat-full" + postfixout;
165  // The existence of region is not checked here
166  // In fact, it can be check through enumeration of certain binary
          representations
167  var outregionname = prefixout + "export-predict-region" + postfixout;

```

```

168     var outselvarintname = prefixout + "export-select-var-int" + postfixout
        ; // selected variables (integer)
169     var outselvarstrname = prefixout + "export-select-var-str" + postfixout
        ; // selected variables (string)
170
171     // Engine log (initialized)
172     var logfilename = "log/" + ftime + "-engine-" + cpostfixname.split(".")
        [0] + ".log";
173     var outlog = new IloOplOutputFile(logfilename);
174
175     // OPL
176     var source = new IloOplModelSource("p-mixed-cuts-alt-seltol.mod");
177     var cplex = new IloCplex();
178     var def = new IloOplModelDefinition(source);
179     var opl = new IloOplModel(def,cplex);
180     var data = new IloOplDataElements();
181
182     data.dimold = thisOplModel.mdimold;
183     data.dimcontold = thisOplModel.mdimcontold;
184     data.dim = thisOplModel.mdim;
185     data.dimcont = thisOplModel.mdimcont;
186     //data.dimcat = thisOplModel.mdimcat;
187     data.N = thisOplModel.mN;
188     data.n = thisOplModel.mn;
189     data.xcontold = thisOplModel.mxcontold;
190     data.xcat = thisOplModel.mxcat;
191     data.y = thisOplModel.my;
192
193     var pred = thisOplModel.mpred; // set of predicted labels
194
195     data.seltol = thisOplModel.mseltol;
196     data.selcont = thisOplModel.mselcont;
197     data.exccont = thisOplModel.mexccont;
198
199     data.m = thisOplModel.mm;
200     for (var j=1; j<=data.dimcont; j++)

```

```

201     data.m[j] = m0;
202
203     var f = new IloOplInputFile(infilename); // training dataset
204     f.readline();           // skip a header
205     for (var i=1; i<=data.N; i++) {
206         var myitem = f.readline().split(",");
207         data.y[i] = Opl.intValue(myitem[data.dimold]);
208         for (var j=1; j<=data.dimcontold; j++)
209             data.xcontold[i][j] = Opl.floatValue(myitem[j-1]);
210         for (var j=data.dimcontold+1; j<=data.dimold; j++)
211             data.xcat[i][j-data.exccont] = Opl.intValue(myitem[j-1]);
212     }
213     f.close();
214
215     data.p = thisOplModel.mp;
216     for (var j=1; j<=data.dimcont; j++)
217         data.p[j] = pcont0;
218
219     data.M = thisOplModel.mM;
220     data.maxlab = thisOplModel.mmaxlab;
221     var M0cont = 1;
222     var f = new IloOplInputFile(varfilename); // variable info
223     f.readline();           // skip a header
224     for (var j=1; j<=data.dimold; j++) {
225         var myitem = f.readline().split(",");
226         if (j <= data.dimcontold) {
227             var curMcont = 1 + Opl.max1(Opl.abs(Opl.intValue(myitem[3])),
228                                         Opl.abs(Opl.intValue(myitem[4])));
229             M0cont = Opl.max1(M0cont, curMcont);
230         }
231         else {
232             data.p[j-data.exccont] = Opl.intValue(myitem[5]);
233             data.maxlab[j-data.exccont] = Opl.intValue(myitem[4]);
234             data.M[j-data.exccont] = 1 + Opl.intValue(myitem[5]);
235         }
236     }

```

```

236     f.close();
237
238     for (var j=1; j<=data.dimcont; j++)
239         data.M[j] = M0cont;
240
241     data.coef = thisOplModel.mcoef;
242     data.coef[1] = 1;
243     for (var j=2; j<=data.dim; j++)
244         data.coef[j] = data.coef[j-1]*(data.p[j]+1);
245
246     var nump = 0; // total number of cuts
247     for (var j=1; j<=data.dim; j++)
248         nump += data.p[j];
249
250     opl.addDataSource(data);
251     opl.generate();
252     opl.settings.mainEndEnabled = true;
253
254     // Cplex limits (excluding time limit)
255     if (limit == 1) {
256         cplex.intsollim = intsollim; // MIP solution number limit (> 0)
257     }
258
259     // Cplex performance
260     if (perf == 1) {
261         cplex.threads = threads; // parallel threads
262         cplex.workmem = workmem; // working memory before compression and
            swap (in MB)
263         cplex.treelim = treelim; // uncompressed tree memory limit (in MB)
264         cplex.nodefileind = nodefileind; // node storage file switch
265     }
266
267     // Initialization
268     var status = -9; // solution status code (initialized)
269     var iter = 0; // iteration
270     var acctime = 0; // accumulated running time (in seconds)

```

```

271     var texceed = 0; // whether acctime > tilimmin (1 = total time limit
        exceeded / 0 = not)

272
273     // Calculation
274     if (timelimit == 1)
275         var acctimelim = 60*acctimelimmin; // accumulated time limit (in
            seconds)
276     else
277         var acctimelim = -1;
278
279     // Optimization
280     while (texceed == 0) { // accumulated time limit not exceeded
281
282         // Exit status codes
283         if (status == 1) // 1: CPX_STAT_OPTIMAL
284             break;
285         else if (status == 101) // 101: CPXMIP_OPTIMAL
286             break;
287         else if (status == 102) // 102: CPXMIP_OPTIMAL_TOL
288             break;
289         else if (status == 111) // 111: CPXMIP_MEM_LIM_FEAS
290             break;
291         else if (status == 112) // 112: CPXMIP_MEM_LIM_INFEAS
292             break;
293
294         /* Non-exit status codes
295         * 11: CPX_STAT_ABORT_TIME_LIM
296         * 104: CPXMIP_SOL_LIM
297         */
298
299         // In the case when the previous status is not one of the above
300         if (timelimit == 1) // time limit for each call to optimizer (in
            seconds)
301             cplex.tilim = acctimelim - acctime;
302         var start = new Date(); // begin a timer
303

```



```

304     pred.clear(); // clear previous set of predicted labels
305
306     // Solve
307     if (cplex.solve()) {
308
309         var end = new Date(); // end a timer
310         var solvetime = end.getTime() - start.getTime(); // compute
            solving time
311         acctime += solvetime/1000; // accumulated running time (in s)
312
313         if ((timelimit == 1) && (acctime >= acctimelim)) // total time
            limit exceeded (in seconds)
314             texceed = 1;
315
316         iter += 1; // update iteration
317
318         var error = data.N + cplex.getObjValue(); // the number of
            misclassified instances
319         var accuracy = (1-error/data.N)*100; // training accuracy
320
321         status = cplex.status; // solution status code (1 = opt / 11 =
            time limit / ...)
322         var lberr = data.N + cplex.getBestObjValue(); // LB on minimum
            (optimal) error
323         var relgap = cplex.getMIPRelativeGap(); // relative objective
            gap for MIP
324
325         // Open output text files (append = true)
326         var outerror = new IloOplOutputFile(outerrorname, true);
327         var outinstance = new IloOplOutputFile(outinstancename, true);
328         var outcutcont = new IloOplOutputFile(outcutcontname, true);
329         var outcutcat = new IloOplOutputFile(outcutcatname, true);
330         var outregion = new IloOplOutputFile(outregionname, true);
331         var outselvarint = new IloOplOutputFile(outselvarintname, true);

```

```

332     var outselvarstr = new IloOplOutputFile(outselvarstrname, true);

333
334     // outerror
335     if (!outerror.exists) {
336         outerror.write("iter,");
337         for (var j=1; j<=data.dim; j++)
338             outerror.write("p", j, ",");
339         outerror.write("error,accuracy,ms,acctmin,status,lberr,
            relgap");
340     }
341     outerror.write("\n", iter, ",");
342     for (var j=1; j<=data.dim; j++)
343         outerror.write(data.p[j], ",");
344     outerror.write(error, ",", accuracy, ",");
345     outerror.write(solvetime, ",", acctime/60, ",");
346     outerror.write(status, ",", lberr, ",", relgap);
347
348     // Scripting logs 1
349     writeln("\n-----");
350     writeln("Iteration ", iter);
351     writeln("Bounds on # of cuts = ", nump, " with", data.p);
352     writeln("Error = ", error, " (out of ", data.N, " instances)");
353     writeln("Accuracy = ", accuracy);
354     writeln("Solving time = ", solvetime/60000, " min (minutes)");
355     writeln("Accumulated time = ", acctime/60, " min (minutes)");
356     writeln("\nSolution status code = ", status);
357     writeln("LB on error = ", lberr);
358     writeln("Relative objective gap = ", relgap);
359     writeln("\nSelected variables:");
360
361     // Create a set of predicted labels (majority voting)
362     for (var b=0; b<opl.B; b++) {
363         var lset = Opl.operatorUNION(thisOplModel.emptyset,
            thisOplModel.emptyset);
364         var maxnum = 0;

```

```

365         for (var k=0; k<=data.n; k++) {
366             var num = 0;
367             for (var i=1; i<=data.N; i++)
368                 num += (data.y[i] == k)*opl.g.solutionValue[i][b];

369             if (num == maxnum)
370                 lset.add(k);
371             else if (num > maxnum) {
372                 maxnum = num;
373                 lset.clear();
374                 lset.add(k);
375             }
376         }
377         pred.add(b, lset);
378     }
379
380     // outinstance
381     if (!outinstance.exists)
382         outinstance.write("iter,id,class,region,predict");
383     for (var i=1; i<=data.N; i++) {
384         outinstance.write("\n", iter, ",", i, ",", data.y[i], ",");
385         for (var b=0; b<opl.B; b++)
386             if (opl.g.solutionValue[i][b] == 1) { // occur only once
387                 outinstance.write(b, ",");
388                 outinstance.write(pred.get(b).label);
389                 break; // terminate the loop
390             }
391     }
392
393     // outcutcont
394     if (!outcutcont.exists)
395         outcutcont.write("iter,j,q,bc");
396     for (var j=1; j<=data.dimcont; j++) {
397         for (var q=1; q<=data.p[j]; q++) {
398             outcutcont.write("\n", iter, ",", j, ",", q, ",");

```

```

399         outcutcont.write(opl.bc.solutionValue[thisOplModel.
              mContPairs.find(j,q)]);
400     }
401 }
402
403 // outcutcat
404 if (!outcutcat.exists)
405     outcutcat.write("iter,j,l,v");
406 for (var j=data.dimcont+1; j<=data.dim; j++) {
407     for (var l=0; l<=data.maxlab[j]; l++) {
408         outcutcat.write("\n", iter, ",", j, ",", l, ",");
409         outcutcat.write(opl.v.solutionValue[thisOplModel.
              mCatPairs.find(j,l)]);
410     }
411 }
412
413 // outregion
414 if (!outregion.exists)
415     outregion.write("iter,region,occupy,predict");
416 for (var b=0; b<opl.B; b++) {
417     outregion.write("\n", iter, ",", b, ",");
418     var s = 0; // initialize s (presumably unoccupied)
419     for (var i=1; i<=data.N; i++)
420         if (opl.g.solutionValue[i][b] == 1) { // occupied
421             s = 1;
422             break; // interminate the loop
423         }
424     outregion.write(s, ",");
425     outregion.write(pred.get(b).label);
426 }
427
428 // outselvarint
429 if (!outselvarint.exists)
430     outselvarint.write("iter,j,jold,mselect,type"); // mselect =
              model select (not actual)

```

```

431     for (var j=1; j<=data.dimcont; j++) { // selected continuous
        features
432         outselvarint.write("\n", iter, ",", j, ",");
433         var seljold = -1;
434         for (var jold=1; jold<=data.dimcontold; jold++)
435             // Determine which old continuous feature is selected
436             if (opl.ccont.solutionValue[j][jold] == 1) {
437                 seljold = jold;
438                 break; // terminate the loop
439             }
440         outselvarint.write(seljold, ",");
441         outselvarint.write("1,"); // Based on model, all new cont
            features are selected
442         outselvarint.write("cont");
443     }
444     for (var j=data.dimcont+1; j<=data.dim; j++) { // categorical
        feature
445         outselvarint.write("\n", iter, ",", j, ",", j+data.exccont,
            ",");
446         if (opl.f.solutionValue[j] == 1) // selected categorical
            feature (model)
447             outselvarint.write("1,");
448         else // unselected categorical feature (model)
449             outselvarint.write("0,");
450         outselvarint.write("cat");
451     }
452
453     // outselvarstr
454     if (!outselvarstr.exists)
455         outselvarstr.write("iter,jold,jnew,aselect,type,variable");
            // aselect = actual select
456     var varinfile = new IloOplInputFile(varfilename); // variable
        info
457     varinfile.readline(); // skip a header
458     var numselcont = 0; // initialized number of actually selected
        continuous features

```

```

459     var numselcat = 0; // initialized number of actually selected
        categorical features
460     for (var jold=1; jold<=data.dimcontold; jold++) { // CONTINUOUS
461         outselvarstr.write("\n", iter, ",", jold, ",");
462         var jnew = -1;
463         var aselect = 0; // initialized to be unselected (continuous
            )
464         for (var j=1; j<=data.dimcont; j++)
465             // Determine whether a current old continuous feature is
                selected
466             if (opl.ccont.solutionValue[j][jold] == 1) { // selected
                    (actual 1/2)
467                 jnew = j;
468                 break; // terminate the loop
469             }
470         outselvarstr.write(jnew, ",");
471         var myitem = varinfile.readline().split(",");
472         if (jnew > 0) { // selected continuous feature (actual 1/2)
473             aselect = 1; // seem to be selected (initialization for
                actual 2/2)
474             for (var q=0; q<=data.p[jnew]; q++) {
475                 var bcleft = opl.bc.solutionValue[thisOplModel.
                    mContPairs.find(jnew,q)];
476                 var bcrigh = opl.bc.solutionValue[thisOplModel.
                    mContPairs.find(jnew,q+1)];
477                 var minxjnew = Opl.intValue(myitem[3]);
478                 var maxxjnew = Opl.intValue(myitem[4]);
479                 if ((bcleft <= minxjnew) && (bcrigh >= maxxjnew)) {
                    // cover [min,max]
480                     aselect = 0; // unselected (actual 2/2)
481                     break;
482                 }
483             }
484         }
485         outselvarstr.write(aselect, ",");
486         if (aselect == 1) { // actually selected continuous feature

```

```

487         // Scripting logs 2 (continuous)
488         write("\t", myitem[1], " (Continuous)\n");
489         numselcont += 1;
490     }
491     outselvarstr.write("cont,");
492     outselvarstr.write(myitem[1]); // variable name
493 }
494 for (var jold=data.dimcontold+1; jold<=data.dimold; jold++) { //
    CATEGORICAL
495     var jnew = jold-data.exccont;
496     outselvarstr.write("\n", iter, ",", jold, ",", jnew, ",");
497     var aselect = 0; // initialized to be unselected (
        categorical)
498     var myitem = varinfile.readline().split(",");
499     if (opl.f.solutionValue[jnew] == 1) { // selected
        categorical feature (actual 1/2)
500         var vat0 = opl.v.solutionValue[thisOplModel.mCatPairs.
            find(jnew,0)];
501         for (var l=1; l<=data.maxlab[jnew]; l++) {
502             var vcur = opl.v.solutionValue[thisOplModel.mCatPairs
                .find(jnew,l)];
503             if (vcur != vat0) { // distinct new groups are
                detected
504                 aselect = 1; // selected categorical feature (
                    actual 2/2)
505                 break;
506             }
507         }
508     }
509     outselvarstr.write(aselect, ",");
510     if (aselect == 1) { // actually selected categorical feature
        // Scripting logs 2 (categorical)
511         write("\t", myitem[1], " (Categorical)\n");
512         numselcat += 1;
513     }
514 }
515 outselvarstr.write("cat,");

```

```

516         outselvarstr.write(myitem[1]);
517     }
518     varinfile.close();
519
520     // Scripting logs 3
521     var numselall = numselcont + numselcat;
522     writeln("\nNumber of selected variables = ", numselall, " (",
523         numselcont, " continuous + ", numselcat, " categorical)");
524     writeln("-----");
525
526     // Closing output text files
527     outerror.close();
528     outinstance.close();
529     outcutcont.close();
530     outcutcat.close();
531     outregion.close();
532     outselvarint.close();
533     outselvarstr.close();
534 }
535 else
536     writeln("No solution");
537 }
538
539 opl.end();
540 data.end();
541 def.end();
542 cplex.end();
543 source.end();
544
545 // Engine log (exported)
546 var inlog = new IloOplInputFile("tmp/current-engine.log");
547 while (!inlog.eof) {
548     outlog.writeln(inlog.readline());
549 }
550 inlog.close();
551 outlog.close();

```



551 }

Code 4.2: Box classifier OPL model

```

1  /*****
2   * OPL 22.1.1.0 Model
3   * Author: songkomkrit
4   * Creation Date: Nov 4, 2024 at 1:15:57 AM
5   *****/
6
7  /*****
8   * DATA INFORMATION (INPUTS)
9   *****/
10 int dimold = ...; // old dimension
11 int dimcontold = ...; // old continuous dimension
12 int dim = ...; // new dimension
13 int dimcont = ...; // new continuous dimension
14 //int dimcat = ...; // categorical dimension
15 int N = ...; // number of instances
16 int n = ...; // number of classes
17
18 /*****
19  * FEATURE SELECTION (INPUTS)
20  *****/
21 int seltol = ...; // given number of total selected cont/cat dimensions (
    at most)
22 int selcont = ...; // UB on number of selected continuous dimensions
23 int excont = ...; // computed LB on number of excluded continuous
    dimensions
24
25 /*****
26  * INDEX RANGES 1
27  *****/
28 range DS = 1..dim; // for dimensions
29 range DSCONTOLD = 1..dimcontold; // for old continuous dimensions

```

```

30 range DSCONT = 1..dimcont; // for new continuous dimensions
31 range DSCAT = dimcont+1..dim; // for shifted categorical dimensions
32 range IS = 1..N; // for instances
33 range KS = 0..n; // for classes
34
35 /*****
36  * INITIAL PARAMETERS (INPUTS)
37  *****/
38 float M[DS] = ...; // big-M for all new/shifted dimensions (continuous
    and categorical)
39 float m[DSCONT] = ...; // small-m for new continuous dimensions
40
41 /*****
42  * DATA EXTRACTION (INPUTS)
43  *****/
44 float xcontold[IS][DSCONTOLD] = ...; // instances along old continuous
    dimensions
45 int xcat[IS][DSCAT] = ...; // instances along shifted categorical
    dimensions
46 int y[IS] = ...; // targets
47 int maxlab[DSCAT] = ...; // maximum labels for new categorical dimensions
48 int p[DS] = ...; // number of cuts along axes
49 int coef[DS] = ...; // product coefficients
50
51 /*****
52  * NUMBER OF BOXES
53  *****/
54 int B = 1; // initialize the number of boxes
55 execute {
56     for (var j in DS)
57         B = B*(p[j]+1); // compute the number of boxes
58 }
59
60 /*****
61  * INDEX RANGES 2
62  *****/

```

```

63 range BS = 0..B-1; // for regions
64
65 /*****
66  * TUPLES
67  *****/
68 tuple ContPairType { // index for continuous cut
69     int j;
70     int q;
71 };
72
73 {ContPairType} ContPairs = {<j, q> | j in DSCONT, q in 0..p[j]+1};
74
75 tuple ContTripleType { // index for continuous cut of each individual
76     instance
77     int i;
78     int j;
79     int q;
80 };
81 {ContTripleType} ContTriples = {<i, j, q> | i in IS, j in DSCONT, q in 0..
82     p[j]};
83
84 tuple CatPairType { // index for categorical group
85     int j;
86     int l;
87 };
88 {CatPairType} CatPairs = {<j, l> | j in DSCAT, l in 0..maxlab[j]};
89
90 /*****
91  * DECISION VARIABLES
92  *****/
93 dvar float l[ContTriples];
94 dvar float r[ContTriples];
95 dvar float bc[ContPairs]; // bc is in R (c = cut)
96 // Note that b is used for beta indexing

```

```

97 dvar float h[BS]; // h
98 dvar boolean a[ContTriples]; // alpha
99 dvar int+ v[CatPairs]; // v (categorical features)
100 dvar boolean g[IS][BS]; // gamma
101 dvar boolean z[BS][KS]; //
102 // Feature selection
103 dvar boolean ccont[DSCONT][DSCONTOLD]; // select continuous dimensions
104 dvar boolean f[DSCAT]; // select categorical dimensions
105
106 /*****
107  * OBJECTIVE FUNCTION
108  *****/
109 minimize sum(b in BS) h[b]; // min total number of misclassified
    instances
110
111 /*****
112  * CONSTRAINTS
113  *****/
114 subject to {
115
116     forall(j in DSCONT)
117         getnewcont:
118             sum(jold in DSCONTOLD) ccont[j][jold] <= 1;
119
120     forall(jold in DSCONTOLD)
121         seloldcont:
122             sum(j in DSCONT) ccont[j][jold] <= 1;
123
124     forall(j in DSCONT, q in 0..p[j])
125         bc[<j,q+1>] - bc[<j,q>] >= 0;
126
127     forall(i in IS, j in DSCONT) {
128         lbound:
129             (sum(jold in DSCONTOLD) xcontold[i][jold]*ccont[j][jold]) - (
                sum(q in 0..p[j]) l[<i,j,q>]) >= 0;
130         rbound:

```

```

131         (sum(jold in DSCONTOLD) xcontold[i][jold]*ccont[j][jold]) - (
            sum(q in 0..p[j]) r[<i,j,q>]) <= 0;
132     }
133
134     forall(i in IS, j in DSCONT, q in 0..p[j]) {
135         l[<i,j,q>] + M[j]*a[<i,j,q>] >= 0;
136         l[<i,j,q>] - M[j]*a[<i,j,q>] <= 0;
137         l[<i,j,q>] - bc[<j,q>] + M[j]*a[<i,j,q>] <= M[j] + m[j];
138         l[<i,j,q>] - bc[<j,q>] - M[j]*a[<i,j,q>] >= -M[j] + m[j];
139         r[<i,j,q>] + M[j]*a[<i,j,q>] >= 0;
140         r[<i,j,q>] - M[j]*a[<i,j,q>] <= 0;
141         r[<i,j,q>] - bc[<j,q+1>] + M[j]*a[<i,j,q>] <= M[j] - m[j];
142         r[<i,j,q>] - bc[<j,q+1>] - M[j]*a[<i,j,q>] >= -M[j] - m[j];
143     }
144
145     forall(i in IS)
146         (sum(j in DSCONT) coef[j]*(sum(q in 0..p[j]) q*a[<i,j,q>])) + (sum(
            j in DSCAT) coef[j]*v[<j,xcat[i][j]>]) - (sum(b in BS) b*g[i][b
            ]) == 0;
147
148     forall(i in IS, j in DSCONT)
149         pregon:
150             sum(q in 0..p[j]) a[<i,j,q>] == 1;
151
152     forall(i in IS) {
153         bregion:
154             sum(b in BS) g[i][b] == 1;
155     }
156
157     forall(b in BS, k in KS)
158         error1:
159             h[b] + (sum(i in IS) (y[i] == k)*g[i][b]) + N*z[b][k] >= 0;
160
161     forall(b in BS)
162         error2:
163             sum(k in KS) z[b][k] == n;

```

```

164
165     forall(j in DSCAT, l in 0..maxlab[j])
166         v[<j,l>] <= p[j];
167
168     forall(i in IS, j in DSCAT) {
169         selcat1:
170             v[<j,xcat[i][j]>] + M[j]*f[j] >= 0;
171         selcat2:
172             v[<j,xcat[i][j]>] - M[j]*f[j] <= 0;
173     }
174
175     seltolnum:
176         (sum(j in DSCONT, jold in DSCONTOLD) ccont[j][jold]) + (sum(j in
            DSCAT) f[j]) <= seltol;
177 }

```

#### 4.4 Recalculation of Decision Boxes

Some of selected  $d$  features may be trivial; therefore, they cannot be contributing factors. This occurs when two consecutive splitting values along a continuous feature covers an entire dataset or all categorical values are reallocated to the same group. Moreover, the proposed classification model usually assumes that there are up to  $d$  new continuous features ( $|\mathcal{C}_{\text{cont}}| \leq d$ ), but a new continuous feature  $j \in \mathcal{C}_{\text{cont}}$  may turn unselected:  $c_{j,\tilde{j}}^* = 0$  for all  $\tilde{j} \in \tilde{\mathcal{C}}_{\text{cont}}$ . All of these circumstances lead to excessive number of decision boxes. A close examination of optimal splitting values  $b_{j,q}^*$  and  $v_{j,x_j^i}^*$  can further provide which feature is actually important and should be finally selected, thereby reducing number of boxes. To determine which two distinct boxes can be merged, all numerical decision box labels are recalculated through a transformation  $g$  to new labels in a final feature space.

Suppose only  $d'$  out of  $d$  features are finally selected. The feature map  $\sigma : \{0, 1, \dots, d\} \rightarrow \{-1\} \cup \{0, 1, \dots, d'\}$  is defined by

$$\sigma(j) = \begin{cases} \text{feature in new space,} & \text{for finally selected feature } j \\ -1, & \text{for finally unselected feature } j \\ 0, & \text{if } j = 0. \end{cases}$$

There is a one-to-one corresponding between  $j$  and  $\sigma(j) \geq 0$ , and the image of  $\sigma$  includes  $0, 1, \dots, d'$ . Consider a decision box  $1 \leq \beta \leq B$ . Define its position along a feature  $j$  by

$$q_j = \begin{cases} \sum_{q=0}^{p_j} q\beta_{j,q}, & \text{for continuous feature } j \\ u_j, & \text{for categorical feature } j. \end{cases}$$

Let  $w = \min\{j : q_j \neq 0\}$ . If  $w = 1$ , then both positions of the current box  $\beta$  and the previous counterpart  $\beta - 1$  along the first feature differ by 1. For  $w > 1$ , the previous box  $\beta - 1$  locates at position  $p_j$  along every feature  $j < w$ , and the position of both boxes at feature  $w$  differs by 1. Based on this observation, the following recurrence relation of new box labels can be obtained:

$$g(\beta) - g(\beta - 1) = - \sum_{j=1}^{w-1} p_j \prod_{j' \in \Sigma_j} (p_{j'} + 1) + 1 \cdot \prod_{j' \in \Sigma_w} (p_{j'} + 1)$$

where  $g(0) = 0$  and  $\Sigma_j = \{j' : 0 \leq \sigma(j') < \sigma(j)\}$ .

The utility module in Code 4.3 includes file copying, floating point number rounding, retrieving all keys of maximum dictionary value, finding an interval containing a given number, and exporting DataFrame with nonduplicate entries. The typecasting module in Code 4.4 can convert a set in string format to a Python set and vice versa, and also express an immutable interval object in string format. The recalculation module in Code 4.5 computes a full list of final numerical decision regions  $g(\beta)$ . Modules 4.6 and 4.7 returns the dictionaries of selected features and their splitting values respectively. True decision regions including their predicted class labels are computed by Module 4.8. Similar results generated by Module 4.9 is based solely on numerical decision regions, possibly redundant before merging, and their predicted class labels directly reported by CPLEX optimizer. As shown in Chapter 5, CPLEX solutions are inconsistent and therefore infeasible during first few iterations. Module 4.10 calculates the number of correctly classified instances based on the true decision region from Module 4.8 and the CPLEX counterpart from Module 4.9. Clearly, the first is more accurate than the latter. Code 4.11 is the main execution file. A DataFrame iterator initially constructed by the method `itertuples` is utilized only when a DataFrame, an iterable, can be iterated row by row using the method `next` during an informational query; nonetheless, its usage is not recommended when a query answer is scattered over rows.

Code 4.3: Basic utility for recalculation of region (module/operation/xutil.py)

```

1  import os
2  import shutil
3  import json
4  import math
5  import numpy as np
6  import pandas as pd
7
8  # Create directory (if not exist)
9  def create_dir(dir):
10     '''
11         Usage: create directory (if not exist)
12         Required arguments:
13             dir: directory name
14     '''
15
16     try: os.makedirs(dir)
17     except FileExistsError: pass
18
19
20 # Copy single file
21 def copy(srcpath, destpath):
22     '''
23         Usage: copy single file
24         Required arguments:
25             srcpath: source pathname
26             destpath: destination pathname
27     '''
28
29     # Split path into directory and file
30     srcdir, srcfile = os.path.split(srcpath) # source
31     destdir, destfile = os.path.split(destpath) # destination
32

```



```

33     # Create destination directory (if not exist)
34     create_dir(destdir)
35
36     # Copy source file into destination folder (filename unchanged)
37     shutil.copy2(srcpath, destdir) # preserve file metadata
38
39     # Rename copied file to correct destination filename
40     os.rename(f"{destdir}/{srcfile}", destpath)
41
42
43 # Round up or down number to decimal places
44 def round_num(number, decimals, direction):
45     '''
46     Usage: round up or down number to decimal places
47     Required arguments:
48         number: number to be rounded
49         decimals: number of decimal places to round to
50         direction: either up or down ('up', 'down')
51     Outputs:
52         rounded number to specified decimal places
53     '''
54
55     if isinstance(decimals, int) or isinstance(decimals, np.integer):
56         if decimals >= 0:
57             if direction == 'up':
58                 return math.ceil(number*10**decimals)/10**decimals
59             elif direction == 'down':
60                 return math.floor(number*10**decimals)/10**decimals
61             else:
62                 raise TypeError("Direction can be either up or down")
63         else:
64             raise TypeError("Number of decimal places to round to must be
65                               nonnegative")
66     else:
67         raise TypeError("Number of decimal places must be an integer")

```

```

68
69 # Find maximum value of dictionary and key set
70 def max_dictval(dc):
71     '''
72         Usage: find maximum value of dictionary and all of its
73                 corresponding keys
74         Required arguments:
75             dc: dictionary
76         Outputs:
77             kmax: set of all keys of maximum value
78             vmax: maximum value
79     '''
80     kmax = set()
81     vmax = dc[next(iter(dc))] # value of first key
82     for k, v in dc.items():
83         if v > vmax:
84             vmax = v
85             kmax = {k}
86         elif v == vmax:
87             kmax.add(k)
88
89     return kmax, vmax
90
91
92 # Find interval index of specific value from list of real-line splits
93 def itvpos(x, splits, closed='neither'):
94     '''
95         Usage: find interval index of specific value from array of real-
96                 line splits
97         Required arguments:
98             x: specific value of interest
99             splits: list of real line splits
100             closed: whether intervals are closed on left-side, right-side
101                     or neither ('left', 'right', 'neither')
102     Outputs:

```

```

101         interval index of specific input value
102     '''
103
104     if closed == 'left': # [_ , s), [s, _)
105         for i, s in enumerate(splits):
106             if x < s: return i
107     elif closed == 'neither': # (_, s), (s, _)
108         for s in splits:
109             if x == s:
110                 raise Exception(f"Open intervals are chosen but input value
                                {x} is at split value {s}")
111         closed = 'right' # now safe to be extended to (_, s], (s, _]
112
113     if closed == 'right': # (_, s], (s, _]
114         for i, s in enumerate(splits):
115             if x <= s:
116                 return i
117
118     # Last interval
119     return i + 1
120
121
122 # Return left and right endpoints of rounded interval
123 def itvtopts(itv, decimals=2, extend=True):
124     '''
125     Usage: return left and right endpoints of rounded interval
126     Required arguments:
127         itv: Pandas interval to be rounded
128     Optional arguments:
129         decimals: number of decimal places to round to (default: 2)
130         extend: whether extend (true) or shrink (default) interval (
                default: True)
131     Outputs:
132         lpt: left endpoint of rounded interval
133         rpt: right endpoint of rounded interval
134     '''

```

```

135
136     if isinstance(itv, pd._libs.interval.Interval):
137         if extend:
138             ldirect, rdirect = 'down', 'up'
139         else:
140             ldirect, rdirect = 'up', 'down'
141
142         if np.isinf(itv.left):
143             lpt = itv.left
144         else:
145             lpt = round_num(itv.left, decimals, ldirect)
146
147         if np.isinf(itv.right):
148             rpt = itv.right
149         else:
150             rpt = round_num(itv.right, decimals, rdirect)
151
152         return lpt, rpt
153
154     else:
155         raise TypeError("Only Pandas intervals are allowed")
156
157
158 # Import dictionary from JSON file
159 def import_dict(jsonpath):
160     '''
161     Usage: parse JSON data into dictionary
162     Required arguments:
163         jsonpath: JSON filepath (usually metadata filepath)
164     Outputs:
165         dictionary
166     '''
167
168     with open(jsonpath) as file:
169         contents = file.read()
170

```

```

171     # JSON data is parsed into dictionary
172     return json.loads(contents)
173
174
175 # Export dataframe with nonduplicate entries
176 def nondup(df, ndcols, intcols=list(), intdtype='Int16'):
177     '''
178     Usage: export dataframe with nonduplicate entries
179     Required arguments:
180         df: dataframe
181         ndcols: two-dimensional multilevel column lists with
182                 nonduplicate entries
183     Optional arguments:
184         intcols: integer columns (default: empty list)
185         intdtype: Pandas integer data type (default: 'Int16' or pd.
186                 Int16Dtype())
187     Outputs: same dataframe but without duplicate entries
188     '''
189
190     dfn = df.copy(deep=True)
191     for i in range(len(ndcols),0,-1): # iterate over multilevel column
192         lists with nonduplicate entries
193         ccols = [f for cols in ndcols[0:i] for f in cols]
194         dfn.loc[dfn[ccols].duplicated(), ccols] = pd.NA
195     for col in intcols:
196         dfn[col] = pd.array(dfn[col], dtype=intdtype)
197
198     return dfn

```

Code 4.4: Typecasting (module/operation/typecast.py)

```

1  import re
2  import numpy as np
3  import pandas as pd
4
5  from module.operation.xutil import itvtopts
6
7
8  # Convert set/number in string format to Python set
9  def strtoset(setstr):
10     '''
11         Usage: convert set/number in string format to Python set
12         Required arguments:
13             setstr: set/number in string format
14         Outputs: corresponding set
15     '''
16
17     elems = re.findall(r'[^{};,\\s]+', setstr)
18     numset = set(map(int, elems))
19
20     return numset
21
22
23 # Convert set to string
24 def settostr(st, sep=',', left='{', right='}'):
25     '''
26         Usage: convert set to string
27         Required arguments:
28             st: set
29         Optional arguments:
30             sep: separator (default: ',')
31             left: left symbol (default: '{')
32             right: right symbol (default: '}')

```

```

33         Outputs: string representing given set
34     '''
35
36     stre = sep.join([str(e) for e in st])
37
38     return f"{left}{stre}{right}"
39
40
41 # Convert Pandas interval to string
42 def itvtostr(itv, decimals=2, extend=True):
43     '''
44         Usage: convert Pandas interval to string
45         Required arguments:
46             itv: Pandas interval
47         Optional arguments:
48             decimals: number of decimal places to round to (default: 2)
49             extend: whether extend (true) or shrink (default) interval (
                    default: True)
50         Outputs: string interval
51     '''
52
53     lpt, rpt = itvtopts(itv, decimals, extend)
54     l = f"{lpt:.{decimals}f}"
55     r = f"{rpt:.{decimals}f}"
56
57     if itv.closed == 'neither': return f"({l}, {r})"
58     elif itv.closed == 'left': return f"[{l}, {r})"
59     elif itv.closed == 'right': return f"({l}, {r}]"
60     else: return f"[{l}, {r}]"
61
62
63 # Describe Pandas interval in text format
64 def itvtodesc(itv, decimals=2, extend=True):
65     '''
66         Usage: describe Pandas interval in text format
67         Required arguments:

```

```

68         itv: Pandas interval
69     Optional arguments:
70         decimals: number of decimal places to round to (default: 2)
71         extend: whether extend (true) or shrink (default) interval (
                default: True)
72     Outputs: description of interval in text format
73     '''
74
75     lpt, rpt = itvtopts(itv, decimals, extend)
76     l = f"{lpt:.{decimals}f}"
77     r = f"{rpt:.{decimals}f}"
78
79     esum = itv.left + itv.right
80     if np.isnan(esum): # -np.inf, np.inf
81         return "any number"
82     elif not np.isinf(esum): # num, num
83         return f"between {l} and {r}"
84     elif esum < 0: # -np.inf, num
85         return f"below {r}"
86     else: # num, np.inf
87         return f"above {l}"

```

Code 4.5: Recalculation of regions (module/operation/calregs.py)

```

1  import numpy as np
2
3
4  # Calculate new corresponding region label (helper)
5  def hcalbn(bo, bnprev, idxn, pcuto, pocum, pncumx):
6      '''
7          Usage: calculate new corresponding region label (helper)
8          Required arguments:
9              bo: region label for old features (nonzero)
10             bnprev: previous region label for new features
11             idxn: new feature indexes

```



```

12         pcuto: old cut numbers
13         pocum: cumulative number of box regions across old features
14         pncumx: cumulative number of extended box regions across new
           features
15     Outputs: corresponding region label
16     '''
17
18     # bo must be between 1 and np.prod(pcuto+1)-1
19     bn = bnprev
20     for jmax in range(len(pcuto)-1,-1,-1):
21         # bo (incremented by 1) in base representation has the last nonzero
           at digit jmax
22         if bo%pocum[jmax] == 0:
23             for j in range(jmax):
24                 bn -= pcuto[j]*pncumx[idxn[j]]
25                 bn += pncumx[idxn[jmax]]
26             break
27
28     return bn
29
30
31 # Calculate corresponding decision regions (helper)
32 def hcalregs(B0, idxn, pcuto, pocum, pncumx):
33     '''
34     Usage: calculate corresponding decision regions (helper)
35     Required arguments:
36         B0: total number of old box regions
37         idxn: new feature indexes
38         pcuto: old cut numbers
39         pocum: cumulative number of box regions across old features
40         pncumx: cumulative number of extended box regions across new
           features
41     Outputs: corresponding region label
42     '''
43
44     bns = [0] # list of corresponding box regions (region 0)

```

```

45     for bo in range(1, B0):
46         bnprev = bns[-1]
47         bn = hcalbn(bo, bnprev, idxn, pcuto, pocum, pncumx)
48         bns.append(bn)
49
50     return bns
51
52
53 # Calculate new corresponding decision regions (main)
54 def calregs(pcuto, sidx, pdtype=np.int16, idtype=np.int16, rdtype=np.int16
55            ):
56     '''
57     Usage: calculate new corresponding decision regions (main)
58     Required arguments:
59         pcuto: old cut numbers
60         sidx: selected feature indexes (in order)
61     Optional arguments:
62         pdtype: NumPy data type of cut number (default: np.int16)
63         idtype: NumPy data type of index (default: np.int16)
64         rdtype: NumPy data type of region number (default: np.int16)
65     Outputs: new corresponding regions
66     '''
67     # Typecasting
68     pcuto = np.array(pcuto, dtype=pdtype)
69     sidx = np.array(sidx, dtype=idtype)
70
71     # Basic calculation
72     dimo = pcuto.size # old dimension
73     dimn = sidx.size # new dimension
74     pcutn = pcuto[sidx] # new cut numbers
75     B0 = np.prod(pcutn+1).astype(rdtype) # number of old regions
76     BN = np.prod(pcutn+1).astype(rdtype) # number of new regions
77
78     # New feature indexes
79     idxn = np.full(dimo, -1, dtype=idtype)

```

```

80     idxn[sidx] = np.arange(dimn, dtype=idtype)
81     idxn[idxn < 0] = np.arange(dimn, dimo, dtype=idtype)
82
83     # Cumulative number of box regions
84     pocum = np.cumprod(np.append([1], pcuto[0:-1]+1), dtype=rdtype) # old
85     pncum = np.cumprod(np.append([1], pcutn[0:-1]+1), dtype=rdtype) # new
86     pncumx = np.concatenate((pncum, np.zeros(dimo-dimn, dtype=rdtype))) #
        new and extended
87
88     # New corresponding regions (helper function called)
89     bns = np.array(hcalregs(B0, idxn, pcuto, pocum, pncumx), dtype=rdtype)
90
91     # Output
92     return bns
93
94
95 # Illustration
96 '''
97 print('pcuto: {0}\nsidx: {1}\nbns: {2}\n'.format(pcuto:= [3, 4], sidx:= [0],
        calregs(pcuto, sidx)))
98 print('pcuto: {0}\nsidx: {1}\nbns: {2}\n'.format(pcuto:= [3, 4], sidx:= [1],
        calregs(pcuto, sidx)))
99 print('pcuto: {0}\nsidx: {1}\nbns: {2}\n'.format(pcuto:= [3, 4], sidx:= [0,
        1], calregs(pcuto, sidx)))
100 print('pcuto: {0}\nsidx: {1}\nbns: {2}\n'.format(pcuto:= [3, 4], sidx:= [1,
        0], calregs(pcuto, sidx)))
101 '''

```

Code 4.6: Feature selection (module/model/findsels.py)

```

1  # Find feature selection
2  def findsels(itself, pcuto):
3      '''
4          Usage: find feature selection (per file)
5          Required arguments:
6              itself: selected string variables (DataFrame iterator)
7              pcuto: old cut numbers
8          Outputs:
9              tsels: dictionary of selected variables and given number of
                     cuts
10         '''
11
12         csrow = next(itself) # iterator of selected string variables across all
                               iterations
13         tsels = dict() # selected variables and given number of cuts
14
15         citer = -1 # current iteration
16         while True:
17             try:
18                 if csrow.aselect == 1: # for selected variable
19                     if csrow.iter != citer:
20                         citer = csrow.iter
21                         tsels[citer] = {
22                             'variables': list(), # selected feature
23                             'types': list(), # type of selected feature
24                             'js': list(), # selected index
25                             'ps': list() # given cut number
26                         }
27                         tsels[citer]['variables'].append(csrow.variable)
28                         tsels[citer]['types'].append(csrow.type)
29                         tsels[citer]['js'].append(csrow.jnew)
30                         tsels[citer]['ps'].append(pcuto[csrow.jnew-1])

```

```

31         csrow = next(itself) # update DataFrame iterator
32     except StopIteration:
33         break
34
35     return tsels

```

Code 4.7: Cuts or split values (module/model/findcuts.py)

```

1  import numpy as np
2  import pandas as pd
3
4  # Find cuts and groups
5  def findcuts(tsels, itcont, itcat, intvclosed='neither', intvsubtype='
    float32'):
6      '''
7          Usage: find cuts and groups (per file)
8          Required arguments:
9              tsels: dictionary of selected variables and given number of
                cuts
10             itcont: full continuous cuts (DataFrame iterator)
11             itcat: full categorical cuts (DataFrame iterator)
12          Optional arguments:
13             intvclosed: types of Pandas interval sides (values: 'left', '
                right', 'both', 'neither')
14             intvsubtype: types of Pandas interval bounds (subtype of pandas.
                IntervalDtype)
15          Outputs:
16             tcuts: dictionary of cuts and groups along all selected
                features
17      '''
18
19     ccontrow = next(itcont) # iterator of full continuous cuts across all
        iterations
20     ccatrow = next(itcat) # iterator of full categorical cuts across all
        iterations

```

```

21     tcuts = dict() # cuts and groups along all selected features
22
23     for citer, sel in tsels.items(): # cuts across all selected features
24         tcuts[citer] = dict()
25         for ind, j in enumerate(sel['js']):
26             tcuts[citer][j] = {
27                 'variable': tsels[citer]['variables'][ind],
28                 'type': tsels[citer]['types'][ind],
29                 'cuts': list(),
30                 'groups': dict()
31             }
32
33     # Cuts
34     while ccontrow.iter < citer: # previous iteration may select no
        continuous feature
35         ccontrow = next(itcont)
36     while ccatrow.iter < citer: # previous iteration may select no
        categorical feature
37         ccatrow = next(itcat)
38     for jcur in sorted(sel['js']): # numerically sorted features
        selected
39         cuts = tcuts[citer][jcur]['cuts'] # list of cuts along specific
            selected feature
40         try: # iterate over full continuous cuts
41             while ccontrow.iter == citer:
42                 if ccontrow.j > jcur: # seek no more than current
                    feature
43                     break
44                 else:
45                     if ccontrow.j == jcur: # at current selected feature
46                         cuts.append(ccontrow.bc) # continuous feature
                            seen
47                         ccontrow = next(itcont) # update DataFrame iterator
48         except StopIteration:
49             pass
50         try: # iterate over full categorical cuts

```

```

51         while ccatrow.iter == citer:
52             if ccatrow.j > jcur: # seek no more than current feature
53                 break
54             else:
55                 if ccatrow.j == jcur: # at current selected feature
56                     cuts.append(ccatrow.v) # categorical feature seen
57                     ccatrow = next(itcat) # update DataFrame iterator
58         except StopIteration:
59             pass
60
61     # Groups
62     pcutdc = dict(zip(tsels[citer]['js'], tsels[citer]['ps'])) # cut
        numbers along selected features
63     for j, info in tcuts[citer].items():
64         pnum = pcutdc[j] # number of cuts on current selected feature
65         cuts = info['cuts']
66         if info['type'] == 'cont': # continuous feature
67             excuts = [-np.inf] + cuts + [np.inf]
68             intvs = pd.arrays.IntervalArray.from_breaks(
69                 breaks=excuts,
70                 copy=False, # default: False
71                 closed=intvclosed, # types of Pandas interval sides
72                 dtype=pd.IntervalDtype(subtype=intvsubtype) # types of
        Pandas interval bounds
73         )
74         info['groups'] = {gr: intvs[gr] for gr in range(pnum+1)}
75     else: # categorical feature
76         info['groups'] = {gr: set() for gr in range(pnum+1)}
77         for val, gr in enumerate(cuts):
78             info['groups'][gr].add(val) # categorical value in cut/
        group
79
80     return tcuts

```

Code 4.8: True decision regions (module/model/findtrejs.py)

```

1  import numpy as np
2  import pandas as pd
3
4  from module.operation.xutil import max_dictval, itvpos
5
6
7  # Calculate new true decision regions and predictions (truly correct)
8  def findtrejs(tsels, tcuts, df, pdtype=np.int16):
9      '''
10         Usage: calculate new true decision regions and predictions (per
11                file)
12
13         Required arguments:
14
15             tsels: dictionary of selected variables and given number of
16                   cuts
17
18             tcuts: dictionary of cuts and groups along all selected
19                   features
20
21             df: training dataset including target variable (DataFrame, not
22                 iterator)
23
24         Optional arguments:
25
26             pdtype: NumPy data type of cut number (default: np.int16)
27
28         Outputs:
29
30             ttregs: dictionary of new true decision regions and their
31                   predicted classes
32
33         '''
34
35     ttregs = dict() # new true regions with predicted classes (truly
36                    correct)
37
38     classes = df['class'].unique() # all possible classes
39
40
41     for citer in tsels.keys():
42         regs = pd.Series([0]*len(df))
43         js = tsels[citer]['js']

```



```

27     pcutn = np.array(tsels[citer]['ps'], dtype=pdtype) # new cut
        numbers
28     pncum = np.cumprod(np.append([1], pcutn[0:-1]+1), dtype=pdtype) #
        cumulative number of new box regions
29     BN = np.prod(pcutn+1) # number of new regions
30
31     # Convert base representation of decision region to base 10
32     for ind, j in enumerate(js):
33         info = tcuts[citer][j]
34         attr = info['variable']
35         cuts = info['cuts']
36         if info['type'] == 'cont': # continuous feature
37             regs = regs + pncum[ind]*df[attr].apply(lambda x: itvpos(x,
                cuts))
38         else: # categorical feature
39             regs = regs + pncum[ind]*pd.Series([cuts[x] for x in df[attr
                ]])
40
41     # Find predicted classes in decision regions
42     ttregs[citer] = {
43         b: {
44             'classes': set(), # true predicted class set
45             'correct': 0, # number of instances correctly predicted
46             'ninst': 0, # number of training instances (total)
47             'ncinst': {n: 0 for n in range(len(classes))} # number of
                training instances in targets
48         } for b in range(BN)
49     }
50     for i in range(len(df)):
51         ttregs[citer][regs[i]]['ninst'] += 1 # instance in region
52         ttregs[citer][regs[i]]['ncinst'][df['class'][i]] += 1 #
                instance of specific target in region
53     for b in range(BN):
54         kmax, vmax = max_dictval(ttregs[citer][b]['ncinst']) # true
                majority voting

```

```

55         ttregs[citer][b]['classes'] = kmax # all classes that have
           maximum number of instances
56         ttregs[citer][b]['correct'] = vmax # maximum number of
           instances
57
58     return ttregs

```

Code 4.9: CPLEX decision regions (module/model/findcregs.py)

```

1  import numpy as np
2
3  from module.operation.typecast import strtoset
4  from module.operation.calregs import calregs
5
6
7  # Calculate new cplex decision regions and predictions (partially correct)
8  def findcregs(tsels, itpred, pcuto, idtype=np.int16, pdtype=np.int16):
9      '''
10         Usage: calculate new cplex decision regions and predictions (per
              file)
11         Required arguments:
12             tsels: dictionary of selected variables and given number of
                   cuts
13             itpred: individual result of cplex prediction (DataFrame
                   iterator)
14             pcuto: old cut numbers
15         Optional arguments:
16             pdtype: NumPy data type of cut number (default: np.int16)
17             idtype: NumPy data type of index (default: np.int16)
18         Outputs:
19             tcregs: dictionary of new cplex decision regions and their
                   predicted classes
20     '''
21

```

```

22     cprow = next(itpred) # iterator of instance predictions across all
        iterations
23     tcregs = dict() # new cplex regions with predicted classes (partially
        correct)
24     classes = set() # set all possible classes (collected from training
        dataset)
25
26     citer = -1 # current iteration
27
28     while True: # reported by cplex as occupied region
29         try:
30             if cprow.iter != citer: # new iteration
31                 citer = cprow.iter
32                 if citer in tsels.keys(): # current iteration actually
                    selects at least one feature
33                     keep = True # keep doing in this while loop
34                     pcutn = np.array(tsels[citer]['ps'], dtype=pdtype)
35                     sidx = np.array(tsels[citer]['js'], dtype=idtype) - 1 #
                        index starts at 0
36                     BN = np.prod(pcutn+1) # number of new regions
37                     bns = calregs(pcutn, sidx) # new corresponding regions
38                     tcregs[citer] = {
39                         b: {
40                             'lclasses': list(), # list of cplex predicted
                                class set
41                             'nlcinst': list() # list of instance number in
                                corresponding cplex class set
42                         } for b in range(BN)
43                     }
44                 else: # current iteration selects no feature
45                     keep = False # update iterator and go to the next while
                        loop
46                 if keep and cprow.iter == citer: # every record in iteration
                    that selects feature
47                     creg = tcregs[citer][bns[cprow.region]] # new cplex region

```

```

48         pset = strtoset(cprow.predict) # current set of classes
           predicted by cplex
49         classes = classes.union(pset) # add to set of all possible
           classes
50         try: # current set of predicted classes already exists
51             creg['nlcinst'][creg['lclasses'].index(pset)] += 1
52         except ValueError: # new set of predicted classes
53             creg['lclasses'].append(pset)
54             creg['nlcinst'].append(1)
55         cprow = next(itpred) # update DataFrame iterator
56     except StopIteration:
57         break
58
59     for cregs in tcregs.values(): # reported by cplex as unoccupied region
60         for creg in cregs.values():
61             if not creg['lclasses']:
62                 creg['lclasses'] = [classes] # predict only one of the
           entire set
63                 nlcinst = [0] # no instance reported by cplex in the rest of
           new regions
64
65     return tcregs

```

Code 4.10: Classification correctness (module/model/findcorr.py)

```

1  # Find both true and recalculated cplex correctness
2  def findcorr(ttregs, tcregs):
3      '''
4          Usage: find both true and recalculated cplex correctness (per file)
5          Required arguments:
6              ttregs: dictionary of new true decision regions and their
                     predicted classes
7              tcregs: dictionary of new cplex decision regions and their
                     predicted classes
8          Outputs:

```

```

9         tcorr: true number of correctly classified instances per region
10        ccorr: recalculated cplex number of correctly classified
           instances per region
11    '''
12
13    tcorr = dict() # true correctness
14    ccorr = dict() # cplex correctness
15    for citer, tregs in ttregs.items(): # true classification
16        tcorr[citer] = {
17            'correct': 0,
18            'detail': {b: tregs[b]['correct'] for b in tregs.keys()}
19        }
20        tcorr[citer]['correct'] = sum(tcorr[citer]['detail'].values())
21    for citer, cregs in tcregs.items(): # cplex classification
22        ccorr[citer] = {
23            'correct': 0,
24            'detail': {b: 0 for b in cregs.keys()}
25        }
26        for b in cregs.keys():
27            for soc in tcregs[citer][b]['lclasses']:
28                ccorr[citer]['detail'][b] = max([ttregs[citer][b]['ncinst'][
                    c] for c in soc])
29        ccorr[citer]['correct'] = sum(ccorr[citer]['detail'].values())
30
31    return tcorr, ccorr

```

Code 4.11: Final mixed box classifier (finalbox.py)

```

1  import csv
2  import re
3  import pandas as pd
4
5  from module.operation.xutil import *
6  from module.operation.typecast import *
7  from module.operation.calregs import calregs
8  from module.model.findsels import findsels
9  from module.model.findcuts import findcuts
10 from module.model.findtregs import findtregs
11 from module.model.findcregs import findcregs
12 from module.model.findcorr import findcorr
13
14
15 # Parameters
16 pcuto = [3,3,2] # original cut numbers across all given features
17 isexample = True # whether example is shown
18 issreport = True # whether reports of feature selection are written
19 isrreport = True # whether reports of detailed decision regions are
    written
20
21 # Informational prefixes/postfixes
22 ts = "75305" # last digits of timestamp
23 data = "seltrain20num3each20" # data name (no file extension)
24 inprefix = f"{ts}-{data}-export-" # input filename prefix
25 inpostfix = "-mfullaltseltol-2-t-1440" # input filename postfix
26
27 # Required inputs
28 datdir = "../../../Projects/Box Classifiers/alternative/input" # directory
    of training instances (cplex inputs)
29 indir = "../../../Projects/Box Classifiers/alternative/output" # main
    input directory (cplex results)

```

```

30 datfile = f"{data}.csv" # training dataset with target variable
31 datpredfile = f"{inprefix}predict-instance-pcont-3{inpostfix}.csv" #
    individual result of cplex prediction
32 inerrfile = f"{inprefix}error{inpostfix}.csv" # classification errors and
    performance metrics
33 inselfile = f"{inprefix}select-var-str-pcont-3{inpostfix}.csv" # selected
    string variables
34 incutcontfile = f"{inprefix}cutcont-full-pcont-3{inpostfix}.csv" #
    continuous cuts
35 incutcatfile = f"{inprefix}cutcat-full-pcont-3{inpostfix}.csv" #
    categorical cuts
36
37 # Optional inputs
38 if issreport: # reports of feature selection must be written
39     metadir = "../../Data/Encoded/metadata" # metadata directory
40     metafile = "meta-indep-pppub20enc.json" # metadata (after encoding)
        file
41     # Relabel case-insensitive NIU values for all selected categorical
        features
42     niudc = {'SS_YN': "NIU (aged below 15)", 'PEMLR': "NIU"}
43 if isrreport: # reports of detailed decision regions must be written
44     clabels = {0: 'NNN', 1: 'NNY', 2: 'NY_', 3: 'YNN', 4: 'Y1Y'}
45
46 # Required outputs
47 outdir = f"../../Outputs/Main/Box/{data}" # main output directory
48 outeperffile = f"{ts}-eperf.csv" # classification performances (accuracy/
    error/time)
49 outselfile = f"{ts}-selvarfin.csv" # selected string variables, cuts and
    groups
50 outregfile = f"{ts}-predregfin.csv" # full decision regions
51
52 # Optional outputs
53 outcutcontfile = f"{ts}-cutcont.csv" # continuous cuts
54 outcutcatfile = f"{ts}-cutcat.csv" # categorical cuts
55 if issreport: # reports of feature selection must be written
56     outsrepwdfile = f"{ts}-report-sel-dup.csv" # with duplicate entries

```

```

57     outsrepndfile = f"{ts}-report-sel-nondup.csv" # with nonduplicate
        entries
58 if isrreport: # reports of detailed decision regions
59     outrrepwdfile = f"{ts}-report-reg-dup.csv" # with duplicate entries
60     outrrepndfile = f"{ts}-report-reg-nondup.csv" # with nonduplicate
        entries
61
62 # Create main output directory (if not exist)
63 create_dir(outdir)
64
65 # Import datasets
66 dfe = pd.read_csv(f"{indir}/{inerrfile}") # cplex classification errors
        and performance metrics
67 dfs = pd.read_csv(f"{indir}/{inselfile}") # selected string variables
68 dfcont = pd.read_csv(f"{indir}/{incutcontfile}") # full continuous cuts
69 dfcat = pd.read_csv(f"{indir}/{incutcatfile}") # full categorical cuts
70 df = pd.read_csv(f"{datdir}/{datfile}") # training dataset including
        target variable
71 dfp = pd.read_csv(f"{indir}/{datpredfile}") # individual result of cplex
        prediction
72
73 # Initialize DataFrame iterators
74 itsel = dfs.itertuples() # selected string variables
75 itcont = dfcont.itertuples() # full continuous cuts
76 itcat = dfcat.itertuples() # full categorical cuts
77 itpred = dfp.itertuples() # individual result of cplex prediction
78
79 # Main execution
80 tsels = findsels(itself, pcuto) # selected variables
81 tcuts = findcuts(tsels, itcont, itcat) # cuts along all selected features
82 ttregs = findtregs(tsels, tcuts, df) # new true regions and predicted
        classes
83 tcregs = findcregs(tsels, itpred, pcuto) # new cplex regions and predicted
        classes
84 tcorr, ccorr = findcorr(ttregs, tcregs) # true/cplex correctness
85

```



```

86 # Calculate performance results
87 dfen = pd.DataFrame({
88     'iter': tcorr.keys(), # iteration that selects feature
89     'taccuracy': [info['correct']*100/len(df) for info in tcorr.values()],
          # true accuracies
90     'caccuracy': [info['correct']*100/len(df) for info in ccorr.values()],
          # recalculated cplex accuracies
91     'terror': [len(df) - info['correct'] for info in tcorr.values()], #
          true errors
92     'cerror': [len(df) - info['correct'] for info in ccorr.values()] #
          recalculated cplex errors
93 })
94 dfen = pd.merge(dfen, dfe, how='outer')
95 dfen.rename(columns = {
96     'error': 'rerror', # reported cplex errors
97     'accuracy': 'raccuracy' # reported cplex accuracies
98 }, inplace=True)
99 cols = dfen.columns.tolist()
100 new_cols = cols[0:1] + cols[5:5+len(pcuto)] + cols[1:3] + cols[-6:-5] +
          cols[3:5] + cols[-7:-6] + cols[-5:]
101 dfen = dfen[new_cols] # rearranged columns
102 dfen['ms'] = dfen['ms']/60000 # convert milliseconds to minutes
103 dfen = dfen.rename(columns={'ms':'minute'})
104
105 # Display performance results
106 print(f"\n{dfen}\n")
107
108 # Examples
109 if isexample:
110     iters = [1, 2, 15]
111     for citer in iters:
112         try:
113             print(f"Selected features (iteration {citer})\n{tsels[citer]}\n
                  ")
114             print(f"Cuts (iteration {citer})\n{tcuts[citer]}\n")

```

```

115         print(f"True decision regions (iteration {citer})\n{ttregs[
            citer]}\n")
116         print(f"Cplex decision regions (iteration {citer})\n{tcregs[
            citer]}\n")
117         print(f"True correctness (iteration {citer})\n{tcorr[citer]}\n")

118         print(f"Cplex correctness (iteration {citer})\n{ccorr[citer]}\n
            ")
119     except KeyError:
120         print(f"Iteration {citer} selects no features\n")
121
122     # Export non-edited information
123     copy(f"{indir}/{incutcontfile}", f"{outdir}/{outcutcontfile}") #
        continuous cuts
124     copy(f"{indir}/{incutcatfile}", f"{outdir}/{outcutcatfile}") # categorical
        cuts
125
126     # Export performance results (accuracy/error/time)
127     dfen.to_csv(f"{outdir}/{outeperffile}", float_format="%.2f", header=True,
        index=False)
128
129     # Export selected variables, cuts and groups
130     with open(f"{outdir}/{outselfile}", 'w', newline='') as file:
131         writer = csv.DictWriter(
132             file,
133             fieldnames = [
134                 'iter', 'jfin', 'j', 'var', 'type',
135                 'p', 'cuts', 'groups'
136             ]
137         )
138         writer.writeheader()
139     for citer, info in tsels.items():
140         cuts = [[round(cut, 2) for cut in tcuts[citer][j]['cuts']] for j in
            info['js']]
141         groups = list()
142         for ind, j in enumerate(info['js']):

```

```

143         if info['types'][ind] == 'cont': # continuous feature
144             jgrs = dict()
145             for gr, member in tcuts[citer][j]['groups'].items():
146                 jgrs[gr] = itvtostr(member)
147             groups.append(jgrs)
148         else: # categorical feature
149             groups.append(tcuts[citer][j]['groups'])
150     dfstmp = pd.DataFrame({
151         'iter': citer,
152         'jfin': range(1, len(info['js'])+1), # 1, 2, ...
153         'j': info['js'], # j in cplex model
154         'variable': info['variables'],
155         'type': info['types'],
156         'p': info['ps'],
157         'cuts': cuts,
158         'groups': groups
159     })
160     dfstmp.to_csv(f"{outdir}/{outselfile}", mode='a', header=False, index=
        False)
161 del dfstmp
162
163 # Export predicted classes and number of instances in all decision regions
164 with open(f"{outdir}/{outregfile}", 'w', newline='') as file:
165     writer = csv.DictWriter(
166         file,
167         fieldnames = [
168             'iter', 'reg', 'ninst', 'tpred', 'lrpreds',
169             'tcorr', 'ccorr', 'ncinst'
170         ]
171     )
172     writer.writeheader()
173     for citer, tregs in ttregs.items():
174         for b, treg in tregs.items():
175             # List of predicted classes reported by cplex in string format
176             lrpreds = setttostr(map(setttostr, tcregs[citer][b]['lclasses']),
                left='[', right=']')

```

```

177         writer.writerow({
178             'iter': citer,
179             'reg': b,
180             'ninst': treg['ninst'], # number of instances
181             'tpred': settostr(treg['classes']), # true predicted class
182             'lrpreds': lrpreds,
183             'tcorr': tcorr[citer]['detail'][b], # true correctness
184             'ccorr': ccorr[citer]['detail'][b], # cplex correctness
185             'ncinst': treg['ncinst'] # targets and number of member
                instances
186         })
187
188
189 # Export final reports of feature selection (with duplicate/nonduplicate
    entries) (if specified)
190
191 if issreport: # reports of feature selection must be written
192
193     # New labels of selected categorical features (catvdc)
194     metadc = import_dict(jsonpath=f"{metadir}/{metafile}") # metadata after
        encoding
195     catvars = set() # all selected categorical features (initialized)
196     pattern = r'(^|[\^w])(niu)([\^w]|$)' # regex to search for niu
197     pattern = re.compile(pattern, re.IGNORECASE)
198     for info in tsels.values():
199         for ind, attr in enumerate(info['variables']):
200             if info['types'][ind] == 'cat':
201                 catvars.add(attr)
202     catvdc = {attr: metadc[attr]['values'] for attr in catvars} # labels of
        selected categorical features
203     for attr, valdc in catvdc.items():
204         for val, desc in valdc.items():
205             matches = re.search(pattern, desc.replace(',', ' '))
206             if bool(matches): # case-insensitive value label containing niu
207                 try:
208                     catvdc[attr][val] = niudc[attr] # relabel

```

```

209         except KeyError: # new NIU label of current feature is
                missing
210         pass
211
212     # True classification accuracies and performance metrics
213     efields = ['iter', 'taccuracy', 'minute', 'acctmin', 'status']
214
215     # Groups
216     grls = list() # list of all member groups across all features and
                iterations
217     for citer, scuts in tcuts.items():
218         for j, info in scuts.items(): # cuts along all selected feature
219             vartype = 'Continuous' if info['type']=='cat' else 'Categorical
                '
220             if info['type'] == 'cont': # continuous feature (groups not
                displayed for convenience)
221                 for gr, member in info['groups'].items():
222                     dc = {
223                         'iter': citer,
224                         'j': j, 'variable': info['variable'],
225                         'type': 'Continuous',
226                         'label': metadc[info['variable']]['label'],
227                         'group': gr,
228                         'member': itvtostr(member),
229                         'desc': itvtodesc(member, decimals=0, extend=False).
                            capitalize()
230                     }
231                     grls.append(dc)
232             else: # categorical feature (groups displayed)
233                 for gr, member in info['groups'].items():
234                     for elem in member: # all elements in group member
235                         desc = catvdc[info['variable']][str(elem)]
236                         dc = {
237                             'iter': citer,
238                             'j': j, 'variable': info['variable'],
239                             'type': 'Categorical',

```

```

240         'label': metadc[info['variable']]['label'],
241         'group': gr,
242         'member': elem,
243         'desc': desc
244     }
245     grls.append(dc)
246     dfg = pd.DataFrame(grls) # group dataframe
247
248     # Report dataframe of feature selection with duplicate entries (dfrp)
249     dfsrp = pd.merge(dfen[efields], dfg) # merge two dataframes: error/
        metric and group
250
251     # Report dataframe of feature selection with nonduplicate entries (dfn)
252     dfsrpn = nondup(
253         dfsrp,
254         ndcols=[
255             ['iter', 'taccuracy', 'minute', 'acctmin', 'status'],
256             ['j', 'variable', 'type', 'label'],
257             ['group']
258         ],
259         intcols=['iter', 'status', 'j', 'group'] # integer columns
260     )
261
262     # Export final reports of feature selection
263     dfsrp.to_csv( # with duplicate entries
264         f"{outdir}/{outsrepwdfile}",
265         float_format="%.2f",
266         header=True, index=False
267     )
268     dfsrpn.to_csv( # with nonduplicate entries
269         f"{outdir}/{outsrepndfile}",
270         sep=',', na_rep='',
271         float_format="%.2f",
272         header=True, index=False
273     )
274

```



```

307         grls.append(settostr(member))
308     else:
309         raise TypeError("Cut intervals can be either Pandas
310                           intervals or sets")
311
312     writer.writerow({
313         'iter': citer,
314         'ordvars': f"({'','.join([str(j) for j in js])})", #
315                     ordered pair of selected features
316         'strvars': strvars, # string of selected features
317         'reg': b,
318         'ordreg': f"({'','.join([str(q) for q in qs])})", #
319                     ordered pair of numerical region
320         'crossreg': ' x '.join(grls), # cross product of
321                     features in string format
322         'tpreds': ','.join([str(v) for v in treg['classes']]), #
323                     true predicted numerical classes
324         'strtpreds': ', '.join([clabels[v] for v in treg['
325                     classes']]), # true predicted class labels
326         'ninst': treg['ninst'] # number of training instances in
327                     region
328     })
329
330     for ind in range(len(ps)): # increment base representation
331         of region for next for loop
332         qs[ind] += 1 # increment by 1
333         if qs[ind] > ps[ind]: qs[ind] = 0 # new leading one
334         else: break # same leading one
335
336 # Export final reports of detailed regions (with nonduplicate entries)
337 dfrrp = pd.read_csv(f"{outdir}/{outrrpwdfile}")
338 dfrrpn = nondup(dfrrp, ndcols=[['iter', 'ordvars', 'strvars']], intcols
339                     =['iter'])
340 dfrrpn.to_csv( # with nonduplicate entries
341     f"{outdir}/{outrrpndfile}",
342     sep=',', na_rep='',
343     header=True, index=False
344 )

```



```

334
335 print(f"{dfrrp.head()}\n") # detailed decision regions (with duplicate
    entries)
336 print(f"{dfrrpn.head()}\n") # detailed decision regions (with nonduplicate
    entries)
337
338
339 # Reexamination of CPLEX Results
340
341 # Additional output files
342 outexffile = f"{ts}-exam-full.csv" # full cplex reexamination
343 outexdfile = f"{ts}-exam-diff.csv" # difference in new decision regions
344 outexnfile = f"{ts}-exam-diffnum.csv" # number of difference
345
346 # Convert full coordinate to position in new feature space
347 def tonpos(citer, coord):
348     ls = list()
349     for j in tsels[citer]['js']:
350         if tcuts[citer][j]['type'] == 'cont':
351             ls.append(itvpos(coord[j-1], tcuts[citer][j]['cuts']))
352         else:
353             ls.append(tcuts[citer][j]['cuts'][coord[j-1]])
354     return tuple(ls)
355
356 # Compute new numerical region from given position to new feature space
357 def tonreg(citer, pos):
358     pcutn = np.array(tsels[citer]['ps'], dtype=np.int16)
359     pncum = np.cumprod(np.append([1], pcutn[0:-1]+1), dtype=np.int16)
360     return np.dot(pncum, pos)
361
362 dfpn = dfp.copy() # copy of individual result of cplex prediction
363 dfpn = dfpn[dfpn['iter'].isin(tsels.keys())] # exclude iterations of no
    feature selection
364
365 nregdc = dict() # new numerical regions in all iterations
366 for citer, info in tsels.items():

```

```

367     nregdc[citer] = calregs(pcuto=pcuto,sidx=np.array(info['js'])-1)
368     dfpn['creg'] = dfpn.apply(lambda x: nregdc[x.iter][x.region], axis=1) #
        new region based on cplex result
369     dfpn['cpred'] = dfpn.apply(lambda x: ttregs[x.iter][x.creg]['classes'],
        axis=1) # cplex predicted class
370
371     dfc = pd.merge(df, dfpn, how='right', left_on=df.index+1, right_on='id',
        suffixes=('', '_pn')) # include instance
372     del dfc['class_pn']
373     cols = dfc.columns.tolist()
374     new_cols = cols[len(pcuto)+1:len(pcuto)+3] + cols[0:len(pcuto)+1] + cols
        [-4:]
375     dfc = dfc[new_cols]
376     dfc = dfc.rename(columns={'region': 'rreg', 'predict': 'rpred'})
377     dfc['rpred'] = dfc['rpred'].apply(strtoset)
378
379     dfc['coord'] = dfc.iloc[:,2:len(pcuto)+2].apply(tuple, axis=1) # full
        original coordinate
380     dfc['tpos'] = dfc.apply(lambda x: tonpos(x.iter, x.coord), axis=1) # true
        position in new feature space
381     dfc['treg'] = dfc.apply(lambda x: tonreg(x.iter, x.tpos), axis=1) # true
        decision region
382     dfc['tpred'] = dfc.apply(lambda x: ttregs[x.iter][x.treg]['classes'], axis
        =1) # true predicted class
383
384     dfcd = dfc[dfc['creg'] != dfc['treg']] # new cplex region differs from new
        true region
385     dfcn = dfcd.groupby('iter').size().reset_index(name='dnum') # number of
        difference
386
387     print(f"{dfcn}\n") # display number of difference in region recalculation
388     print(f"{dfcd}\n") # display difference in new regions
389
390     # Export cplex reexamination results
391     dfc.to_csv(f"{outdir}/{outexffile}", header=True, index=False) # full
        cplex reexamination

```

```
392 dfcd.to_csv(f"{outdir}/{outexdfnfile}", header=True, index=False) #  
    difference in new decision regions  
393 dfcn.to_csv(f"{outdir}/{outexnfile}", header=True, index=False) #  
    difference number
```

# CHAPTER V

## RESULTS ON HEALTH INSURANCE

### 5.1 Training Data

The box classifier proposed in Chapter 4 is illustrated on the sample of size 100 (25 per class) and three preselected features: A\_AGE, PEMLR and SS\_YN. The variable description and cross tabulation analysis with five bins on a continuous feature is displayed in Table 5.1. Each bin covers at least two different insurance coverage types. Although survey participants are unique, some sample records can be the same in feature and even in target due to initial preselection of features and resultant partial loss of personal information. The sampling result can be seen during Iteration 7 in Table 5.7. This chapter investigates two contributing factors out of three based solely on highest training accuracy.

Table 5.1: Cross tabulation of sample data by preselected variables and health insurance coverage types

| Preselected Variable             | Insurance Coverage Type (GRP, DIR, PUB) |     |     |     |     |  |
|----------------------------------|---|-----|-----|-----|-----|--|
|                                  | NNN                                     | NNY | NY_ | Y1Y | YNN |  |
| A_AGE: Age                       |   |     |     |     |     |  |
| Universe: All persons            |   |     |     |     |     |  |
| (1.917, 18.6]                    | 4                                       | 8   | 2   | 0   | 5   |  |
| (18.6, 35.2]                     | 10                                      | 2   | 1   | 4   | 8   |  |
| (35.2, 51.8]                     | 5                                       | 1   | 5   | 2   | 5   |  |
| (51.8, 68.4]                     | 1                                       | 4   | 8   | 6   | 2   |  |
| (68.4, 85.0]                     | 0                                       | 5   | 4   | 8   | 0   |  |
| PEMLR: Major labor force recode  |   |     |     |     |     |  |
| Universe: All persons            |   |     |     |     |     |  |
| 0: NIU                           | 4                                       | 5   | 2   | 0   | 4   |  |
| 1: Employed - at work            | 8                                       | 3   | 7   | 9   | 12  |  |
| 2: Employed - absent             | 0                                       | 0   | 3   | 1   | 0   |  |
| 3: Unemployed - on layoff        | 1                                       | 1   | 0   | 0   | 0   |  |
| 4: Unemployed - looking          | 1                                       | 1   | 1   | 0   | 2   |  |
| 5: Not in labor force - retired  | 0                                       | 5   | 5   | 9   | 0   |  |
| 6: Not in labor force - disabled | 0                                       | 2   | 1   | 0   | 0   |  |

Table 5.1: Cross tabulation of sample data by preselected variables and health insurance coverage types (continued)

| Preselected Variable   | Insurance Coverage Type (GRP, DIR, PUB) |     |     |     |     |
|--|---|-----|-----|-----|-----|
|  | NNN                                     | NNY | NY_ | Y1Y | YNN |
| 7: Not in labor force - other  | 6                                       | 3   | 1   | 1   | 2   |
| SS_YN: Who received social security payments either for themselves or as combined payments with other family members ? |   |     |     |     |     |
| Universe: All persons aged 15 +  |   |     |     |     |     |
| 0: NIU   | 3                                       | 5   | 2   | 0   | 4   |
| 1: Yes   | 0                                       | 9   | 7   | 10  | 1   |
| 2: No  | 17                                      | 6   | 11  | 10  | 15  |

## 5.2 Decision Tree

The goal is to find up to two significant determinants of health insurance coverage out of three features namely A\_AGE, PEMLR and SS\_YN. The first is continuous whereas the last two are categorical. Three splits are assumed in Code 4.1 on an individual feature. Since SS\_YN has only three possible values, this feature can have up to two splits. In total, there should be at most  $(3 + 1)(3 + 1) = 16$  decision boxes. As a result, decision trees of at least depth 3 and at most 16 leaf nodes are considered. Code 5.1 computes the trees of depths 3, 4 and 5 built by the Gini impurity within 5 seconds each as displayed in Figures ??, ?? and ?? respectively. They give training accuracies of 45%, 50% and 54% with 7, 11 and 15 splitting values in total and 8, 12 and 16 decision boxes. The two splits  $A\_AGE = 70.5$  and  $A\_AGE = 75$  in Figures ?? and ?? are redundant because both cannot distinguish the classes of training instances in left and right nodes by predicting the same class label 4.

Figure 5.1: Gini-based decision tree with depth 3, 7 non-leaf nodes and 8 leaf nodes giving a training accuracy of 45%

ig:tree-md3

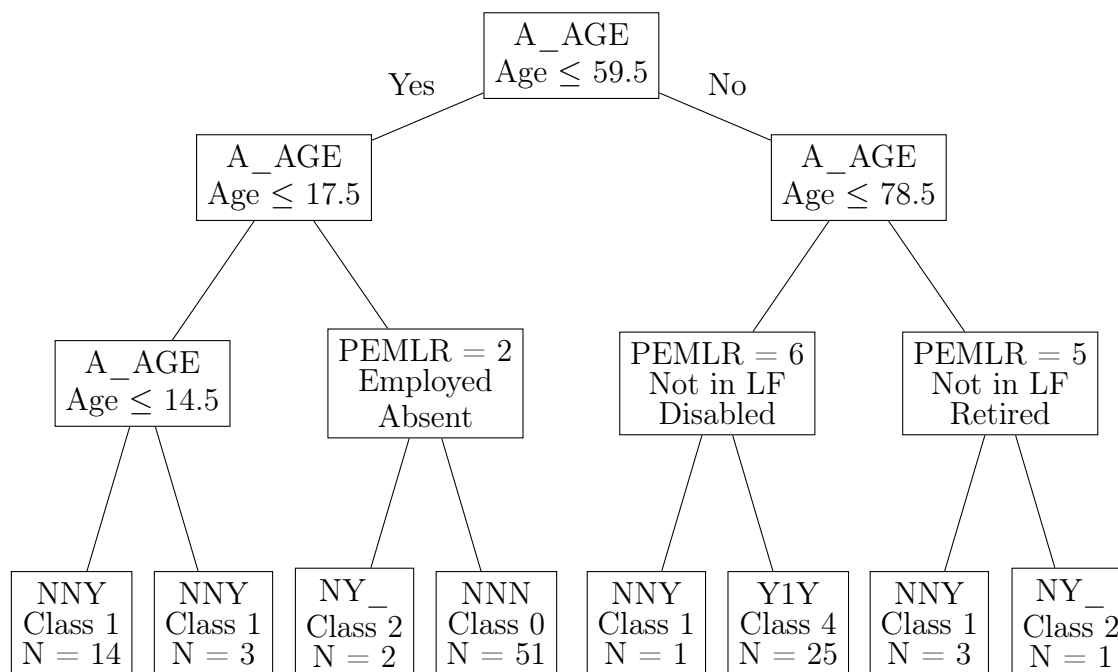






Figure 5.2: Gini-based decision tree with depth 4, 11 non-leaf nodes and 12 leaf nodes giving training accuracy of 50%

ig:tree-md4

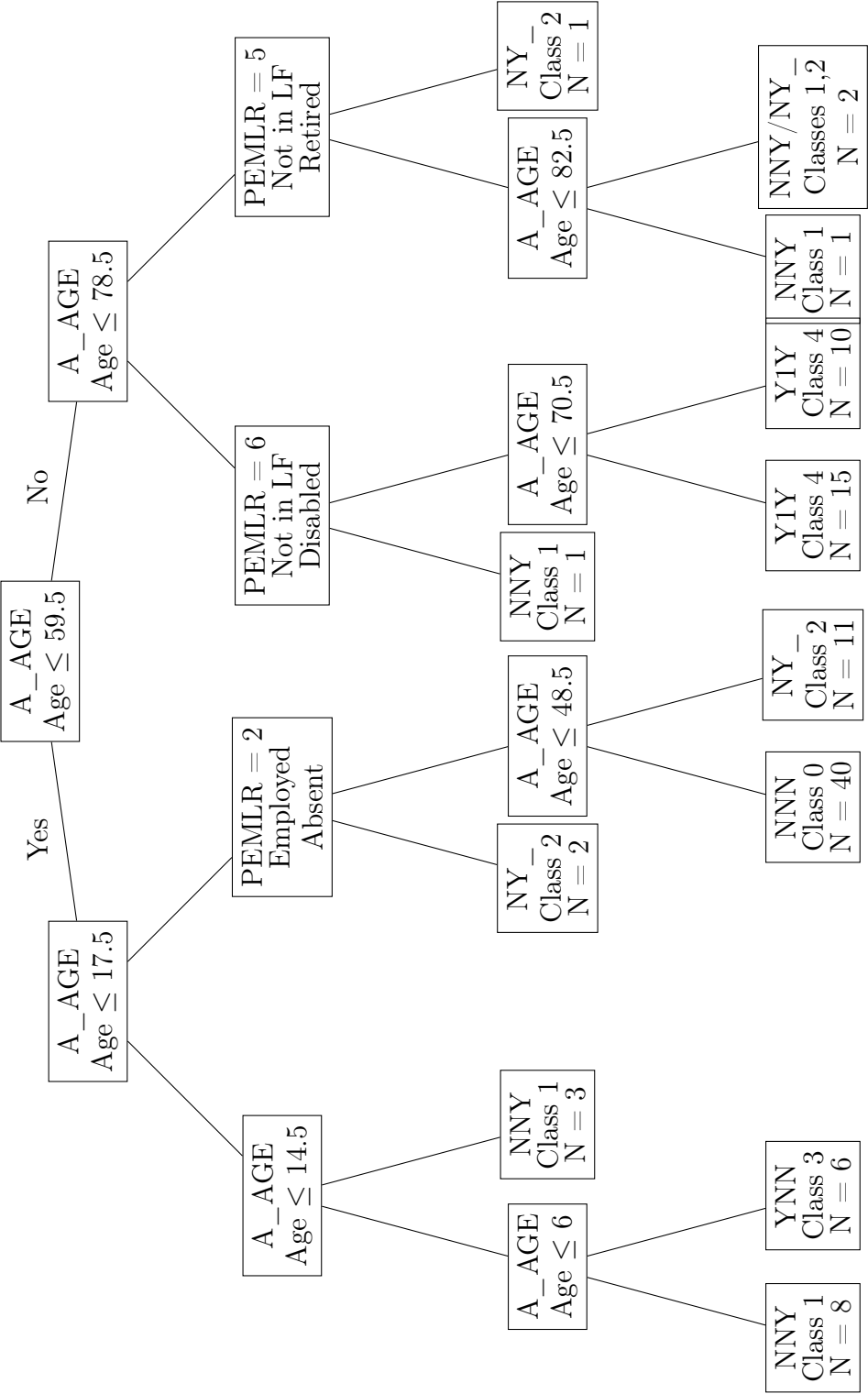
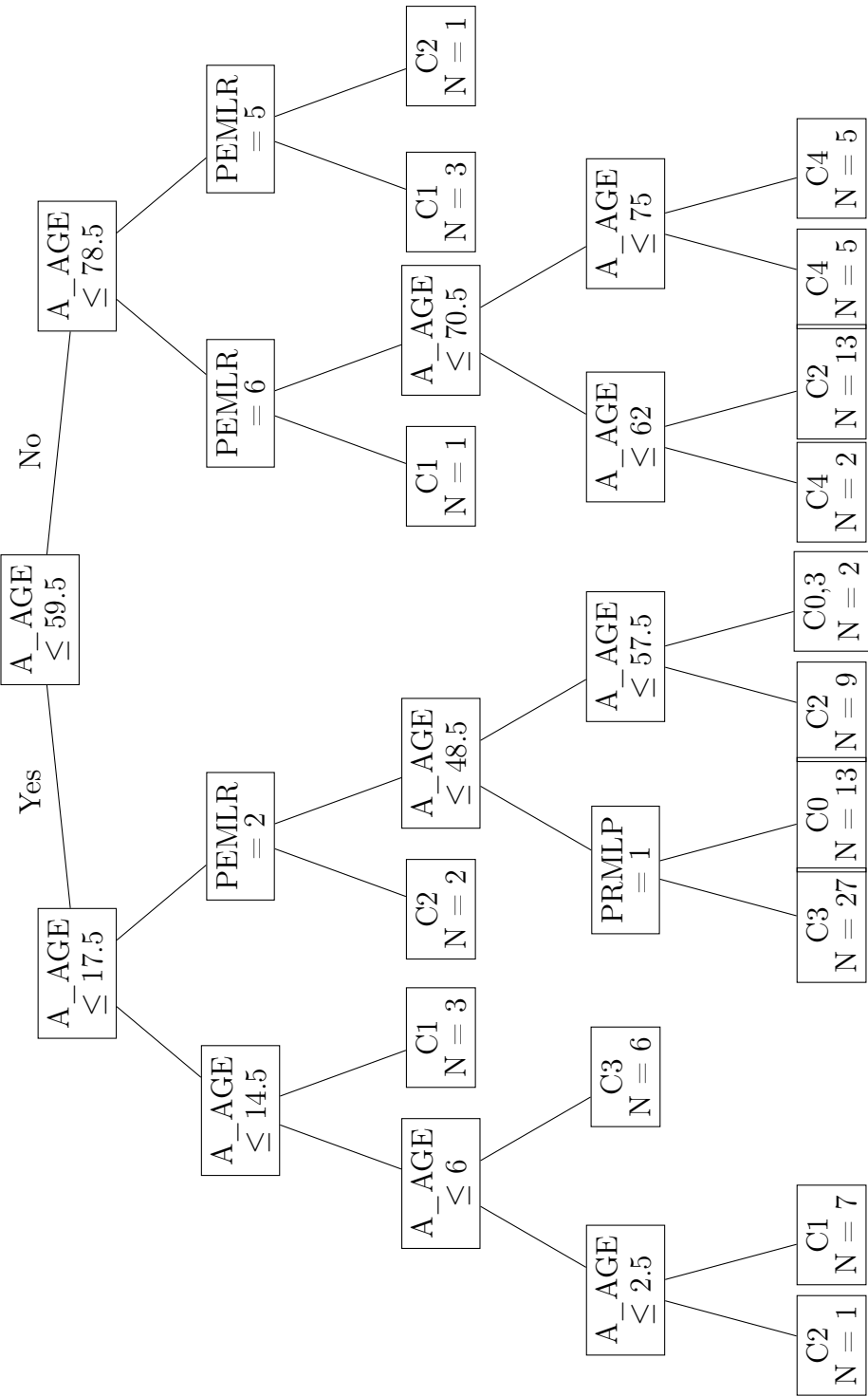


Figure 5.3: Gini-based decision tree with depth 5, 15 non-leaf nodes and 16 leaf nodes giving training accuracy of 54%

ig:tree-md5



Code 5.1: Gini-based decision tree classifier

```

1  import matplotlib.pyplot as plt
2  import pandas as pd
3  import numpy as np
4  import csv
5  import os
6  from sklearn.tree import DecisionTreeClassifier, export_text, plot_tree
7
8  def create_dir(dir):
9      try:
10         os.makedirs(dir)
11     except FileExistsError:
12         pass
13
14  # Given Information
15  data_ls = []
16  data_ls.append({
17      'data': "../../../Samples/cplex/seltrain20num3each20.csv",
18      'info': "../../../Samples/cplex/selproc20num3co3ca3cutinfo.csv",
19      'configs': [
20          {'max_depth': 3, 'max_leaves': 16},
21          {'max_depth': 4, 'max_leaves': 16},
22          {'max_depth': 5, 'max_leaves': 16}
23      ],
24      'outdir': "../../../Outputs/Main/Tree"
25  })
26  print(f"{data_ls}\n")
27
28  # Decision Tree
29  def dtree(df_data, df_info, max_depth, max_leaves, data_path='', info_path
30             = ''):
31      # One-hot encoding

```

```

32     feat_cat = list(df_info[df_info['type'] == 'Categorical']['variable'])
33     for v in feat_cat:
34         df_data[v] = df_data[v].astype('category')
35     one_hot_data = pd.get_dummies(df_data[feat_cat], drop_first=True)
36     X = df_data.iloc[:,0:-(len(feat_cat)+1)].join(one_hot_data)
37     y = df_data['class']
38
39     # Build decision tree
40     clf = DecisionTreeClassifier(
41         max_depth=max_depth,
42         max_leaf_nodes=max_leaves,
43         random_state=0
44     )
45     clf.fit(X, y)
46
47     # Performance
48     score = clf.score(X, y)
49     y_pred = clf.predict(X)
50     err_ind = (y_pred != y.to_numpy().flatten()).astype(int)
51     error = np.count_nonzero(err_ind)
52     accuracy = (1-error/len(y_pred))*100
53
54     # Tree structure
55     depth = clf.tree_.max_depth
56     nodes = clf.tree_.node_count
57     leaves = clf.tree_.n_leaves
58     splits = nodes - leaves
59
60     # Decision tree summary
61     summary = {
62         'error': error, 'accuracy': accuracy, 'score': score,
63         'depth': depth,
64         'nodes': nodes, 'leaves': leaves, 'splits': splits
65     }
66
67     # Decision rules

```

```

68     rules = export_text(clf, feature_names=list(X.columns))
69
70     # Predicted values
71     df_pred = pd.DataFrame({
72         'y_true': df_data['class'],
73         'y_pred': y_pred,
74         'e': err_ind
75     })
76
77     # Display results
78     if data_path != '':
79         print(f"Data: {data_path}")
80     if info_path != '':
81         print(f"Info: {info_path}")
82     print(f"Maximum depth: {max_depth}")
83     print(f"Maximum number of leaves: {max_leaves}\n")
84     print(f"Categorical features: {feat_cat}")
85     print(f"X: {X.columns.values}\n")
86     print(f"Summary:")
87     print(f"\tDepth = {depth} | Leaves = {leaves}")
88     print(f"\tError = {error} | Accuracy = {accuracy} | Score = {score}")
89     print(f"\tNodes = {nodes} | Splits = {splits}\n")
90     print(f"Decision rules:\n{rules}\n")
91
92     # Return statement
93     return clf, summary, rules, df_pred
94
95 # Implementation
96 for dc in data_ls:
97
98     # Export information
99     datname = os.path.splitext(os.path.basename(dc['data']))[0] # without
        file extension
100     outdatdir = f"{dc['outdir']}/{datname}"
101     outprefix = datname
102     outsumfile = f"{outdatdir}/{outprefix}-summary.csv"

```

```

103     outruledir = f"{outdatdir}/rules"
104     outpreddir = f"{outdatdir}/prediction"
105     outfigdir = f"{outdatdir}/figures"
106
107     # Import
108     df_data = pd.read_csv(dc['data'])
109     df_info = pd.read_csv(dc['info'])
110
111     # Exported figure formats
112     fig_formats = ['svg', 'pgf', 'pdf']
113
114     # Create directories
115     create_dir(f"{outdatdir}/rules")
116     create_dir(f"{outdatdir}/prediction")
117     for format in fig_formats:
118         create_dir(f"{outdatdir}/figures/{format}")
119
120     # Export summary file in CSV format
121     with open(outsumfile, 'w') as sumfile:
122
123         sumheader = [
124             'mdepth', 'mleaves', 'depth', 'leaves',
125             'error', 'accuracy', 'score',
126             'nodes', 'splits'
127         ]
128         writer = csv.DictWriter(sumfile, fieldnames=sumheader)
129         writer.writeheader()
130
131         for config in dc['configs']:
132
133             # Tree configuration
134             mdepth = config['max_depth'] # depth
135             mleaves = config['max_leaves'] # number of leaves
136
137             # Postfix of exported files with specific depth and number of
138                 leaves

```

```

138     outpostfix = f"mdepth-{mdepth}-mleaves-{mleaves}"
139
140     # Decision tree
141     clf, summary, rules, df_pred = dtree(
142         df_data, df_info, mdepth, mleaves,
143         data_path=dc['data'], info_path=dc['info']
144     )
145
146     # Export summary result to CSV file
147     summary['mdepth'] = mdepth
148     summary['mleaves'] = mleaves
149     writer.writerow(summary)
150
151     # Decision rules
152     with open(f"{outruledir}/{outprefix}-rule-{outpostfix}.txt", 'w
153         ') as rulefile:
154         rulefile.write(rules)
155
156     # Prediction
157     outpredfile = f"{outpredidir}/{outprefix}-pred-{outpostfix}.csv"
158     df_pred.index = df_pred.index + 1
159     df_pred.to_csv(outpredfile, index_label='id')
160
161     # Tree plots
162     plot_tree(clf)
163     #plot_tree(clf, label='none', impurity=False)
164     for format in fig_formats:
165         outfigfile = f"{outfigdir}/{format}/{outprefix}-fig-{
166             outpostfix}.{format}"
167         plt.savefig(outfigfile, bbox_inches='tight')
168     #plt.show()
169
170     # Newline
171     print()

```

### 5.3 Proposed Model

A record of an MIP solution returned by a CPLEX solver is counted as an iteration. The proposed box classifier is given within 15 iterations as reported by the solver, or 13 iterations by careful reexamination, before all CPLEX node files fully occupy the reserved disk space of 200 GB where the optimal solution status is inconclusive. As shown in Tables 5.2 and 5.3, the box classifier gives six splitting values in total, three per each contributing factor, whereas all three decision trees at least seven. It achieves a high training accuracy of 51%, compared to the trees of 12 and 16 boxes at 50% and 54%. Although the first requires a significantly longer building time of at least 78.88 minutes (iteration 13) or up to 209.93 minutes (last iteration 15), the latter two output superfluous 11 and 15 total splits. Interestingly, the box classifier and all three decision trees consider A\_AGE and PEMLR significant features, and they have consistent, though nonidentical, categorical splitting values on PEMLR. Based on the box classifier,  $PEMLR = 3, 4, 5$  and  $7$  share similar characteristics, and they are grouped together as a new single unit or splitting value. Another group of  $PEMLR = 0$  and  $6$  is also generated. Nonetheless, all decision trees lack the capability to bundle similar categorical values.

The training accuracy, the execution time and the minimum storage size of a box classifier per iteration are reported in Table 5.4. Feature selection occurs as of iteration 2. The training accuracy directly reported by a CPLEX solver as the negative of the objective value differs from the true accuracy produced and recomputed by the proposed box classifier based solely on the splitting values during the first 13 iterations. Certain training instances do not exactly lie until iteration 10 in their CPLEX decision regions, whether original or merged, as indicated by inconsistency between both CPLEX and true training accuracies when both region types are assumed to generate identical predictions. The acceptable box classifier of training accuracy 51% is given since iteration 13 within 78.88 minutes, taking up at least 5.92 GB of disk space but no more than 7 GB, and with a relative MIP gap of 6.35 defined by the relative difference between the best integer objective and the objective of the best CPLEX tree node remaining. The CPLEX engine log can be examined in an appendix.



Groups of values on selected features and their resultant box regions including predicted class labels are shown in Tables 5.5 and 5.6 respectively. Some bins as a result of feature splits may be empty, and their corresponding decision boxes are therefore nonexistent. The dimension of new continuous features in Code 4.1 is one, but iterations 2 to 9 select only categorical features. As a result, splits on the continuous feature `A_AGE` is redundant, and the number of decision boxes is overly reported by a CPLEX solver. After recalculating numerical decision regions and merging boxes, the difference between CPLEX and true decision regions occurs as illustrated on a per-instance basis in Table 5.7. This is possibly due to the insufficiently small CPLEX feasibility tolerance of  $10^{-6}$  by default. At least 41 training instances suffer from this inconsistency, and all especially in iteration 7. No difference can be detected as of iteration 10.

Table 5.2: Comparison between multiple decision tree of depths 3 to 5 and proposed classifier in iterations 13 to 15 based on number of splitting values, number of decision boxes, training accuracy and execution time

| Classification Model |               | Num of Splitting Values |       |        |       | Num of Boxes | Training Accuracy (%) | Execution Time (min) |
|----------------------|---------------|-------------------------|-------|--------|-------|--------------|-----------------------|----------------------|
| Model                | Specification | A_ AGE                  | PEMLR | SS_ YN | Total |              |                       |                      |
| Decision tree        | Depth of 3    | 4                       | 3     | 0      | 7     | 8            | 45                    | 0.08                 |
|                      | Depth of 4    | 8                       | 3     | 0      | 11    | 12           | 50                    |                      |
|                      | Depth of 5    | 12                      | 3     | 0      | 15    | 16           | 54                    |                      |
| Proposed classifier  | Iteration 13  | 3                       | 3     | 0      | 6     | 16           | 51                    | 78.88                |
|                      | Iteration 14  | 3                       | 3     | 0      | 6     | 16           | 51                    | 82.02                |
|                      | Iteration 15  | 3                       | 3     | 0      | 6     | 16           | 51                    | 209.93               |

Table 5.3: Splitting values on features of multiple decision tree of depths 3 to 5 and proposed classifier in iterations 13 to 15

| Classification Model |                     | Splitting Values  |                                |       | Training Accuracy (%) |
|----------------------|---------------------|---|--------------------------------|-------|-----------------------|
| Model                | Specification       | A_AGE   | PEMLR                          | SS_YN |                       |
| Decision tree        | Depth of 3          | 14.5, 17.5, 59.5, 78.5                                      | {2}, {5}, {6}, {0, 1, 3, 4, 7} | -     | 45                    |
|                      | Depth of 4          | 6, 14.5, 17.5, 48.5, 59.5,<br>70.5, 78.5, 82.5              | {2}, {5}, {6}, {0, 1, 3, 4, 7} | -     | 50                    |
|                      | Depth of 5          | 2.5, 6, 14.5, 17.5, 48.5, 57.5,<br>59.5, 62, 70.5, 75, 78.5 | {2}, {5}, {6}, {0, 1, 3, 4, 7} | -     | 54                    |
| Proposed classifier  | Iteration 13        | 24.99, 55.99, 64.99   | {2}, {1}, {3, 4, 5, 7}, {0, 6} | -     | 51                    |
|                      | Iterations 14 to 15 | 24.01, 55.99, 64.99   | {2}, {1}, {3, 4, 5, 7}, {0, 6} | -     | 51                    |

Table 5.4: Training accuracy, execution time, minimum storage usage, relative MIP gap and number of inconsistent data across all iterations

| Iteration | Accuracy (%) |       | Execution Time (min) |        | Min Storage (GB) |        |        | Rel Gap | Inconsistent |
|-----------|--------------|-------|----------------------|--------|------------------|--------|--------|---------|--------------|
|           | True         | CPLEX | Reported             | Each   | Accum            | Tree   | Nodes  | Comp    |              |
| 1         |              |       | 20                   | 0      | 0                |        |        | 279     |              |
| 2         | 38           | 35    | 28                   | 0.03   | 0.03             |        |        | 27.57   | 41           |
| 3         | 38           | 35    | 31                   | 0.01   | 0.04             |        |        | 22.14   | 41           |
| 4         | 38           | 35    | 36                   | 0.01   | 0.06             |        |        | 17.25   | 41           |
| 5         | 38           | 35    | 38                   | 0.03   | 0.09             |        |        | 15.5    | 41           |
| 6         | 40           | 36    | 39                   | 13.3   | 13.39            | 0.99   | 0      | 8.67    | 41           |
| 7         | 40           | 30    | 40                   | 5.27   | 18.66            | 1.24   | 0      | 8.42    | 100          |
| 8         | 43           | 40    | 43                   | 4.64   | 23.3             | 2.74   | 0.49   | 7.75    | 41           |
| 9         | 44           | 42    | 44                   | 7.67   | 30.97            | 3.68   | 1.3    | 7.54    | 41           |
| 10        | 47           | 47    | 46                   | 37.23  | 68.2             | 3.35   | 1.34   | 7.01    |              |
| 11        | 48           | 48    | 48                   | 1.18   | 69.38            | 3.46   | 1.5    | 6.67    |              |
| 12        | 50           | 50    | 49                   | 7.17   | 76.55            | 4.11   | 1.64   | 6.51    |              |
| 13        | 51           | 51    | 50                   | 2.33   | 78.88            | 8.13   | 5.92   | 6.35    |              |
| 14        | 51           | 51    | 51                   | 3.14   | 82.02            | 9.06   | 7      | 6.2     |              |
| 15        | 51           | 51    | 51                   | 127.91 | 209.93           | 192.68 | 190.58 | 167.06  | 6.08         |

Table 5.5: Selected variables and groups of values across all iterations

| Iteration | Selected Variable |        |             | Group | Member |                               |
|-----------|-------------------|--------|-------------|-------|--------|-------------------------------|
|           | Index             | Symbol | Type        |       | Index  | Label                         |
| 2         | 2                 | PEMLR  | Categorical | 0     | 1      | Employed - at work            |
|           |                   |        |             |       | 3      | Unemployed - on layoff        |
|           |                   |        |             |       | 7      | Not in labor force - other    |
|           |                   |        |             |       | 5      | Not in labor force - retired  |
|           |                   |        |             | 2     |        |                               |
|           |                   |        |             | 3     | 0      | NIU                           |
|           | 3                 | SS_YN  | Categorical | 0     | 2      | Employed - absent             |
|           |                   |        |             |       | 4      | Unemployed - looking          |
|           |                   |        |             |       | 6      | Not in labor force - disabled |
|           |                   |        |             |       | 2      | No                            |
|           |                   |        |             | 1     | 1      | Yes                           |
|           |                   |        |             | 2     | 0      | NIU (aged below 15)           |
| 3         | 2                 | PEMLR  | Categorical | 0     | 1      | Employed - at work            |
|           |                   |        |             |       | 3      | Unemployed - on layoff        |
|           |                   |        |             |       | 7      | Not in labor force - other    |
|           |                   |        |             | 2     | 5      | Not in labor force - retired  |
|           |                   |        |             | 3     | 0      | NIU                           |

Table 5.5: Selected variables and groups of values across all iterations (continued)

| Iteration | Selected Variable |        |             | Group | Member |                               |
|-----------|-------------------|--------|-------------|-------|--------|-------------------------------|
|           | Index             | Symbol | Type        |       | Index  | Label                         |
|           | 3                 | SS_YN  | Categorical | 0     | 2      | Employed - absent             |
|           |                   |        |             |       | 4      | Unemployed - looking          |
|           |                   |        |             |       | 6      | Not in labor force - disabled |
|           |                   |        |             |       | 2      | No                            |
|           |                   |        |             |       | 1      | Yes                           |
|           |                   |        |             |       | 0      | NIU (aged below 15)           |
| 4         | 2                 | PEMLR  | Categorical | 0     | 1      | Employed - at work            |
|           |                   |        |             |       | 3      | Unemployed - on layoff        |
|           |                   |        |             |       | 7      | Not in labor force - other    |
|           |                   |        |             |       | 5      | Not in labor force - retired  |
|           |                   |        |             |       | 0      | NIU                           |
|           |                   |        |             |       | 2      | Employed - absent             |
|           |                   |        |             |       | 4      | Unemployed - looking          |
|           |                   |        |             |       | 6      | Not in labor force - disabled |
|           |                   |        |             |       | 2      | No                            |
|           |                   |        |             |       | 1      | Yes                           |
|           | 3                 | SS_YN  | Categorical | 0     | 2      | No                            |
|           |                   |        |             |       | 1      | Yes                           |

Table 5.5: Selected variables and groups of values across all iterations (continued)

| Iteration | Selected Variable |        | Group       | Member |                               |
|-----------|-------------------|--------|-------------|--------|-------------------------------|
|           | Index             | Symbol | Type        | Index  | Label                         |
| 5         | 2                 | PEMLR  | Categorical | 2      | NIU (aged below 15)           |
|           |                   |        |             | 0      |                               |
|           |                   |        |             | 1      | Employed - at work            |
|           |                   |        |             | 3      | Unemployed - on layoff        |
|           |                   |        |             | 7      | Not in labor force - other    |
|           |                   |        |             | 5      | Not in labor force - retired  |
|           |                   |        |             | 0      | NIU                           |
|           |                   |        |             | 2      | Employed - absent             |
|           |                   |        |             | 4      | Unemployed - looking          |
|           |                   |        |             | 6      | Not in labor force - disabled |
|           |                   |        |             | 2      | No                            |
|           |                   |        |             | 1      | Yes                           |
|           |                   |        |             | 0      | NIU (aged below 15)           |
|           |                   |        |             |        |                               |
| 6         | 2                 | PEMLR  | Categorical | 0      | Employed - at work            |
|           |                   |        |             | 3      | Unemployed - on layoff        |
|           |                   |        |             | 7      | Not in labor force - other    |
|           |                   |        |             | 2      | Employed - absent             |

Table 5.5: Selected variables and groups of values across all iterations (continued)

| Iteration | Selected Variable |        |             | Group | Member |                               |
|-----------|-------------------|--------|-------------|-------|--------|-------------------------------|
|           | Index             | Symbol | Type        |       | Index  | Label                         |
|           | 3                 | SS_YN  | Categorical | 2     | 5      | Not in labor force - retired  |
|           |                   |        |             | 3     | 0      | NIU                           |
|           |                   |        |             |       | 4      | Unemployed - looking          |
|           |                   |        |             |       | 6      | Not in labor force - disabled |
|           |                   |        |             | 0     | 2      | No                            |
|           |                   |        |             | 1     | 1      | Yes                           |
|           |                   |        |             | 2     | 0      | NIU (aged below 15)           |
|           |                   |        |             |       |        |                               |
| 7         | 2                 | PEMLR  | Categorical | 0     | 1      | Employed - at work            |
|           |                   |        |             |       | 2      | Employed - absent             |
|           |                   |        |             |       | 4      | Unemployed - looking          |
|           |                   |        |             | 2     | 0      | NIU                           |
|           |                   |        |             |       | 3      | Unemployed - on layoff        |
|           |                   |        |             |       | 6      | Not in labor force - disabled |
|           |                   |        |             |       | 7      | Not in labor force - other    |
|           |                   |        |             | 3     | 5      | Not in labor force - retired  |
|           |                   |        |             | 1     | 0      | NIU (aged below 15)           |
|           |                   |        |             |       |        |                               |



Table 5.5: Selected variables and groups of values across all iterations (continued)

| Iteration | Selected Variable |             | Group       | Member |                               |
|-----------|-------------------|-------------|-------------|--------|-------------------------------|
|           | Index             | Symbol      | Type        | Index  | Label                         |
| 8         | 2                 | PEMLR       | Categorical | 2      | No                            |
|           |                   |             |             | 1      | Yes                           |
|           |                   |             |             | 2      | Employed - absent             |
|           |                   |             |             | 1      | Employed - at work            |
|           |                   |             |             | 6      | Not in labor force - disabled |
|           |                   |             |             | 0      | NIU                           |
|           |                   |             |             | 3      | Unemployed - on layoff        |
|           |                   |             |             | 4      | Unemployed - looking          |
|           |                   |             |             | 7      | Not in labor force - other    |
|           |                   |             |             | 5      | Not in labor force - retired  |
| 3         | SS_YN             | Categorical | 3           | 2      | No                            |
|           |                   |             | 2           | 0      | NIU (aged below 15)           |
|           |                   |             |             | 1      | Yes                           |
|           |                   |             | 0           | 2      | Employed - absent             |
|           |                   |             | 1           | 1      | Employed - at work            |
|           |                   |             | 2           | 0      | NIU                           |
|           |                   |             |             |        |                               |
|           |                   |             |             |        |                               |
|           |                   |             |             |        |                               |
|           |                   |             |             |        |                               |
| 9         | 2                 | PEMLR       | Categorical | 0      | Employed - absent             |
|           |                   |             |             | 1      | Employed - at work            |
|           |                   |             |             | 2      | NIU                           |

Table 5.5: Selected variables and groups of values across all iterations (continued)

| Iteration | Selected Variable |        |             | Group | Member             |                               |
|-----------|-------------------|--------|-------------|-------|--------------------|-------------------------------|
|           | Index             | Symbol | Type        |       | Index              | Label                         |
|           | 3                 | SS_YN  | Categorical |       | 3                  | Unemployed - on layoff        |
|           |                   |        |             |       | 4                  | Unemployed - looking          |
|           |                   |        |             |       | 6                  | Not in labor force - disabled |
|           |                   |        |             |       | 7                  | Not in labor force - other    |
|           |                   |        |             |       | 5                  | Not in labor force - retired  |
|           |                   |        |             | 3     | 2                  | No                            |
|           |                   |        |             | 0     |                    |                               |
|           |                   |        |             | 2     | 0                  | NIU (aged below 15)           |
|           |                   |        |             |       | 1                  | Yes                           |
|           |                   |        |             |       |                    |                               |
| 10        | 1                 | A_AGE  | Continuous  | 0     | $(-\infty, 24.01)$ | Below 24                      |
|           |                   |        |             |       | $(24.01, 40.99)$   | Between 25 and 40             |
|           |                   |        |             |       | $(40.99, 65.99)$   | Between 41 and 65             |
|           |                   |        |             |       | $(65.99, \infty)$  | Above 66                      |
|           |                   |        |             | 3     |                    |                               |
|           |                   |        |             | 0     | 2                  | Employed - absent             |
|           |                   |        |             | 1     | 1                  | Employed - at work            |
|           |                   |        |             |       | 7                  | Not in labor force - other    |
|           |                   |        |             | 2     | 4                  | Unemployed - looking          |
|           |                   |        |             |       |                    |                               |

Table 5.5: Selected variables and groups of values across all iterations (continued)

| Iteration | Selected Variable |        | Group       | Member |                               |
|-----------|-------------------|--------|-------------|--------|-------------------------------|
|           | Index             | Symbol | Type        | Index  | Label                         |
| 11        | 1                 | A_AGE  | Continuous  | 5      | Not in labor force - retired  |
|           |                   |        |             | 0      | NIU                           |
|           |                   |        |             | 3      | Unemployed - on layoff        |
|           |                   |        |             | 6      | Not in labor force - disabled |
|           | 2                 | PEMLR  | Categorical | 0      | Below 24                      |
|           |                   |        |             | 1      | Between 25 and 40             |
|           |                   |        |             | 2      | Between 41 and 64             |
|           |                   |        |             | 3      | Above 65                      |
|           | 3                 |        |             | 2      | Employed - absent             |
|           |                   |        |             | 1      | Employed - at work            |
|           |                   |        |             | 7      | Not in labor force - other    |
|           |                   |        |             | 4      | Unemployed - looking          |
| 12        | 1                 |        |             | 5      | Not in labor force - retired  |
|           |                   |        |             | 0      | NIU                           |
|           |                   |        |             | 3      | Unemployed - on layoff        |
|           |                   |        |             | 6      | Not in labor force - disabled |

Table 5.5: Selected variables and groups of values across all iterations (continued)

| Iteration | Selected Variable |        |             | Group | Member             |                               |
|-----------|-------------------|--------|-------------|-------|--------------------|-------------------------------|
|           | Index             | Symbol | Type        |       | Index              | Label                         |
| 12        | 1                 | A_AGE  | Continuous  | 0     | $(-\infty, 24.99)$ | Below 24                      |
|           |                   |        |             | 1     | $(24.99, 40.01)$   | Between 25 and 40             |
|           |                   |        |             | 2     | $(40.00, 64.01)$   | Between 41 and 64             |
|           |                   |        |             | 3     | $(64.01, \infty)$  | Above 65                      |
|           | 2                 | PEMLR  | Categorical | 0     | 2                  | Employed - absent             |
|           |                   |        |             | 1     | 1                  | Employed - at work            |
|           |                   |        |             | 2     | 4                  | Unemployed - looking          |
| 13        | 1                 | A_AGE  | Continuous  |       | 5                  | Not in labor force - retired  |
|           |                   |        |             |       | 7                  | Not in labor force - other    |
|           |                   |        |             |       | 0                  | NIU                           |
|           |                   |        |             |       | 3                  | Unemployed - on layoff        |
|           |                   |        |             | 3     | 6                  | Not in labor force - disabled |
|           |                   |        |             |       |                    |                               |
|           |                   |        |             |       |                    |                               |
|           |                   |        |             |       |                    |                               |
|           |                   |        |             | 0     | $(-\infty, 24.99)$ | Below 24                      |
|           |                   |        |             | 1     | $(24.99, 55.99)$   | Between 25 and 55             |
|           |                   |        |             | 2     | $(55.99, 64.99)$   | Between 56 and 64             |
|           |                   |        |             | 3     | $(64.99, \infty)$  | Above 65                      |

Table 5.5: Selected variables and groups of values across all iterations (continued)

| Iteration | Selected Variable |        |             | Group      | Member            |                               |                   |
|-----------|-------------------|--------|-------------|------------|-------------------|-------------------------------|-------------------|
|           | Index             | Symbol | Type        |            | Index             | Label                         |                   |
|           | 2                 | PEMLR  | Categorical | 0          | 2                 | Employed - absent             |                   |
|           |                   |        |             | 1          | 1                 | Employed - at work            |                   |
|           |                   |        |             | 2          | 3                 | Unemployed - on layoff        |                   |
|           |                   |        |             |            | 4                 | Unemployed - looking          |                   |
|           |                   |        |             |            | 5                 | Not in labor force - retired  |                   |
|           |                   |        |             |            | 7                 | Not in labor force - other    |                   |
|           |                   |        |             | 3          | 0                 | NIU                           |                   |
|           |                   |        |             |            | 6                 | Not in labor force - disabled |                   |
|           | 14                | 1      | A_AGE       | Continuous | 0                 | $(-\infty, 24.01)$            | Below 24          |
|           |                   |        |             |            | 1                 | $(24.01, 55.99)$              | Between 25 and 55 |
|           |                   |        |             | 2          | $(55.99, 64.99)$  | Between 56 and 64             |                   |
|           |                   |        |             | 3          | $(64.99, \infty)$ | Above 65                      |                   |
|           | 2                 | PEMLR  | Categorical | 0          | 2                 | Employed - absent             |                   |
|           |                   |        |             | 1          | 1                 | Employed - at work            |                   |
|           |                   |        |             | 2          | 3                 | Unemployed - on layoff        |                   |
|           |                   |        |             |            | 4                 | Unemployed - looking          |                   |

Table 5.5: Selected variables and groups of values across all iterations (continued)

| Iteration | Selected Variable |        | Group       | Member |                               |
|-----------|-------------------|--------|-------------|--------|-------------------------------|
|           | Index             | Symbol | Type        | Index  | Label                         |
| 15        | 1                 | A_AGE  | Continuous  | 5      | Not in labor force - retired  |
|           |                   |        |             | 7      | Not in labor force - other    |
|           |                   |        |             | 0      | NIU                           |
|           |                   |        |             | 6      | Not in labor force - disabled |
|           | 2                 | PEMLR  | Categorical | 0      | Below 24                      |
|           |                   |        |             | 1      | Between 25 and 55             |
|           |                   |        |             | 2      | Between 56 and 64             |
|           |                   |        |             | 3      | Above 65                      |
|           | 3                 |        |             | 2      | Employed - absent             |
|           |                   |        |             | 1      | Employed - at work            |
|           |                   |        |             | 3      | Unemployed - on layoff        |
|           |                   |        |             | 4      | Unemployed - looking          |
|           | 4                 |        |             | 5      | Not in labor force - retired  |
|           |                   |        |             | 7      | Not in labor force - other    |
|           |                   |        |             | 0      | NIU                           |
|           |                   |        |             | 6      | Not in labor force - disabled |

Table 5.6: Decision regions and predicted class labels across all iterations

| Iter | Selected Variables |              | Decision Region |       |                               | Predicted Classes |                          | Num |
|------|--------------------|--------------|-----------------|-------|-------------------------------|-------------------|--------------------------|-----|
|      | Tuple              | Symbol       | Ind             | Tuple | Cross Product                 | Ind               | Label                    |     |
| 2    | (2,3)              | PEMLR, SS_YN | 0               | (0,0) | $\{1, 3, 7\} \times \{2\}$    | 0                 | NNN                      | 48  |
|      |                    |              | 1               | (1,0) | $\emptyset \times \{2\}$      | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 2               | (2,0) | $\{5\} \times \{2\}$          | 2                 | NY_-                     | 3   |
|      |                    |              | 3               | (3,0) | $\{0, 2, 4, 6\} \times \{2\}$ | 2                 | NY_-                     | 8   |
|      |                    |              | 4               | (0,1) | $\{1, 3, 7\} \times \{1\}$    | 2,4               | NY_-, Y1Y                | 6   |
|      |                    |              | 5               | (1,1) | $\emptyset \times \{1\}$      | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 6               | (2,1) | $\{5\} \times \{1\}$          | 4                 | Y1Y                      | 16  |
|      |                    |              | 7               | (3,1) | $\{0, 2, 4, 6\} \times \{1\}$ | 1                 | NNY                      | 5   |
|      |                    |              | 8               | (0,2) | $\{1, 3, 7\} \times \{0\}$    | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 9               | (1,2) | $\emptyset \times \{0\}$      | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 10              | (2,2) | $\{5\} \times \{0\}$          | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 11              | (3,2) | $\{0, 2, 4, 6\} \times \{0\}$ | 1                 | NNY                      | 14  |
| 3    | (2,3)              | PEMLR, SS_YN | 0               | (0,0) | $\{1, 3, 7\} \times \{2\}$    | 0                 | NNN                      | 48  |
|      |                    |              | 1               | (1,0) | $\emptyset \times \{2\}$      | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 2               | (2,0) | $\{5\} \times \{2\}$          | 2                 | NY_-                     | 3   |
|      |                    |              | 3               | (3,0) | $\{0, 2, 4, 6\} \times \{2\}$ | 2                 | NY_-                     | 8   |

Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |              | Decision Region |       |                               | Predicted Classes |                          | Num |
|------|--------------------|--------------|-----------------|-------|-------------------------------|-------------------|--------------------------|-----|
|      | Tuple              | Symbol       | Ind             | Tuple | Cross Product                 | Ind               | Label                    |     |
| 4    | (2,3)              | PEMLR, SS_YN | 4               | (0,1) | $\{1, 3, 7\} \times \{1\}$    | 2,4               | NY_-, Y1Y                | 6   |
|      |                    |              | 5               | (1,1) | $\emptyset \times \{1\}$      | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 6               | (2,1) | $\{5\} \times \{1\}$          | 4                 | Y1Y                      | 16  |
|      |                    |              | 7               | (3,1) | $\{0, 2, 4, 6\} \times \{1\}$ | 1                 | NNY                      | 5   |
|      |                    |              | 8               | (0,2) | $\{1, 3, 7\} \times \{0\}$    | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 9               | (1,2) | $\emptyset \times \{0\}$      | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 10              | (2,2) | $\{5\} \times \{0\}$          | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 11              | (3,2) | $\{0, 2, 4, 6\} \times \{0\}$ | 1                 | NNY                      | 14  |
|      |                    |              | 0               | (0,0) | $\{1, 3, 7\} \times \{2\}$    | 0                 | NNN                      | 48  |
|      |                    |              | 1               | (1,0) | $\emptyset \times \{2\}$      | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 2               | (2,0) | $\{5\} \times \{2\}$          | 2                 | NY_-                     | 3   |
| 5    | (2,3)              | PEMLR, SS_YN | 3               | (3,0) | $\{0, 2, 4, 6\} \times \{2\}$ | 2                 | NY_-                     | 8   |
|      |                    |              | 4               | (0,1) | $\{1, 3, 7\} \times \{1\}$    | 2,4               | NY_-, Y1Y                | 6   |
|      |                    |              | 5               | (1,1) | $\emptyset \times \{1\}$      | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 6               | (2,1) | $\{5\} \times \{1\}$          | 4                 | Y1Y                      | 16  |
|      |                    |              | 7               | (3,1) | $\{0, 2, 4, 6\} \times \{1\}$ | 1                 | NNY                      | 5   |



Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |                               | Decision Region |                          | Predicted Classes             |           | Num                      |       |
|------|--------------------|-------------------------------|-----------------|--------------------------|-------------------------------|-----------|--------------------------|-------|
|      | Tuple              | Symbol                        | Ind             | Tuple                    | Cross Product                 | Ind       |                          | Label |
| 5    | (2,3)              | PEMLR, SS_YN                  | 8               | (0,2)                    | $\{1, 3, 7\} \times \{0\}$    | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y | 0     |
|      |                    |                               | 9               | (1,2)                    | $\emptyset \times \{0\}$      | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y | 0     |
|      |                    |                               | 10              | (2,2)                    | $\{5\} \times \{0\}$          | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y | 0     |
|      |                    |                               | 11              | (3,2)                    | $\{0, 2, 4, 6\} \times \{0\}$ | 1         | NNY                      | 14    |
|      |                    |                               | 0               | (0,0)                    | $\{1, 3, 7\} \times \{2\}$    | 0         | NNN                      | 48    |
|      |                    |                               | 1               | (1,0)                    | $\emptyset \times \{2\}$      | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y | 0     |
|      |                    |                               | 2               | (2,0)                    | $\{5\} \times \{2\}$          | 2         | NY_                      | 3     |
|      |                    |                               | 3               | (3,0)                    | $\{0, 2, 4, 6\} \times \{2\}$ | 2         | NY_                      | 8     |
|      |                    |                               | 4               | (0,1)                    | $\{1, 3, 7\} \times \{1\}$    | 2,4       | NY_-, Y1Y                | 6     |
|      |                    |                               | 5               | (1,1)                    | $\emptyset \times \{1\}$      | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y | 0     |
|      |                    |                               | 6               | (2,1)                    | $\{5\} \times \{1\}$          | 4         | Y1Y                      | 16    |
| 7    | (3,1)              | $\{0, 2, 4, 6\} \times \{1\}$ | 1               | NNY                      | 5                             |           |                          |       |
| 8    | (0,2)              | $\{1, 3, 7\} \times \{0\}$    | 0,1,2,3,4       | NNN, NNY, NY_-, YNN, Y1Y | 0                             |           |                          |       |
| 9    | (1,2)              | $\emptyset \times \{0\}$      | 0,1,2,3,4       | NNN, NNY, NY_-, YNN, Y1Y | 0                             |           |                          |       |
| 10   | (2,2)              | $\{5\} \times \{0\}$          | 0,1,2,3,4       | NNN, NNY, NY_-, YNN, Y1Y | 0                             |           |                          |       |
| 11   | (3,2)              | $\{0, 2, 4, 6\} \times \{0\}$ | 1               | NNY                      | 14                            |           |                          |       |

Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |              | Decision Region |       |                            | Predicted Classes |                          | Num |
|------|--------------------|--------------|-----------------|-------|----------------------------|-------------------|--------------------------|-----|
|      | Tuple              | Symbol       | Ind             | Tuple | Cross Product              | Ind               | Label                    |     |
| 6    | (2,3)              | PEMLR, SS_YN | 0               | (0,0) | $\{1, 3, 7\} \times \{2\}$ | 0                 | NNN                      | 48  |
|      |                    |              | 1               | (1,0) | $\{2\} \times \{2\}$       | 2                 | NY_                      | 3   |
|      |                    |              | 2               | (2,0) | $\{5\} \times \{2\}$       | 2                 | NY_                      | 3   |
|      |                    |              | 3               | (3,0) | $\{0, 4, 6\} \times \{2\}$ | 0,3               | NNN, YNN                 | 5   |
|      |                    |              | 4               | (0,1) | $\{1, 3, 7\} \times \{1\}$ | 2,4               | NY_ , Y1Y                | 6   |
|      |                    |              | 5               | (1,1) | $\{2\} \times \{1\}$       | 2                 | NY_                      | 1   |
|      |                    |              | 6               | (2,1) | $\{5\} \times \{1\}$       | 4                 | Y1Y                      | 16  |
|      |                    |              | 7               | (3,1) | $\{0, 4, 6\} \times \{1\}$ | 1                 | NNY                      | 4   |
|      |                    |              | 8               | (0,2) | $\{1, 3, 7\} \times \{0\}$ | 0,1,2,3,4         | NNN, NNY, NY_ , YNN, Y1Y | 0   |
|      |                    |              | 9               | (1,2) | $\{2\} \times \{0\}$       | 0,1,2,3,4         | NNN, NNY, NY_ , YNN, Y1Y | 0   |
|      |                    |              | 10              | (2,2) | $\{5\} \times \{0\}$       | 0,1,2,3,4         | NNN, NNY, NY_ , YNN, Y1Y | 0   |
|      |                    |              | 11              | (3,2) | $\{0, 4, 6\} \times \{0\}$ | 1                 | NNY                      | 14  |

Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |                          | Decision Region |                                |                                   | Predicted Classes             |                                | Num       |    |
|------|--------------------|--------------------------|-----------------|--------------------------------|-----------------------------------|-------------------------------|--------------------------------|-----------|----|
|      | Tuple              | Symbol                   | Ind             | Tuple                          | Cross Product                     | Ind                           | Label                          |           |    |
|      |                    |                          | 4               | (0,1)                          | $\{1, 2, 4\} \times \{0, 2\}$     | 3                             | YNN                            | 42        |    |
|      |                    |                          | 5               | (1,1)                          | $\emptyset \times \{0, 2\}$       | 0,1,2,3,4                     | NNN, NNY, NY $_{-}$ , YNN, Y1Y | 0         |    |
|      |                    |                          | 6               | (2,1)                          | $\{0, 3, 6, 7\} \times \{0, 2\}$  | 0                             | NNN                            | 28        |    |
|      |                    |                          | 7               | (3,1)                          | $\{5\} \times \{0, 2\}$           | 2                             | NY $_{-}$                      | 3         |    |
|      |                    |                          | 8               | (0,2)                          | $\{1, 2, 4\} \times \{1\}$        | 2                             | NY $_{-}$                      | 6         |    |
|      |                    |                          | 9               | (1,2)                          | $\emptyset \times \{1\}$          | 0,1,2,3,4                     | NNN, NNY, NY $_{-}$ , YNN, Y1Y | 0         |    |
|      |                    |                          | 10              | (2,2)                          | $\{0, 3, 6, 7\} \times \{1\}$     | 1                             | NNY                            | 5         |    |
|      |                    |                          | 11              | (3,2)                          | $\{5\} \times \{1\}$              | 4                             | Y1Y                            | 16        |    |
|      | 8                  | (2,3)                    | PEMLR, SS_YN    | 0                              | (0,0)                             | $\{2\} \times \{2\}$          | 2                              | NY $_{-}$ | 3  |
|      |                    |                          |                 | 1                              | (1,0)                             | $\{1, 6\} \times \{2\}$       | 3                              | YNN       | 35 |
|      |                    |                          |                 | 2                              | (2,0)                             | $\{0, 3, 4, 7\} \times \{2\}$ | 0                              | NNN       | 18 |
| 3    |                    |                          |                 | (3,0)                          | $\{5\} \times \{2\}$              | 2                             | NY $_{-}$                      | 3         |    |
| 4    |                    |                          |                 | (0,1)                          | $\{2\} \times \emptyset$          | 0,1,2,3,4                     | NNN, NNY, NY $_{-}$ , YNN, Y1Y | 0         |    |
| 5    |                    |                          |                 | (1,1)                          | $\{1, 6\} \times \emptyset$       | 0,1,2,3,4                     | NNN, NNY, NY $_{-}$ , YNN, Y1Y | 0         |    |
| 6    |                    |                          |                 | (2,1)                          | $\{0, 3, 4, 7\} \times \emptyset$ | 0,1,2,3,4                     | NNN, NNY, NY $_{-}$ , YNN, Y1Y | 0         |    |
| 7    | (3,1)              | $\{5\} \times \emptyset$ | 0,1,2,3,4       | NNN, NNY, NY $_{-}$ , YNN, Y1Y | 0                                 |                               |                                |           |    |

Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |              | Decision Region |       | Predicted Classes                    |           | Num                      |
|------|--------------------|--------------|-----------------|-------|--------------------------------------|-----------|--------------------------|
|      | Tuple              | Symbol       | Ind             | Tuple | Cross Product                        | Ind       | Label                    |
| 9    | (2,3)              | PEMLR, SS_YN | 8               | (0,2) | $\{2\} \times \{0, 1\}$              | 2         | NY_                      |
|      |                    |              | 9               | (1,2) | $\{1, 6\} \times \{0, 1\}$           | 2         | NY_                      |
|      |                    |              | 10              | (2,2) | $\{0, 3, 4, 7\} \times \{0, 1\}$     | 1         | NNY                      |
|      |                    |              | 11              | (3,2) | $\{5\} \times \{0, 1\}$              | 4         | Y1Y                      |
|      |                    |              | 0               | (0,0) | $\{2\} \times \{2\}$                 | 2         | NY_                      |
|      |                    |              | 1               | (1,0) | $\{1\} \times \{2\}$                 | 3         | YNN                      |
|      |                    |              | 2               | (2,0) | $\{0, 3, 4, 6, 7\} \times \{2\}$     | 0         | NNN                      |
|      |                    |              | 3               | (3,0) | $\{5\} \times \{2\}$                 | 2         | NY_                      |
|      |                    |              | 4               | (0,1) | $\{2\} \times \emptyset$             | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |
|      |                    |              | 5               | (1,1) | $\{1\} \times \emptyset$             | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |
|      |                    |              | 6               | (2,1) | $\{0, 3, 4, 6, 7\} \times \emptyset$ | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |
| 10   | (2,3)              | PEMLR, SS_YN | 7               | (3,1) | $\{5\} \times \emptyset$             | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |
|      |                    |              | 8               | (0,2) | $\{2\} \times \{0, 1\}$              | 2         | NY_                      |
|      |                    |              | 9               | (1,2) | $\{1\} \times \{0, 1\}$              | 2         | NY_                      |
|      |                    |              | 10              | (2,2) | $\{0, 3, 4, 6, 7\} \times \{0, 1\}$  | 1         | NNY                      |
|      |                    |              | 11              | (3,2) | $\{5\} \times \{0, 1\}$              | 4         | Y1Y                      |
|      |                    |              | 0               | (0,0) | $\{2\} \times \{2\}$                 | 2         | NY_                      |
|      |                    |              | 1               | (1,0) | $\{1\} \times \{2\}$                 | 3         | YNN                      |
|      |                    |              | 2               | (2,0) | $\{0, 3, 4, 6, 7\} \times \{2\}$     | 0         | NNN                      |
|      |                    |              | 3               | (3,0) | $\{5\} \times \{2\}$                 | 2         | NY_                      |
|      |                    |              | 4               | (0,1) | $\{2\} \times \emptyset$             | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |
|      |                    |              | 5               | (1,1) | $\{1\} \times \emptyset$             | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |
| 11   | (2,3)              | PEMLR, SS_YN | 6               | (2,1) | $\{0, 3, 4, 6, 7\} \times \emptyset$ | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |
|      |                    |              | 7               | (3,1) | $\{5\} \times \emptyset$             | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |
|      |                    |              | 8               | (0,2) | $\{2\} \times \{0, 1\}$              | 2         | NY_                      |
|      |                    |              | 9               | (1,2) | $\{1\} \times \{0, 1\}$              | 2         | NY_                      |
|      |                    |              | 10              | (2,2) | $\{0, 3, 4, 6, 7\} \times \{0, 1\}$  | 1         | NNY                      |
|      |                    |              | 11              | (3,2) | $\{5\} \times \{0, 1\}$              | 4         | Y1Y                      |
|      |                    |              | 0               | (0,0) | $\{2\} \times \{2\}$                 | 2         | NY_                      |
|      |                    |              | 1               | (1,0) | $\{1\} \times \{2\}$                 | 3         | YNN                      |
|      |                    |              | 2               | (2,0) | $\{0, 3, 4, 6, 7\} \times \{2\}$     | 0         | NNN                      |
|      |                    |              | 3               | (3,0) | $\{5\} \times \{2\}$                 | 2         | NY_                      |
|      |                    |              | 4               | (0,1) | $\{2\} \times \emptyset$             | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |
|      |                    |              | 5               | (1,1) | $\{1\} \times \emptyset$             | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |

Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |                | Decision Region |       |                                       | Predicted Classes |                          | Num |
|------|--------------------|----------------|-----------------|-------|---------------------------------------|-------------------|--------------------------|-----|
|      | Tuple              | Symbol         | Ind             | Tuple | Cross Product                         | Ind               | Label                    |     |
| 10   | (1,2)              | A_ AGE, PEMPLR | 0               | (0,0) | $(-\infty, 24.01) \times \{2\}$       | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |                | 1               | (1,0) | $(24.01, 40.99) \times \{2\}$         | 2                 | NY_-                     | 2   |
|      |                    |                | 2               | (2,0) | $(40.99, 65.99) \times \{2\}$         | 4                 | Y1Y                      | 1   |
|      |                    |                | 3               | (3,0) | $(65.99, \infty) \times \{2\}$        | 2                 | NY_-                     | 1   |
|      |                    |                | 4               | (0,1) | $(-\infty, 24.01) \times \{1, 7\}$    | 0                 | NNN                      | 11  |
|      |                    |                | 5               | (1,1) | $(24.01, 40.99) \times \{1, 7\}$      | 3                 | YNN                      | 17  |
|      |                    |                | 6               | (2,1) | $(40.99, 65.99) \times \{1, 7\}$      | 3                 | YNN                      | 20  |
|      |                    |                | 7               | (3,1) | $(65.99, \infty) \times \{1, 7\}$     | 2,4               | NY_-, Y1Y                | 4   |
|      |                    |                | 8               | (0,2) | $(-\infty, 24.01) \times \{4, 5\}$    | 1,3               | NNY, YNN                 | 2   |
|      |                    |                | 9               | (1,2) | $(24.01, 40.99) \times \{4, 5\}$      | 0,3               | NNN, YNN                 | 2   |
|      |                    |                | 10              | (2,2) | $(40.99, 65.99) \times \{4, 5\}$      | 2                 | NY_-                     | 4   |
|      |                    |                | 11              | (3,2) | $(65.99, \infty) \times \{4, 5\}$     | 4                 | Y1Y                      | 16  |
|      |                    |                | 12              | (0,3) | $(-\infty, 24.01) \times \{0, 3, 6\}$ | 1                 | NNY                      | 15  |
|      |                    |                | 13              | (1,3) | $(24.01, 40.99) \times \{0, 3, 6\}$   | 0                 | NNN                      | 1   |
|      |                    |                | 14              | (2,3) | $(40.99, 65.99) \times \{0, 3, 6\}$   | 1                 | NNY                      | 3   |
|      |                    |                | 15              | (3,3) | $(65.99, \infty) \times \{0, 3, 6\}$  | 1                 | NNY                      | 1   |

Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |               | Decision Region |                                      |                                       | Predicted Classes |                          | Num |
|------|--------------------|---------------|-----------------|--------------------------------------|---------------------------------------|-------------------|--------------------------|-----|
|      | Tuple              | Symbol        | Ind             | Tuple                                | Cross Product                         | Ind               | Label                    |     |
| 11   | (1,2)              | A_ AGE, PEMLR | 0               | (0,0)                                | $(-\infty, 24.01) \times \{2\}$       | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |               | 1               | (1,0)                                | $(24.01, 40.99) \times \{2\}$         | 2                 | NY_-                     | 2   |
|      |                    |               | 2               | (2,0)                                | $(40.99, 64.99) \times \{2\}$         | 4                 | Y1Y                      | 1   |
|      |                    |               | 3               | (3,0)                                | $(64.99, \infty) \times \{2\}$        | 2                 | NY_-                     | 1   |
|      |                    |               | 4               | (0,1)                                | $(-\infty, 24.01) \times \{1, 7\}$    | 0                 | NNN                      | 11  |
|      |                    |               | 5               | (1,1)                                | $(24.01, 40.99) \times \{1, 7\}$      | 3                 | YNN                      | 17  |
|      |                    |               | 6               | (2,1)                                | $(40.99, 64.99) \times \{1, 7\}$      | 3                 | YNN                      | 18  |
|      |                    |               | 7               | (3,1)                                | $(64.99, \infty) \times \{1, 7\}$     | 2,4               | NY_-, Y1Y                | 6   |
|      |                    |               | 8               | (0,2)                                | $(-\infty, 24.01) \times \{4, 5\}$    | 1,3               | NNY, YNN                 | 2   |
|      |                    |               | 9               | (1,2)                                | $(24.01, 40.99) \times \{4, 5\}$      | 0,3               | NNN, YNN                 | 2   |
|      |                    |               | 10              | (2,2)                                | $(40.99, 64.99) \times \{4, 5\}$      | 2                 | NY_-                     | 4   |
|      |                    |               | 11              | (3,2)                                | $(64.99, \infty) \times \{4, 5\}$     | 4                 | Y1Y                      | 16  |
|      |                    |               | 12              | (0,3)                                | $(-\infty, 24.01) \times \{0, 3, 6\}$ | 1                 | NNY                      | 15  |
|      |                    |               | 13              | (1,3)                                | $(24.01, 40.99) \times \{0, 3, 6\}$   | 0                 | NNN                      | 1   |
|      |                    |               | 14              | (2,3)                                | $(40.99, 64.99) \times \{0, 3, 6\}$   | 1                 | NNY                      | 3   |
|      |                    | 15            | (3,3)           | $(64.99, \infty) \times \{0, 3, 6\}$ | 1                                     | NNY               | 1                        |     |

Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |              | Decision Region |       | Predicted Classes                     |           | Num                     |
|------|--------------------|--------------|-----------------|-------|---------------------------------------|-----------|-------------------------|
|      | Tuple              | Symbol       | Ind             | Tuple | Cross Product                         | Ind       | Label                   |
| 12   | (1,2)              | A AGE, PEMLR | 0               | (0,0) | $(-\infty, 24.99) \times \{2\}$       | 0,1,2,3,4 | NNN, NNY, NY_, YNN, Y1Y |
|      |                    |              | 1               | (1,0) | $(24.99, 40.01) \times \{2\}$         | 2         | NY_                     |
|      |                    |              | 2               | (2,0) | $(40.00, 64.01) \times \{2\}$         | 4         | Y1Y                     |
|      |                    |              | 3               | (3,0) | $(64.01, \infty) \times \{2\}$        | 2         | NY_                     |
|      |                    |              | 4               | (0,1) | $(-\infty, 24.99) \times \{1\}$       | 0         | NNN                     |
|      |                    |              | 5               | (1,1) | $(24.99, 40.01) \times \{1\}$         | 3         | YNN                     |
|      |                    |              | 6               | (2,1) | $(40.00, 64.01) \times \{1\}$         | 3         | YNN                     |
|      |                    |              | 7               | (3,1) | $(64.01, \infty) \times \{1\}$        | 2         | NY_                     |
|      |                    |              | 8               | (0,2) | $(-\infty, 24.99) \times \{4, 5, 7\}$ | 1         | NNY                     |
|      |                    |              | 9               | (1,2) | $(24.99, 40.01) \times \{4, 5, 7\}$   | 0         | NNN                     |
|      |                    |              | 10              | (2,2) | $(40.00, 64.01) \times \{4, 5, 7\}$   | 2         | NY_                     |
|      |                    |              | 11              | (3,2) | $(64.01, \infty) \times \{4, 5, 7\}$  | 4         | Y1Y                     |
|      |                    |              | 12              | (0,3) | $(-\infty, 24.99) \times \{0, 3, 6\}$ | 1         | NNY                     |
|      |                    |              | 13              | (1,3) | $(24.99, 40.01) \times \{0, 3, 6\}$   | 0         | NNN                     |
|      |                    |              | 14              | (2,3) | $(40.00, 64.01) \times \{0, 3, 6\}$   | 1         | NNY                     |
|      |                    |              | 15              | (3,3) | $(64.01, \infty) \times \{0, 3, 6\}$  | 1         | NNY                     |

Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |              | Decision Region |       | Predicted Classes                        |           | Num                      |
|------|--------------------|--------------|-----------------|-------|--|-----------|--------------------------|
|      | Tuple              | Symbol       | Ind             | Tuple | Cross Product                            | Ind       | Label                    |
| 13   | (1,2)              | A AGE, PEMLR | 0               | (0,0) | $(-\infty, 24.99) \times \{2\}$          | 0,1,2,3,4 | NNN, NNY, NY_-, YNN, Y1Y |
|      |                    |              | 1               | (1,0) | $(24.99, 55.99) \times \{2\}$            | 2         | NY_-                     |
|      |                    |              | 2               | (2,0) | $(55.99, 64.99) \times \{2\}$            | 4         | Y1Y                      |
|      |                    |              | 3               | (3,0) | $(64.99, \infty) \times \{2\}$           | 2         | NY_-                     |
|      |                    |              | 4               | (0,1) | $(-\infty, 24.99) \times \{1\}$          | 0         | NNN                      |
|      |                    |              | 5               | (1,1) | $(24.99, 55.99) \times \{1\}$            | 3         | YNN                      |
|      |                    |              | 6               | (2,1) | $(55.99, 64.99) \times \{1\}$            | 3         | YNN                      |
|      |                    |              | 7               | (3,1) | $(64.99, \infty) \times \{1\}$           | 2         | NY_-                     |
|      |                    |              | 8               | (0,2) | $(-\infty, 24.99) \times \{3, 4, 5, 7\}$ | 1         | NNY                      |
|      |                    |              | 9               | (1,2) | $(24.99, 55.99) \times \{3, 4, 5, 7\}$   | 0         | NNN                      |
|      |                    |              | 10              | (2,2) | $(55.99, 64.99) \times \{3, 4, 5, 7\}$   | 2         | NY_-                     |
|      |                    |              | 11              | (3,2) | $(64.99, \infty) \times \{3, 4, 5, 7\}$  | 4         | Y1Y                      |
|      |                    |              | 12              | (0,3) | $(-\infty, 24.99) \times \{0, 6\}$       | 1         | NNY                      |
|      |                    |              | 13              | (1,3) | $(24.99, 55.99) \times \{0, 6\}$         | 1         | NNY                      |
|      |                    |              | 14              | (2,3) | $(55.99, 64.99) \times \{0, 6\}$         | 2         | NY_-                     |
|      |                    |              | 15              | (3,3) | $(64.99, \infty) \times \{0, 6\}$        | 1         | NNY                      |



Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |              | Decision Region |                                   |  | Predicted Classes |                          | Num |
|------|--------------------|--------------|-----------------|-----------------------------------|--|-------------------|--------------------------|-----|
|      | Tuple              | Symbol       | Ind             | Tuple                             | Cross Product                            | Ind               | Label                    |     |
| 14   | (1,2)              | A AGE, PEMLR | 0               | (0,0)                             | $(-\infty, 24.01) \times \{2\}$          | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |              | 1               | (1,0)                             | $(24.01, 55.99) \times \{2\}$            | 2                 | NY_-                     | 2   |
|      |                    |              | 2               | (2,0)                             | $(55.99, 64.99) \times \{2\}$            | 4                 | Y1Y                      | 1   |
|      |                    |              | 3               | (3,0)                             | $(64.99, \infty) \times \{2\}$           | 2                 | NY_-                     | 1   |
|      |                    |              | 4               | (0,1)                             | $(-\infty, 24.01) \times \{1\}$          | 0                 | NNN                      | 7   |
|      |                    |              | 5               | (1,1)                             | $(24.01, 55.99) \times \{1\}$            | 3                 | YNN                      | 23  |
|      |                    |              | 6               | (2,1)                             | $(55.99, 64.99) \times \{1\}$            | 3                 | YNN                      | 4   |
|      |                    |              | 7               | (3,1)                             | $(64.99, \infty) \times \{1\}$           | 2                 | NY_-                     | 5   |
|      |                    |              | 8               | (0,2)                             | $(-\infty, 24.01) \times \{3, 4, 5, 7\}$ | 1                 | NNY                      | 6   |
|      |                    |              | 9               | (1,2)                             | $(24.01, 55.99) \times \{3, 4, 5, 7\}$   | 0                 | NNN                      | 9   |
|      |                    |              | 10              | (2,2)                             | $(55.99, 64.99) \times \{3, 4, 5, 7\}$   | 2                 | NY_-                     | 7   |
|      |                    |              | 11              | (3,2)                             | $(64.99, \infty) \times \{3, 4, 5, 7\}$  | 4                 | Y1Y                      | 17  |
|      |                    |              | 12              | (0,3)                             | $(-\infty, 24.01) \times \{0, 6\}$       | 1                 | NNY                      | 15  |
|      |                    |              | 13              | (1,3)                             | $(24.01, 55.99) \times \{0, 6\}$         | 1                 | NNY                      | 1   |
|      |                    |              | 14              | (2,3)                             | $(55.99, 64.99) \times \{0, 6\}$         | 2                 | NY_-                     | 1   |
|      |                    | 15           | (3,3)           | $(64.99, \infty) \times \{0, 6\}$ | 1  | NNY               | 1                        |     |

Table 5.6: Decision regions and predicted class labels across all iterations (continued)

| Iter | Selected Variables |                | Decision Region |       |  | Predicted Classes |                          | Num |
|------|--------------------|----------------|-----------------|-------|--|-------------------|--------------------------|-----|
|      | Tuple              | Symbol         | Ind             | Tuple | Cross Product                            | Ind               | Label                    |     |
| 15   | (1,2)              | A_ AGE, PEMPLR | 0               | (0,0) | $(-\infty, 24.01) \times \{2\}$          | 0,1,2,3,4         | NNN, NNY, NY_-, YNN, Y1Y | 0   |
|      |                    |                | 1               | (1,0) | $(24.01, 55.99) \times \{2\}$            | 2                 | NY_-                     | 2   |
|      |                    |                | 2               | (2,0) | $(55.99, 64.99) \times \{2\}$            | 4                 | Y1Y                      | 1   |
|      |                    |                | 3               | (3,0) | $(64.99, \infty) \times \{2\}$           | 2                 | NY_-                     | 1   |
|      |                    |                | 4               | (0,1) | $(-\infty, 24.01) \times \{1\}$          | 0                 | NNN                      | 7   |
|      |                    |                | 5               | (1,1) | $(24.01, 55.99) \times \{1\}$            | 3                 | YNN                      | 23  |
|      |                    |                | 6               | (2,1) | $(55.99, 64.99) \times \{1\}$            | 3                 | YNN                      | 4   |
|      |                    |                | 7               | (3,1) | $(64.99, \infty) \times \{1\}$           | 2                 | NY_-                     | 5   |
|      |                    |                | 8               | (0,2) | $(-\infty, 24.01) \times \{3, 4, 5, 7\}$ | 1                 | NNY                      | 6   |
|      |                    |                | 9               | (1,2) | $(24.01, 55.99) \times \{3, 4, 5, 7\}$   | 0                 | NNN                      | 9   |
|      |                    |                | 10              | (2,2) | $(55.99, 64.99) \times \{3, 4, 5, 7\}$   | 2                 | NY_-                     | 7   |
|      |                    |                | 11              | (3,2) | $(64.99, \infty) \times \{3, 4, 5, 7\}$  | 4                 | Y1Y                      | 17  |
|      |                    |                | 12              | (0,3) | $(-\infty, 24.01) \times \{0, 6\}$       | 1                 | NNY                      | 15  |
|      |                    |                | 13              | (1,3) | $(24.01, 55.99) \times \{0, 6\}$         | 1                 | NNY                      | 1   |
|      |                    |                | 14              | (2,3) | $(55.99, 64.99) \times \{0, 6\}$         | 2                 | NY_-                     | 1   |
|      |                    |                | 15              | (3,3) | $(64.99, \infty) \times \{0, 6\}$        | 1                 | NNY                      | 1   |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions

| Iter | Training Instance |    |     |       | Reported |        | CPLEX  |         | True   |               |
|------|-------------------|----|-----|-------|----------|--------|--------|---------|--------|---------------|
|      | ID                | A  | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict       |
| 2    | 8                 | 4  | 0   | 0     | 0        | 0      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 10                | 12 | 0   | 0     | 0        | 0      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 20                | 10 | 0   | 0     | 0        | 0      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 21                | 85 | 5   | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 22                | 74 | 5   | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 23                | 64 | 5   | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 24                | 73 | 5   | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 26                | 5  | 0   | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 27                | 4  | 0   | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 28                | 10 | 0   | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 29                | 54 | 6   | 6     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 30                | 3  | 0   | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 33                | 17 | 4   | 4     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 35                | 77 | 6   | 6     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 36                | 5  | 0   | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 37                | 80 | 5   | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |   |     |       | Reported |        | CPLEX  |               | True   |         |
|------|-------------------|---|-----|-------|----------|--------|--------|---------------|--------|---------|
|      | ID                | A | AGE | PEMLR | SSYN     | Target | Region | Predict       | Region | Predict |
| 40   | 21                | 7 | 1   | 1     | 1        | 14     | 2      | 2             | 3      | 4       |
| 44   | 79                | 1 | 1   | 2     | 2        | 14     | 2      | 2             | 3      | 4       |
| 47   | 5                 | 0 | 0   | 2     | 2        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 48   | 76                | 5 | 1   | 2     | 2        | 22     | 4      | 0, 1, 2, 3, 4 | 5      | 6       |
| 51   | 2                 | 0 | 0   | 2     | 2        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 53   | 67                | 1 | 1   | 2     | 2        | 14     | 2      | 2             | 3      | 4       |
| 54   | 67                | 5 | 1   | 2     | 2        | 22     | 4      | 0, 1, 2, 3, 4 | 5      | 6       |
| 56   | 85                | 5 | 1   | 2     | 2        | 22     | 4      | 0, 1, 2, 3, 4 | 5      | 6       |
| 58   | 70                | 2 | 1   | 2     | 2        | 26     | 1      | 4             | 6      | 7       |
| 60   | 56                | 6 | 1   | 2     | 2        | 26     | 1      | 4             | 6      | 7       |
| 64   | 63                | 1 | 1   | 3     | 3        | 14     | 2      | 2             | 3      | 4       |
| 65   | 14                | 0 | 0   | 3     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 74   | 4                 | 0 | 0   | 3     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 75   | 12                | 0 | 0   | 3     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 78   | 7                 | 0 | 0   | 3     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 87   | 73                | 5 | 1   | 4     | 4        | 22     | 4      | 0, 1, 2, 3, 4 | 5      | 6       |
| 90   | 76                | 5 | 1   | 4     | 4        | 22     | 4      | 0, 1, 2, 3, 4 | 5      | 6       |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       |      | Reported |        | CPLEX   |        | True          |        |
|------|-------------------|----|-----|-------|------|----------|--------|---------|--------|---------------|--------|
|      | ID                | A  | AGE | PEMLR | SSYN | Target   | Region | Predict | Region | Predict       | Region |
|      | 91                | 77 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 93                | 71 | 1   | 1     | 1    | 4        | 14     | 2       | 3      | 2             | 4      |
|      | 94                | 70 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 95                | 78 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 96                | 67 | 7   | 1     | 1    | 4        | 14     | 2       | 3      | 2             | 4      |
|      | 97                | 71 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 98                | 66 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 99                | 67 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 3                 | 8  | 4   | 0     | 0    | 0        | 38     | 1       | 9      | 0, 1, 2, 3, 4 | 11     |
|      | 10                | 12 | 0   | 0     | 0    | 0        | 38     | 1       | 9      | 0, 1, 2, 3, 4 | 11     |
|      | 20                | 10 | 0   | 0     | 0    | 0        | 38     | 1       | 9      | 0, 1, 2, 3, 4 | 11     |
|      | 21                | 85 | 5   | 1     | 1    | 1        | 22     | 4       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 22                | 74 | 5   | 1     | 1    | 1        | 22     | 4       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 23                | 64 | 5   | 1     | 1    | 1        | 22     | 4       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 24                | 73 | 5   | 1     | 1    | 1        | 22     | 4       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 26                | 5  | 0   | 0     | 0    | 1        | 38     | 1       | 9      | 0, 1, 2, 3, 4 | 11     |
|      |                   |    |     |       |      |          |        |         |        |               |        |
|      |                   |    |     |       |      |          |        |         |        |               |        |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       | Reported |        | CPLEX  |         | True   |               |
|------|-------------------|----|-----|-------|----------|--------|--------|---------|--------|---------------|
|      | ID                | A  | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict       |
|      | 27                | 4  |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 28                | 10 |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 29                | 54 |     | 6     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 30                | 3  |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 33                | 17 |     | 4     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 35                | 77 |     | 6     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 36                | 5  |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 37                | 80 |     | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 40                | 21 |     | 7     | 1        | 1      | 14     | 2       | 3      | 2             |
|      | 44                | 79 |     | 1     | 1        | 2      | 14     | 2       | 3      | 2             |
|      | 47                | 5  |     | 0     | 0        | 2      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 48                | 76 |     | 5     | 1        | 2      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 51                | 2  |     | 0     | 0        | 2      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 53                | 67 |     | 1     | 1        | 2      | 14     | 2       | 3      | 2             |
|      | 54                | 67 |     | 5     | 1        | 2      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 56                | 85 |     | 5     | 1        | 2      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 58                | 70 |     | 2     | 1        | 2      | 26     | 1       | 6      | 4             |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       | Reported |        | CPLEX  |         | True   |               |
|------|-------------------|----|-----|-------|----------|--------|--------|---------|--------|---------------|
|      | ID                | A  | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict       |
|      | 60                | 56 | 6   | 6     | 1        | 2      | 26     | 1       | 6      | 4             |
|      | 64                | 63 | 1   | 1     | 1        | 3      | 14     | 2       | 3      | 2             |
|      | 65                | 14 | 0   | 0     | 0        | 3      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 74                | 4  | 0   | 0     | 0        | 3      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 75                | 12 | 0   | 0     | 0        | 3      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 78                | 7  | 0   | 0     | 0        | 3      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 87                | 73 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 90                | 76 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 91                | 77 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 93                | 71 | 1   | 1     | 1        | 4      | 14     | 2       | 3      | 2             |
|      | 94                | 70 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 95                | 78 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 96                | 67 | 7   | 7     | 1        | 4      | 14     | 2       | 3      | 2             |
|      | 97                | 71 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 98                | 66 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 99                | 67 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       | Reported |        | CPLEX  |         | True   |               |
|------|-------------------|----|-----|-------|----------|--------|--------|---------|--------|---------------|
|      | ID                | A  | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict       |
| 4    | 8                 | 4  |     | 0     | 0        | 0      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 10                | 12 |     | 0     | 0        | 0      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 20                | 10 |     | 0     | 0        | 0      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 21                | 85 |     | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 22                | 74 |     | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 23                | 64 |     | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 24                | 73 |     | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 26                | 5  |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 27                | 4  |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 28                | 10 |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 29                | 54 |     | 6     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 30                | 3  |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 33                | 17 |     | 4     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 35                | 77 |     | 6     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 36                | 5  |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 37                | 80 |     | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |



Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |   |     |       | Reported |        | CPLEX  |               | True   |         |
|------|-------------------|---|-----|-------|----------|--------|--------|---------------|--------|---------|
|      | ID                | A | AGE | PEMLR | SSYN     | Target | Region | Predict       | Region | Predict |
| 40   | 21                | 7 | 1   | 1     | 1        | 14     | 2      | 2             | 3      | 4       |
| 44   | 79                | 1 | 1   | 1     | 2        | 14     | 2      | 2             | 3      | 4       |
| 47   | 5                 | 0 | 0   | 0     | 2        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 48   | 76                | 5 | 1   | 1     | 2        | 22     | 4      | 0, 1, 2, 3, 4 | 5      | 6       |
| 51   | 2                 | 0 | 0   | 0     | 2        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 53   | 67                | 1 | 1   | 1     | 2        | 14     | 2      | 2             | 3      | 4       |
| 54   | 67                | 5 | 1   | 1     | 2        | 22     | 4      | 0, 1, 2, 3, 4 | 5      | 6       |
| 56   | 85                | 5 | 1   | 1     | 2        | 22     | 4      | 0, 1, 2, 3, 4 | 5      | 6       |
| 58   | 70                | 2 | 1   | 1     | 2        | 26     | 1      | 4             | 6      | 7       |
| 60   | 56                | 6 | 1   | 1     | 2        | 26     | 1      | 4             | 6      | 7       |
| 64   | 63                | 1 | 1   | 1     | 3        | 14     | 2      | 2             | 3      | 4       |
| 65   | 14                | 0 | 0   | 0     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 74   | 4                 | 0 | 0   | 0     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 75   | 12                | 0 | 0   | 0     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 78   | 7                 | 0 | 0   | 0     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 9      | 11      |
| 87   | 73                | 5 | 1   | 1     | 4        | 22     | 4      | 0, 1, 2, 3, 4 | 5      | 6       |
| 90   | 76                | 5 | 1   | 1     | 4        | 22     | 4      | 0, 1, 2, 3, 4 | 5      | 6       |



Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       | Reported |        | CPLEX  |         | True   |               |
|------|-------------------|----|-----|-------|----------|--------|--------|---------|--------|---------------|
|      | ID                | A  | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict       |
|      | 27                | 4  |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 28                | 10 |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 29                | 54 |     | 6     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 30                | 3  |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 33                | 17 |     | 4     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 35                | 77 |     | 6     | 1        | 1      | 26     | 1       | 6      | 4             |
|      | 36                | 5  |     | 0     | 0        | 1      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 37                | 80 |     | 5     | 1        | 1      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 40                | 21 |     | 7     | 1        | 1      | 14     | 2       | 3      | 2             |
|      | 44                | 79 |     | 1     | 1        | 2      | 14     | 2       | 3      | 2             |
|      | 47                | 5  |     | 0     | 0        | 2      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 48                | 76 |     | 5     | 1        | 2      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 51                | 2  |     | 0     | 0        | 2      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 53                | 67 |     | 1     | 1        | 2      | 14     | 2       | 3      | 2             |
|      | 54                | 67 |     | 5     | 1        | 2      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 56                | 85 |     | 5     | 1        | 2      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 58                | 70 |     | 2     | 1        | 2      | 26     | 1       | 6      | 4             |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       | Reported |        | CPLEX  |         | True   |               |
|------|-------------------|----|-----|-------|----------|--------|--------|---------|--------|---------------|
|      | ID                | A  | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict       |
|      | 60                | 56 | 6   | 6     | 1        | 2      | 26     | 1       | 6      | 4             |
|      | 64                | 63 | 1   | 1     | 1        | 3      | 14     | 2       | 3      | 2             |
|      | 65                | 14 | 0   | 0     | 0        | 3      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 74                | 4  | 0   | 0     | 0        | 3      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 75                | 12 | 0   | 0     | 0        | 3      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 78                | 7  | 0   | 0     | 0        | 3      | 38     | 1       | 9      | 0, 1, 2, 3, 4 |
|      | 87                | 73 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 90                | 76 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 91                | 77 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 93                | 71 | 1   | 1     | 1        | 4      | 14     | 2       | 3      | 2             |
|      | 94                | 70 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 95                | 78 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 96                | 67 | 7   | 7     | 1        | 4      | 14     | 2       | 3      | 2             |
|      | 97                | 71 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 98                | 66 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |
|      | 99                | 67 | 5   | 5     | 1        | 4      | 22     | 4       | 5      | 0, 1, 2, 3, 4 |



Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |   |     |       | Reported |        | CPLEX  |               | True   |         |
|------|-------------------|---|-----|-------|----------|--------|--------|---------------|--------|---------|
|      | ID                | A | AGE | PEMLR | SSYN     | Target | Region | Predict       | Region | Predict |
| 40   | 21                | 7 | 1   | 1     | 1        | 14     | 2, 3   | 0, 3          | 4      | 2, 4    |
| 44   | 79                | 1 | 1   | 2     | 2        | 14     | 2, 3   | 0, 3          | 4      | 2, 4    |
| 47   | 5                 | 0 | 0   | 2     | 2        | 38     | 1      | 0, 1, 2, 3, 4 | 11     | 1       |
| 48   | 76                | 5 | 1   | 2     | 2        | 22     | 4      | 2             | 6      | 4       |
| 51   | 2                 | 0 | 0   | 2     | 2        | 38     | 1      | 0, 1, 2, 3, 4 | 11     | 1       |
| 53   | 67                | 1 | 1   | 2     | 2        | 14     | 2, 3   | 0, 3          | 4      | 2, 4    |
| 54   | 67                | 5 | 1   | 2     | 2        | 22     | 4      | 2             | 6      | 4       |
| 56   | 85                | 5 | 1   | 2     | 2        | 22     | 4      | 2             | 6      | 4       |
| 58   | 70                | 2 | 1   | 2     | 2        | 18     | 2      | 2, 4          | 5      | 2       |
| 60   | 56                | 6 | 1   | 2     | 2        | 26     | 1      | 4             | 7      | 1       |
| 64   | 63                | 1 | 1   | 3     | 3        | 14     | 2, 3   | 0, 3          | 4      | 2, 4    |
| 65   | 14                | 0 | 0   | 3     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 11     | 1       |
| 74   | 4                 | 0 | 0   | 3     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 11     | 1       |
| 75   | 12                | 0 | 0   | 3     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 11     | 1       |
| 78   | 7                 | 0 | 0   | 3     | 3        | 38     | 1      | 0, 1, 2, 3, 4 | 11     | 1       |
| 87   | 73                | 5 | 1   | 4     | 4        | 22     | 4      | 2             | 6      | 4       |
| 90   | 76                | 5 | 1   | 4     | 4        | 22     | 4      | 2             | 6      | 4       |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       |      | Reported |        | CPLEX   |        | True          |        |
|------|-------------------|----|-----|-------|------|----------|--------|---------|--------|---------------|--------|
|      | ID                | A  | AGE | PEMLR | SSYN | Target   | Region | Predict | Region | Predict       | Region |
|      | 91                | 77 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 2             | 6      |
|      | 93                | 71 | 1   | 1     | 1    | 4        | 14     | 2, 3    | 3      | 0, 3          | 4      |
|      | 94                | 70 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 2             | 6      |
|      | 95                | 78 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 2             | 6      |
|      | 96                | 67 | 7   | 1     | 1    | 4        | 14     | 2, 3    | 3      | 0, 3          | 4      |
|      | 97                | 71 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 2             | 6      |
|      | 98                | 66 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 2             | 6      |
|      | 99                | 67 | 5   | 1     | 1    | 4        | 22     | 4       | 5      | 2             | 6      |
|      | 1                 | 24 | 1   | 2     | 2    | 0        | 14     | 3       | 3      | 0, 1, 2, 3, 4 | 4      |
|      | 2                 | 58 | 7   | 2     | 2    | 0        | 22     | 0       | 5      | 0, 1, 2, 3, 4 | 6      |
| 7    | 3                 | 24 | 1   | 2     | 2    | 0        | 14     | 3       | 3      | 0, 1, 2, 3, 4 | 4      |
|      | 4                 | 40 | 7   | 2     | 2    | 0        | 22     | 0       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 5                 | 24 | 1   | 2     | 2    | 0        | 14     | 3       | 3      | 0, 1, 2, 3, 4 | 4      |
|      | 6                 | 26 | 1   | 2     | 2    | 0        | 14     | 3       | 3      | 0, 1, 2, 3, 4 | 4      |
|      | 7                 | 18 | 7   | 2     | 2    | 0        | 22     | 0       | 5      | 0, 1, 2, 3, 4 | 6      |
|      | 8                 | 4  | 0   | 0     | 0    | 0        | 22     | 0       | 5      | 0, 1, 2, 3, 4 | 6      |
|      |                   |    |     |       |      |          |        |         |        |               |        |
|      |                   |    |     |       |      |          |        |         |        |               |        |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       | Reported |        | CPLEX  |         | True   |               |
|------|-------------------|----|-----|-------|----------|--------|--------|---------|--------|---------------|
|      | ID                | A  | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict       |
|      | 9                 | 38 |     | 3     | 2        | 0      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 10                | 12 |     | 0     | 0        | 0      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 11                | 46 |     | 7     | 2        | 0      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 12                | 26 |     | 1     | 2        | 0      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
|      | 13                | 35 |     | 7     | 2        | 0      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 14                | 19 |     | 7     | 2        | 0      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 15                | 29 |     | 4     | 2        | 0      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
|      | 16                | 24 |     | 0     | 2        | 0      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 17                | 35 |     | 1     | 2        | 0      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
|      | 18                | 48 |     | 1     | 2        | 0      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
|      | 19                | 41 |     | 1     | 2        | 0      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
|      | 20                | 10 |     | 0     | 0        | 0      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 21                | 85 |     | 5     | 1        | 1      | 38     | 4       | 9      | 0, 1, 2, 3, 4 |
|      | 22                | 74 |     | 5     | 1        | 1      | 38     | 4       | 9      | 0, 1, 2, 3, 4 |
|      | 23                | 64 |     | 5     | 1        | 1      | 38     | 4       | 9      | 0, 1, 2, 3, 4 |
|      | 24                | 73 |     | 5     | 1        | 1      | 38     | 4       | 9      | 0, 1, 2, 3, 4 |
|      | 25                | 15 |     | 7     | 2        | 1      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |



Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       | Reported |        | CPLEX  |         | True   |               |
|------|-------------------|----|-----|-------|----------|--------|--------|---------|--------|---------------|
|      | ID                | A  | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict       |
|      | 26                | 5  |     | 0     | 0        | 1      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 27                | 4  |     | 0     | 0        | 1      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 28                | 10 |     | 0     | 0        | 1      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 29                | 54 |     | 6     | 1        | 1      | 34     | 1       | 8      | 2             |
|      | 30                | 3  |     | 0     | 0        | 1      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 31                | 45 |     | 3     | 2        | 1      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 32                | 28 |     | 1     | 2        | 1      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
|      | 33                | 17 |     | 4     | 1        | 1      | 26     | 2       | 6      | 0             |
|      | 34                | 57 |     | 1     | 2        | 1      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
|      | 35                | 77 |     | 6     | 1        | 1      | 34     | 1       | 8      | 2             |
|      | 36                | 5  |     | 0     | 0        | 1      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 37                | 80 |     | 5     | 1        | 1      | 38     | 4       | 9      | 0, 1, 2, 3, 4 |
|      | 38                | 16 |     | 1     | 2        | 1      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
|      | 39                | 57 |     | 7     | 2        | 1      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
|      | 40                | 21 |     | 7     | 1        | 1      | 34     | 1       | 8      | 2             |
|      | 41                | 56 |     | 4     | 2        | 2      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
|      | 42                | 64 |     | 5     | 2        | 2      | 26     | 2       | 6      | 0             |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |   |     |       | Reported |        | CPLEX  |         | True   |               |
|------|-------------------|---|-----|-------|----------|--------|--------|---------|--------|---------------|
|      | ID                | A | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict       |
| 43   | 38                | 2 | 2   | 2     | 2        | 2      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
| 44   | 79                | 1 | 1   | 1     | 2        | 2      | 26     | 2       | 6      | 0             |
| 45   | 57                | 7 | 2   | 2     | 2        | 2      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
| 46   | 65                | 1 | 2   | 2     | 2        | 2      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
| 47   | 5                 | 0 | 0   | 0     | 2        | 2      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
| 48   | 76                | 5 | 1   | 1     | 2        | 2      | 38     | 4       | 9      | 0, 1, 2, 3, 4 |
| 49   | 49                | 1 | 2   | 2     | 2        | 2      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
| 50   | 37                | 2 | 2   | 2     | 2        | 2      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
| 51   | 2                 | 0 | 0   | 0     | 2        | 2      | 22     | 0       | 5      | 0, 1, 2, 3, 4 |
| 52   | 41                | 1 | 2   | 2     | 2        | 2      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
| 53   | 67                | 1 | 1   | 1     | 2        | 2      | 26     | 2       | 6      | 0             |
| 54   | 67                | 5 | 1   | 1     | 2        | 2      | 38     | 4       | 9      | 0, 1, 2, 3, 4 |
| 55   | 63                | 5 | 2   | 2     | 2        | 2      | 26     | 2       | 6      | 0             |
| 56   | 85                | 5 | 1   | 1     | 2        | 2      | 38     | 4       | 9      | 0, 1, 2, 3, 4 |
| 57   | 19                | 1 | 2   | 2     | 2        | 2      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |
| 58   | 70                | 2 | 1   | 1     | 2        | 2      | 26     | 2       | 6      | 0             |
| 59   | 38                | 1 | 2   | 2     | 2        | 2      | 14     | 3       | 3      | 0, 1, 2, 3, 4 |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |   |     |       | Reported |        | CPLEX  |               | True   |         |
|------|-------------------|---|-----|-------|----------|--------|--------|---------------|--------|---------|
|      | ID                | A | AGE | PEMLR | SSYN     | Target | Region | Predict       | Region | Predict |
| 60   | 56                | 6 | 1   | 2     | 34       | 1      | 8      | 2             | 10     | 1       |
| 61   | 29                | 1 | 2   | 3     | 14       | 3      | 3      | 0, 1, 2, 3, 4 | 4      | 3       |
| 62   | 26                | 1 | 2   | 3     | 14       | 3      | 3      | 0, 1, 2, 3, 4 | 4      | 3       |
| 63   | 59                | 1 | 2   | 3     | 14       | 3      | 3      | 0, 1, 2, 3, 4 | 4      | 3       |
| 64   | 63                | 1 | 1   | 3     | 26       | 2      | 6      | 0             | 8      | 2       |
| 65   | 14                | 0 | 0   | 3     | 22       | 0      | 5      | 0, 1, 2, 3, 4 | 6      | 0       |
| 66   | 22                | 4 | 2   | 3     | 14       | 3      | 3      | 0, 1, 2, 3, 4 | 4      | 3       |
| 67   | 25                | 7 | 2   | 3     | 22       | 0      | 5      | 0, 1, 2, 3, 4 | 6      | 0       |
| 68   | 18                | 1 | 2   | 3     | 14       | 3      | 3      | 0, 1, 2, 3, 4 | 4      | 3       |
| 69   | 25                | 1 | 2   | 3     | 14       | 3      | 3      | 0, 1, 2, 3, 4 | 4      | 3       |
| 70   | 46                | 1 | 2   | 3     | 14       | 3      | 3      | 0, 1, 2, 3, 4 | 4      | 3       |
| 71   | 40                | 1 | 2   | 3     | 14       | 3      | 3      | 0, 1, 2, 3, 4 | 4      | 3       |
| 72   | 29                | 4 | 2   | 3     | 14       | 3      | 3      | 0, 1, 2, 3, 4 | 4      | 3       |
| 73   | 33                | 1 | 2   | 3     | 14       | 3      | 3      | 0, 1, 2, 3, 4 | 4      | 3       |
| 74   | 4                 | 0 | 0   | 3     | 22       | 0      | 5      | 0, 1, 2, 3, 4 | 6      | 0       |
| 75   | 12                | 0 | 0   | 3     | 22       | 0      | 5      | 0, 1, 2, 3, 4 | 6      | 0       |
| 76   | 51                | 7 | 2   | 3     | 22       | 0      | 5      | 0, 1, 2, 3, 4 | 6      | 0       |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |   |     |       |      | Reported |        | CPLEX         |        | True    |        |
|------|-------------------|---|-----|-------|------|----------|--------|---------------|--------|---------|--------|
|      | ID                | A | AGE | PEMLR | SSYN | Target   | Region | Predict       | Region | Predict | Region |
| 77   | 29                | 1 | 2   | 3     | 14   | 3        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 78   | 7                 | 0 | 0   | 3     | 22   | 3        | 0      | 0, 1, 2, 3, 4 | 6      | 0       | 0      |
| 79   | 51                | 1 | 2   | 3     | 14   | 3        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 80   | 41                | 1 | 2   | 3     | 14   | 3        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 81   | 78                | 5 | 2   | 4     | 26   | 4        | 2      | 0             | 7      | 2       | 2      |
| 82   | 60                | 2 | 2   | 4     | 14   | 4        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 83   | 27                | 1 | 2   | 4     | 14   | 4        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 84   | 65                | 1 | 2   | 4     | 14   | 4        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 85   | 22                | 1 | 2   | 4     | 14   | 4        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 86   | 42                | 1 | 2   | 4     | 14   | 4        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 87   | 73                | 5 | 1   | 4     | 38   | 4        | 4      | 0, 1, 2, 3, 4 | 11     | 4       | 4      |
| 88   | 45                | 1 | 2   | 4     | 14   | 4        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 89   | 26                | 1 | 2   | 4     | 14   | 4        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 90   | 76                | 5 | 1   | 4     | 38   | 4        | 4      | 0, 1, 2, 3, 4 | 11     | 4       | 4      |
| 91   | 77                | 5 | 1   | 4     | 38   | 4        | 4      | 0, 1, 2, 3, 4 | 11     | 4       | 4      |
| 92   | 27                | 1 | 2   | 4     | 14   | 4        | 3      | 0, 1, 2, 3, 4 | 4      | 3       | 3      |
| 93   | 71                | 1 | 1   | 4     | 26   | 4        | 2      | 0             | 8      | 2       | 2      |



Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       |      | Reported |        | CPLEX   |        | True          |        |
|------|-------------------|----|-----|-------|------|----------|--------|---------|--------|---------------|--------|
|      | ID                | A  | AGE | PEMLR | SSYN | Target   | Region | Predict | Region | Predict       | Region |
|      | 28                | 10 |     | 0     | 0    | 1        | 34     | 1       | 8      | 2             | 10     |
|      | 29                | 54 |     | 6     | 1    | 1        | 30     | 2       | 7      | 0, 1, 2, 3, 4 | 9      |
|      | 30                | 3  |     | 0     | 0    | 1        | 34     | 1       | 8      | 2             | 10     |
|      | 33                | 17 |     | 4     | 1    | 1        | 34     | 1       | 8      | 2             | 10     |
|      | 35                | 77 |     | 6     | 1    | 1        | 30     | 2       | 7      | 0, 1, 2, 3, 4 | 9      |
|      | 36                | 5  |     | 0     | 0    | 1        | 34     | 1       | 8      | 2             | 10     |
|      | 37                | 80 |     | 5     | 1    | 1        | 38     | 4       | 9      | 2             | 11     |
|      | 40                | 21 |     | 7     | 1    | 1        | 34     | 1       | 8      | 2             | 10     |
|      | 44                | 79 |     | 1     | 1    | 2        | 30     | 2       | 7      | 0, 1, 2, 3, 4 | 9      |
|      | 47                | 5  |     | 0     | 0    | 2        | 34     | 1       | 8      | 2             | 10     |
|      | 48                | 76 |     | 5     | 1    | 2        | 38     | 4       | 9      | 2             | 11     |
|      | 51                | 2  |     | 0     | 0    | 2        | 34     | 1       | 8      | 2             | 10     |
|      | 53                | 67 |     | 1     | 1    | 2        | 30     | 2       | 7      | 0, 1, 2, 3, 4 | 9      |
|      | 54                | 67 |     | 5     | 1    | 2        | 38     | 4       | 9      | 2             | 11     |
|      | 56                | 85 |     | 5     | 1    | 2        | 38     | 4       | 9      | 2             | 11     |
|      | 58                | 70 |     | 2     | 1    | 2        | 26     | 2       | 6      | 0, 1, 2, 3, 4 | 8      |
|      | 60                | 56 |     | 6     | 1    | 2        | 30     | 2       | 7      | 0, 1, 2, 3, 4 | 9      |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       |      | Reported |        | CPLEX   |        | True          |        |
|------|-------------------|----|-----|-------|------|----------|--------|---------|--------|---------------|--------|
|      | ID                | A  | AGE | PEMLR | SSYN | Target   | Region | Predict | Region | Predict       | Region |
|      | 64                | 63 | 1   | 1     | 1    | 3        | 30     | 2       | 7      | 0, 1, 2, 3, 4 | 9      |
|      | 65                | 14 | 0   | 0     | 0    | 3        | 34     | 1       | 8      | 2             | 10     |
|      | 74                | 4  | 0   | 0     | 0    | 3        | 34     | 1       | 8      | 2             | 10     |
|      | 75                | 12 | 0   | 0     | 0    | 3        | 34     | 1       | 8      | 2             | 10     |
|      | 78                | 7  | 0   | 0     | 0    | 3        | 34     | 1       | 8      | 2             | 10     |
|      | 87                | 73 | 5   | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
|      | 90                | 76 | 5   | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
|      | 91                | 77 | 5   | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
|      | 93                | 71 | 1   | 1     | 1    | 4        | 30     | 2       | 7      | 0, 1, 2, 3, 4 | 9      |
|      | 94                | 70 | 5   | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
|      | 95                | 78 | 5   | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
|      | 96                | 67 | 7   | 7     | 1    | 4        | 34     | 1       | 8      | 2             | 10     |
|      | 97                | 71 | 5   | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
|      | 98                | 66 | 5   | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
|      | 99                | 67 | 5   | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
| 9    | 8                 | 4  | 0   | 0     | 0    | 0        | 34     | 1       | 8      | 2             | 10     |
|      |                   |    |     |       |      |          |        |         |        |               | 1      |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       | Reported |        | CPLEX  |         | True   |               |
|------|-------------------|----|-----|-------|----------|--------|--------|---------|--------|---------------|
|      | ID                | A  | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict       |
|      | 10                | 12 | 0   | 0     | 0        | 0      | 34     | 1       | 8      | 2             |
|      | 20                | 10 | 0   | 0     | 0        | 0      | 34     | 1       | 8      | 2             |
|      | 21                | 85 | 5   | 5     | 1        | 1      | 38     | 4       | 9      | 2             |
|      | 22                | 74 | 5   | 5     | 1        | 1      | 38     | 4       | 9      | 2             |
|      | 23                | 64 | 5   | 5     | 1        | 1      | 38     | 4       | 9      | 2             |
|      | 24                | 73 | 5   | 5     | 1        | 1      | 38     | 4       | 9      | 2             |
|      | 26                | 5  | 0   | 0     | 0        | 1      | 34     | 1       | 8      | 2             |
|      | 27                | 4  | 0   | 0     | 0        | 1      | 34     | 1       | 8      | 2             |
|      | 28                | 10 | 0   | 0     | 0        | 1      | 34     | 1       | 8      | 2             |
|      | 29                | 54 | 6   | 6     | 1        | 1      | 34     | 1       | 8      | 2             |
|      | 30                | 3  | 0   | 0     | 0        | 1      | 34     | 1       | 8      | 2             |
|      | 33                | 17 | 4   | 4     | 1        | 1      | 34     | 1       | 8      | 2             |
|      | 35                | 77 | 6   | 6     | 1        | 1      | 34     | 1       | 8      | 2             |
|      | 36                | 5  | 0   | 0     | 0        | 1      | 34     | 1       | 8      | 2             |
|      | 37                | 80 | 5   | 5     | 1        | 1      | 38     | 4       | 9      | 2             |
|      | 40                | 21 | 7   | 7     | 1        | 1      | 34     | 1       | 8      | 2             |
|      | 44                | 79 | 1   | 1     | 1        | 2      | 30     | 2       | 7      | 0, 1, 2, 3, 4 |



Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       |      | Reported |        | CPLEX   |        | True          |        |
|------|-------------------|----|-----|-------|------|----------|--------|---------|--------|---------------|--------|
|      | ID                | A  | AGE | PEMLR | SSYN | Target   | Region | Predict | Region | Predict       | Region |
|      | 47                | 5  |     | 0     | 0    | 2        | 34     | 1       | 8      | 2             | 10     |
|      | 48                | 76 |     | 5     | 1    | 2        | 38     | 4       | 9      | 2             | 11     |
|      | 51                | 2  |     | 0     | 0    | 2        | 34     | 1       | 8      | 2             | 10     |
|      | 53                | 67 |     | 1     | 1    | 2        | 30     | 2       | 7      | 0, 1, 2, 3, 4 | 9      |
|      | 54                | 67 |     | 5     | 1    | 2        | 38     | 4       | 9      | 2             | 11     |
|      | 56                | 85 |     | 5     | 1    | 2        | 38     | 4       | 9      | 2             | 11     |
|      | 58                | 70 |     | 2     | 1    | 2        | 26     | 2       | 6      | 0, 1, 2, 3, 4 | 8      |
|      | 60                | 56 |     | 6     | 1    | 2        | 34     | 1       | 8      | 2             | 10     |
|      | 64                | 63 |     | 1     | 1    | 3        | 30     | 2       | 7      | 0, 1, 2, 3, 4 | 9      |
|      | 65                | 14 |     | 0     | 0    | 3        | 34     | 1       | 8      | 2             | 10     |
|      | 74                | 4  |     | 0     | 0    | 3        | 34     | 1       | 8      | 2             | 10     |
|      | 75                | 12 |     | 0     | 0    | 3        | 34     | 1       | 8      | 2             | 10     |
|      | 78                | 7  |     | 0     | 0    | 3        | 34     | 1       | 8      | 2             | 10     |
|      | 87                | 73 |     | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
|      | 90                | 76 |     | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
|      | 91                | 77 |     | 5     | 1    | 4        | 38     | 4       | 9      | 2             | 11     |
|      | 93                | 71 |     | 1     | 1    | 4        | 30     | 2       | 7      | 0, 1, 2, 3, 4 | 9      |

Table 5.7: Inconsistency between numerical CPLEX and true decision regions (continued)

| Iter | Training Instance |    |     |       | Reported |        | CPLEX  |         | True   |         |
|------|-------------------|----|-----|-------|----------|--------|--------|---------|--------|---------|
|      | ID                | A_ | AGE | PEMLR | SSYN     | Target | Region | Predict | Region | Predict |
|      | 94                | 70 |     | 5     | 1        | 4      | 38     | 4       | 9      | 2       |
|      | 95                | 78 |     | 5     | 1        | 4      | 38     | 4       | 9      | 2       |
|      | 96                | 67 |     | 7     | 1        | 4      | 34     | 1       | 8      | 2       |
|      | 97                | 71 |     | 5     | 1        | 4      | 38     | 4       | 9      | 2       |
|      | 98                | 66 |     | 5     | 1        | 4      | 38     | 4       | 9      | 2       |
|      | 99                | 67 |     | 5     | 1        | 4      | 38     | 4       | 9      | 2       |

# CHAPTER VI

## CONCLUDING REMARKS

Throughout this dissertation, the 2020 person-level CPS ASEC health insurance dataset in SAS7BDAT format is converted to feather and CSV formats. The file sizes markedly reduce by 94.02% and 71.31% respectively. Five combinations of health insurance enrollment in employment-based plan (GRP), direct-purchase plan (DIR) and public health insurance (PUB) are considered, leading to five possible classes. All codes are written in Python, well-known for data analysis, except the proposed box classifier in OPL embedded in CPLEX Optimization Studio. A Python class and a pandas DataFrame accessor are introduced so that a method can be called on a DataFrame at any time. All classification models, a Gini-based decision tree and the proposed classifier, are tested on a remote virtual machine to prevent the intervention in local computing resources and also to flexibly configure hardware and operating system. Python 3.13 with the global interpreter lock (GIL) still enabled is built from source. The GitHub repository is also available at <https://github.com/songkomkrit/phd>.

The proposed box classifier is heavily based on the rigorous formulation of 0-1 MILP problem, and it is very large-scale. Only 100 out of 157,681 noninfant survey participants are randomly selected as a sample of equal class size. Prior to the investigation of 2 contributing factors, 3 out of 184 independent variables are preselected by the SelectKBest using mutual information from a mixture of continuous and categorical features. Compared to the decision tree of multiple depths, the proposed model achieves a high training accuracy and low number of total splits within an hour and a half, though optimality not guaranteed, it constructs the branch-and-cut tree of large size between 6 GB and 7 GB, and it can group together similar categorical values to provide better insight into a selected categorical feature. A limitation of this study includes the lack of high-performance computing (HPC) technology of aggregating multiple computer clusters to efficiently serve massive computation required by the proposed model in the nature of 0-1 MILP. Therefore, further investigation into its approximation algorithm with theoretically derived bound on training accuracy compared to the exact 0-1 MILP model is suggested.

# References

- Bernstein, D. J., Duif, N., Lange, T., Schwabe, P., and Yang, B.-Y. (2012). High-speed high-security signatures. Journal of cryptographic engineering, 2(2):77–89.
- Cebula, R. J. (2006). A further analysis of determinants of health insurance coverage. International Advances in Economic Research, 12(3):382–389.
- Cover, T. M. and Thomas, J. A. T. (2005). Elements of Information Theory. John Wiley Sons, Ltd.
- Dolinsky, A. and Caputo, R. K. (1997). Psychological and demographic characteristics as determinants of women’s health insurance coverage. Journal of Consumer Affairs, 31(2):218–237.
- Jin, Y., Hou, Z., and Zhang, D. (2016). Determinants of health insurance coverage among people aged 45 and over in china: Who buys public, private and multiple insurance. PLOS ONE, 11(8):1–15.
- Markowitz, M. A., Gold, M., and Rice, T. (1991). Determinants of health insurance status among young adults. Medical care, pages 6–19.
- Mulenga, J., Mulenga, M. C., Musonda, K., and Phiri, C. (2021). Examining gender differentials and determinants of private health insurance coverage in zambia. BMC Health Services Research, 21(1):1–11.
- Rivest, R. L., Shamir, A., and Adleman, L. (1978). A method for obtaining digital signatures and public-key cryptosystems. Communications of the ACM, 21(2):120–126.
- Ross, B. C. (2014). Mutual information between discrete and continuous data sets. PLOS ONE, 9(2):1–5.
- Scikit-learn (2024a). Decision trees. <https://scikit-learn.org/1.5/modules/tree.html>. Accessed: 2024-11-18.
- Scikit-learn (2024b). Selectkbest. [https://scikit-learn.org/stable/modules/generated/sklearn.feature\\_selection.SelectKBest.html](https://scikit-learn.org/stable/modules/generated/sklearn.feature_selection.SelectKBest.html). Accessed: 2024-11-18.

## APPENDICES

# APPENDIX A

## CPLEX ENGINE LOG

<<< setup

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |        |
|--------------------------------|--------|
| CPXPARAM_MIP_Strategy_File     | 3      |
| CPXPARAM_MIP_Limits_Solutions  | 1      |
| CPXPARAM_TimeLimit             | 86400  |
| CPXPARAM_MIP_Limits_TreeMemory | 204800 |

Tried aggregator 1 time.

MIP Presolve eliminated 402 rows and 800 columns.

MIP Presolve modified 200 coefficients.

Reduced MIP has 4004 rows, 5507 columns, and 22553 nonzeros.

Reduced MIP has 4643 binaries, 11 generals, 0 SOSs, and 0 indicators.

Presolve time = 0.01 sec. (17.75 ticks)

Found incumbent of value -20.000000 after 0.02 sec. (24.01 ticks)

Root node processing (before b&c):

Real time = 0.02 sec. (24.25 ticks)

Parallel b&c, 8 threads:

Real time = 0.00 sec. (0.00 ticks)

Sync time (average) = 0.00 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 0.02 sec. (24.25 ticks)

-----

Iteration 1

Bounds on # of cuts = 8 with [3 3 2]

Error = 80 (out of 100 instances)

Accuracy = 20

Solving time = 0.0003894 min (minutes)

Accumulated time = 0.0003894 min (minutes)

Solution status code = 104

LB on error = -5500

Relative objective gap = 278.999999999

Selected variables:

Number of selected variables = 0 (0 continuous + 0 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |                    |
|--------------------------------|--------------------|
| CPXPARAM_MIP_Strategy_File     | 3                  |
| CPXPARAM_MIP_Limits_Solutions  | 1                  |
| CPXPARAM_TimeLimit             | 86399.976635986328 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800             |

Probing time = 0.01 sec. (4.62 ticks)

Cover probing fixed 8 vars, tightened 40 bounds.

Clique table members: 11812.

MIP emphasis: balance optimality and feasibility.

MIP search method: dynamic search.

Parallel mode: deterministic, using up to 8 threads.

Root relaxation solution time = 0.03 sec. (35.79 ticks)

| Nodes |      |           |      | Cuts/        |            |       |     |  |
|-------|------|-----------|------|--------------|------------|-------|-----|--|
| Node  | Left | Objective | IInf | Best Integer | Best Bound | ItCnt | Gap |  |
| *     | 0+   | 0         |      | -20.0000     | -5600.0000 |       | --- |  |
| 0     | 0    | -800.0000 | 472  | -20.0000     | -800.0000  | 1209  | --- |  |
| 0     | 0    | -800.0000 | 346  | -20.0000     | Cuts: 512  | 1987  | --- |  |
| 0     | 0    | -800.0000 | 651  | -20.0000     | Cuts: 874  | 3508  | --- |  |
| *     | 0+   | 0         |      | -28.0000     | -800.0000  |       | --- |  |

GUB cover cuts applied: 29

Clique cuts applied: 10

Cover cuts applied: 51

Implied bound cuts applied: 242

Flow cuts applied: 6

Mixed integer rounding cuts applied: 186

Zero-half cuts applied: 77

Lift and project cuts applied: 7

Gomory fractional cuts applied: 16

Root node processing (before b&c):

Real time = 1.78 sec. (1803.05 ticks)

Parallel b&c, 8 threads:

Real time = 0.00 sec. (0.00 ticks)

Sync time (average) = 0.00 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 1.78 sec. (1803.05 ticks)

-----

Iteration 2

Bounds on # of cuts = 8 with [3 3 2]

Error = 72 (out of 100 instances)

Accuracy = 28

Solving time = 0.029740967 min (minutes)

Accumulated time = 0.030130367 min (minutes)

Solution status code = 104

LB on error = -700

Relative objective gap = 27.571428571

Selected variables:

PEMLR (Categorical)

SS\_YN (Categorical)

Number of selected variables = 2 (0 continuous + 2 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

CPXPARAM\_MIP\_Strategy\_File 3

CPXPARAM\_MIP\_Limits\_Solutions 1

CPXPARAM\_TimeLimit 86398.192177978519

CPXPARAM\_MIP\_Limits\_TreeMemory 204800

MIP emphasis: balance optimality and feasibility.

MIP search method: dynamic search.

Parallel mode: deterministic, using up to 8 threads.

| Nodes |      |           |      | Cuts/        |            |       |     |
|-------|------|-----------|------|--------------|------------|-------|-----|
| Node  | Left | Objective | IInf | Best Integer | Best Bound | ItCnt | Gap |
| *     | 0+   | 0         |      | -31.0000     | -717.7485  |       | --- |



GUB cover cuts applied: 41

Clique cuts applied: 73

Cover cuts applied: 433

Implied bound cuts applied: 315

Flow cuts applied: 8

Mixed integer rounding cuts applied: 447

Zero-half cuts applied: 145

Lift and project cuts applied: 13

Gomory fractional cuts applied: 57

Root node processing (before b&c):

Real time = 0.74 sec. (861.25 ticks)

Parallel b&c, 8 threads:

Real time = 0.00 sec. (0.00 ticks)

Sync time (average) = 0.00 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 0.74 sec. (861.25 ticks)

-----

Iteration 3

Bounds on # of cuts = 8 with [3 3 2]

Error = 69 (out of 100 instances)

Accuracy = 31

Solving time = 0.01229578 min (minutes)

Accumulated time = 0.042426147 min (minutes)

Solution status code = 104

LB on error = -617.482727096

Relative objective gap = 22.1446041

Selected variables:

PEMLR (Categorical)

SS\_YN (Categorical)

Number of selected variables = 2 (0 continuous + 2 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

```

CPXPARAM_MIP_Strategy_File          3
CPXPARAM_MIP_Limits_Solutions      1
CPXPARAM_TimeLimit                 86397.45443115235
CPXPARAM_MIP_Limits_TreeMemory     204800

```

MIP emphasis: balance optimality and feasibility.

MIP search method: dynamic search.

Parallel mode: deterministic, using up to 8 threads.

| Nodes |      |           |      | Cuts/        |            |       |     |
|-------|------|-----------|------|--------------|------------|-------|-----|
| Node  | Left | Objective | IInf | Best Integer | Best Bound | ItCnt | Gap |
| *     | 0+   | 0         |      | -36.0000     | -657.1275  |       | --- |

GUB cover cuts applied: 41

Clique cuts applied: 73

Cover cuts applied: 623

Implied bound cuts applied: 329

Flow cuts applied: 12

Mixed integer rounding cuts applied: 562

Zero-half cuts applied: 191

Lift and project cuts applied: 22

Gomory fractional cuts applied: 108

Root node processing (before b&c):

Real time = 0.82 sec. (913.50 ticks)

Parallel b&c, 8 threads:

Real time = 0.00 sec. (0.00 ticks)

Sync time (average) = 0.00 sec.

Wait time (average) = 0.00 sec.

-----  
Total (root+branch&cut) = 0.82 sec. (913.50 ticks)

-----  
Iteration 4

Bounds on # of cuts = 8 with [3 3 2]

Error = 64 (out of 100 instances)

Accuracy = 36

Solving time = 0.013641048 min (minutes)

Accumulated time = 0.056067196 min (minutes)

Solution status code = 104  
 LB on error = -557.127521455  
 Relative objective gap = 17.253542263

Selected variables:  
 PEMLR (Categorical)  
 SS\_YN (Categorical)

Number of selected variables = 2 (0 continuous + 2 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |                    |
|--------------------------------|--------------------|
| CPXPARAM_MIP_Strategy_File     | 3                  |
| CPXPARAM_MIP_Limits_Solutions  | 1                  |
| CPXPARAM_TimeLimit             | 86396.635968261719 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800             |

MIP emphasis: balance optimality and feasibility.

MIP search method: dynamic search.

Parallel mode: deterministic, using up to 8 threads.

| Nodes |      |           |      | Cuts/        |            | ItCnt | Gap |
|-------|------|-----------|------|--------------|------------|-------|-----|
| Node  | Left | Objective | IInf | Best Integer | Best Bound |       |     |
| *     | 0+   | 0         |      | -38.0000     | -626.9345  |       | --- |

GUB cover cuts applied: 82

Clique cuts applied: 73

Cover cuts applied: 1063

Implied bound cuts applied: 407

Flow cuts applied: 35

Mixed integer rounding cuts applied: 819

Zero-half cuts applied: 258

Lift and project cuts applied: 22

Gomory fractional cuts applied: 160

Root node processing (before b&c):

Real time = 1.96 sec. (1928.89 ticks)

Parallel b&c, 8 threads:

Real time = 0.00 sec. (0.00 ticks)

Sync time (average) = 0.00 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 1.96 sec. (1928.89 ticks)

-----

Iteration 5

Bounds on # of cuts = 8 with [3 3 2]

Error = 62 (out of 100 instances)

Accuracy = 38

Solving time = 0.032725952 min (minutes)

Accumulated time = 0.088793148 min (minutes)

Solution status code = 104

LB on error = -526.934511415

Relative objective gap = 15.498276616

Selected variables:

PEMLR (Categorical)

SS\_YN (Categorical)

Number of selected variables = 2 (0 continuous + 2 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

CPXPARAM\_MIP\_Strategy\_File 3

CPXPARAM\_MIP\_Limits\_Solutions 1

CPXPARAM\_TimeLimit 86394.672411132808

CPXPARAM\_MIP\_Limits\_TreeMemory 204800

MIP emphasis: balance optimality and feasibility.

MIP search method: dynamic search.

Parallel mode: deterministic, using up to 8 threads.

| Nodes |      |           |      |              | Cuts/      |       |     |
|-------|------|-----------|------|--------------|------------|-------|-----|
| Node  | Left | Objective | IInf | Best Integer | Best Bound | ItCnt | Gap |
| 0     | 0    | -577.3658 | 659  | -38.0000     | Cuts: 836  | 28237 | --- |
| 0     | 0    | -558.5105 | 640  | -38.0000     | Cuts: 955  | 31741 | --- |
| 0     | 0    | -540.9147 | 613  | -38.0000     | Cuts: 870  | 34307 | --- |
| 0     | 0    | -539.0391 | 710  | -38.0000     | Cuts: 924  | 36234 | --- |

```

0      0      -538.9354   762      -38.0000      Cuts: 989      37794      ---
Detecting symmetries...
0      0      -538.8822   778      -38.0000      Cuts: 830      39029      ---
0      0      -538.8578   826      -38.0000      Cuts: 708      40186      ---
0      0      -538.8409   806      -38.0000      Cuts: 266      40928      ---
0      0      -538.8265   840      -38.0000      Cuts: 601      41623      ---
0      2      -538.8265   827      -38.0000      -538.8265      41623      ---
Elapsed time = 5.26 sec. (5435.47 ticks, tree = 0.02 MB, solutions = 5)
2      4      -532.4711   622      -38.0000      -538.8264      44441      ---
9      9      -530.6872   643      -38.0000      -538.8264      47088      ---
27     20     -521.8493   667      -38.0000      -538.6068      60887      ---
46     20     -531.9657   614      -38.0000      -538.6066      60999      ---
80     68     -509.9472   575      -38.0000      -538.6066      103610     ---
118    57     -528.6696   612      -38.0000      -538.6066      98680      ---
156    138     -490.7266   504      -38.0000      -538.6066      147852     ---
194    169     -486.6126   511      -38.0000      -538.6066      164110     ---
248    209     -484.0715   570      -38.0000      -538.6066      181896     ---
625    468     -387.6828   467      -38.0000      -538.6066      243471     ---
Elapsed time = 8.32 sec. (8694.74 ticks, tree = 6.06 MB, solutions = 5)
1551   1044     infeasible      -38.0000      -538.6066      323452     ---

Performing restart 1

Repeating presolve.
Tried aggregator 1 time.
MIP Presolve eliminated 447 rows and 48 columns.
MIP Presolve modified 2098 coefficients.
Reduced MIP has 3557 rows, 5459 columns, and 21635 nonzeros.
Reduced MIP has 4603 binaries, 51 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.01 sec. (20.08 ticks)
Tried aggregator 1 time.
MIP Presolve eliminated 1 rows and 0 columns.
MIP Presolve modified 300 coefficients.
Reduced MIP has 3556 rows, 5459 columns, and 21533 nonzeros.
Reduced MIP has 4603 binaries, 51 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.02 sec. (21.21 ticks)
Represolve time = 0.18 sec. (172.19 ticks)
1603    0      -531.3154   530      -38.0000      Cuts: 989      388606      ---
1603    0      -507.2228   677      -38.0000      Cuts: 989      394828      ---

```

|      |   |           |      |          |           |        |         |
|------|---|-----------|------|----------|-----------|--------|---------|
| 1603 | 0 | -483.0125 | 703  | -38.0000 | Cuts: 989 | 399749 | ---     |
| 1603 | 0 | -460.7636 | 713  | -38.0000 | Cuts: 989 | 407166 | ---     |
| 1603 | 0 | -451.8578 | 687  | -38.0000 | Cuts: 989 | 412425 | ---     |
| 1603 | 0 | -450.6323 | 805  | -38.0000 | Cuts: 989 | 415841 | ---     |
| 1603 | 0 | -432.3823 | 759  | -38.0000 | Cuts: 989 | 423001 | ---     |
| 1603 | 0 | -431.4684 | 871  | -38.0000 | Cuts: 989 | 426280 | ---     |
| 1603 | 0 | -418.8128 | 830  | -38.0000 | Cuts: 989 | 433824 | ---     |
| 1603 | 0 | -417.3207 | 854  | -38.0000 | Cuts: 989 | 437138 | 998.21% |
| 1603 | 0 | -412.4347 | 847  | -38.0000 | Cuts: 989 | 442602 | 985.35% |
| 1603 | 0 | -412.0400 | 919  | -38.0000 | Cuts: 989 | 445973 | 984.32% |
| 1603 | 0 | -411.2439 | 902  | -38.0000 | Cuts: 989 | 449769 | 980.32% |
| 1603 | 0 | -405.6804 | 852  | -38.0000 | Cuts: 989 | 458674 | 967.58% |
| 1603 | 0 | -405.2740 | 821  | -38.0000 | Cuts: 989 | 461351 | 962.76% |
| 1603 | 0 | -400.9631 | 855  | -38.0000 | Cuts: 989 | 468469 | 952.28% |
| 1603 | 0 | -400.5521 | 861  | -38.0000 | Cuts: 989 | 472372 | 952.28% |
| 1603 | 0 | -399.9329 | 893  | -38.0000 | Cuts: 989 | 475615 | 952.28% |
| 1603 | 0 | -397.2191 | 915  | -38.0000 | Cuts: 989 | 483998 | 944.52% |
| 1603 | 0 | -397.1061 | 974  | -38.0000 | Cuts: 989 | 487153 | 944.52% |
| 1603 | 0 | -396.3444 | 963  | -38.0000 | Cuts: 989 | 492117 | 943.01% |
| 1603 | 0 | -395.8637 | 958  | -38.0000 | Cuts: 989 | 496720 | 939.08% |
| 1603 | 0 | -395.7821 | 987  | -38.0000 | Cuts: 989 | 498869 | 938.39% |
| 1603 | 0 | -393.1402 | 932  | -38.0000 | Cuts: 989 | 506111 | 934.58% |
| 1603 | 0 | -393.0317 | 970  | -38.0000 | Cuts: 989 | 508897 | 934.29% |
| 1603 | 0 | -392.7950 | 1024 | -38.0000 | Cuts: 989 | 513782 | 933.67% |
| 1603 | 0 | -391.5060 | 909  | -38.0000 | Cuts: 989 | 518934 | 930.28% |
| 1603 | 0 | -391.4094 | 932  | -38.0000 | Cuts: 989 | 523923 | 930.02% |
| 1603 | 0 | -390.7816 | 965  | -38.0000 | Cuts: 989 | 530008 | 928.37% |
| 1603 | 0 | -390.4502 | 996  | -38.0000 | Cuts: 989 | 535960 | 927.50% |
| 1603 | 0 | -389.7746 | 975  | -38.0000 | Cuts: 964 | 544136 | 925.72% |
| 1603 | 0 | -389.7179 | 1028 | -38.0000 | Cuts: 989 | 548551 | 925.57% |
| 1603 | 0 | -389.2127 | 1004 | -38.0000 | Cuts: 779 | 559361 | 924.24% |
| 1603 | 0 | -389.1541 | 1044 | -38.0000 | Cuts: 989 | 563246 | 924.09% |
| 1603 | 0 | -388.9571 | 1041 | -38.0000 | Cuts: 550 | 570153 | 923.57% |
| 1603 | 0 | -388.9327 | 1102 | -38.0000 | Cuts: 989 | 573533 | 923.51% |
| 1603 | 0 | -388.7011 | 1102 | -38.0000 | Cuts: 689 | 580181 | 922.90% |
| 1603 | 0 | -388.6569 | 1153 | -38.0000 | Cuts: 989 | 583864 | 922.78% |
| 1603 | 2 | -388.6569 | 1138 | -38.0000 | -388.6569 | 583864 | 922.78% |
| 1604 | 3 | -388.2777 | 1073 | -38.0000 | -388.2776 | 587877 | 921.78% |
| 1605 | 4 | -387.6984 | 1112 | -38.0000 | -387.6983 | 589040 | 920.26% |

|   |    |           |      |          |           |         |         |
|---|----|-----------|------|----------|-----------|---------|---------|
| 1606  | 5  | -387.2199 | 1098 | -38.0000 | -387.2194 | 590656  | 919.00% |
| 1607  | 6  | -386.8095 | 1049 | -38.0000 | -387.0084 | 594070  | 918.44% |
| 1609  | 4  | -386.1028 | 771  | -38.0000 | -387.0084 | 595848  | 918.44% |
| 1610  | 5  | -384.6422 | 738  | -38.0000 | -387.0084 | 598389  | 918.44% |
| 1612  | 8  | -382.0306 | 768  | -38.0000 | -387.0084 | 613444  | 918.44% |
| 1615  | 9  | -383.3599 | 777  | -38.0000 | -386.9557 | 622553  | 918.30% |
| Elapsed time = 129.55 sec. (136324.17 ticks, tree = 0.02 MB, solutions = 5) |    |           |      |          |           |         |         |
| 1616  | 9  | -375.8867 | 788  | -38.0000 | -386.9557 | 626524  | 918.30% |
| 1618  | 12 | -381.5367 | 781  | -38.0000 | -386.9557 | 649547  | 918.30% |
| 1620  | 11 | -384.0428 | 927  | -38.0000 | -386.9557 | 645526  | 918.30% |
| 1621  | 7  | -385.0541 | 787  | -38.0000 | -386.9557 | 604066  | 918.30% |
| 1624  | 17 | -380.8858 | 736  | -38.0000 | -386.8091 | 710376  | 917.92% |
| 1626  | 18 | -380.7050 | 773  | -38.0000 | -386.8091 | 720185  | 917.92% |
| 1628  | 20 | -383.5446 | 949  | -38.0000 | -386.8091 | 752988  | 917.92% |
| 1629  | 23 | -382.1894 | 814  | -38.0000 | -386.1685 | 802390  | 916.23% |
| 1633  | 19 | -379.8805 | 765  | -38.0000 | -386.1685 | 724806  | 916.23% |
| 1636  | 21 | -382.9042 | 965  | -38.0000 | -386.1685 | 754400  | 916.23% |
| Elapsed time = 144.26 sec. (150551.65 ticks, tree = 0.16 MB, solutions = 5) |    |           |      |          |           |         |         |
| 1638  | 23 | -380.8078 | 875  | -38.0000 | -386.1685 | 784761  | 916.23% |
| 1640  | 30 | -378.6604 | 789  | -38.0000 | -386.1685 | 871097  | 916.23% |
| 1642  | 33 | -382.5092 | 979  | -38.0000 | -386.1685 | 905127  | 916.23% |
| 1644  | 28 | -369.0237 | 733  | -38.0000 | -386.1685 | 859325  | 916.23% |
| 1645  | 37 | -371.9556 | 867  | -38.0000 | -386.1685 | 939036  | 916.23% |
| 1648  | 39 | -371.2651 | 710  | -38.0000 | -386.1685 | 956044  | 916.23% |
| 1650  | 41 | -372.1191 | 850  | -38.0000 | -386.1685 | 974080  | 916.23% |
| 1653  | 42 | -379.9721 | 743  | -38.0000 | -386.1685 | 985124  | 916.23% |
| 1658  | 49 | -377.9725 | 784  | -38.0000 | -386.1685 | 1012953 | 916.23% |
| 1660  | 42 | -368.8209 | 739  | -38.0000 | -386.1685 | 980397  | 916.23% |
| Elapsed time = 158.38 sec. (165820.30 ticks, tree = 0.22 MB, solutions = 5) |    |           |      |          |           |         |         |
| 1662  | 46 | -371.9569 | 788  | -38.0000 | -386.1685 | 996170  | 916.23% |
| 1664  | 45 | -378.6304 | 890  | -38.0000 | -386.1685 | 993788  | 916.23% |
| 1666  | 48 | -362.4336 | 921  | -38.0000 | -386.1685 | 1004351 | 916.23% |
| 1669  | 57 | -375.2631 | 783  | -38.0000 | -386.1685 | 1054343 | 916.23% |
| 1672  | 65 | -377.0938 | 785  | -38.0000 | -386.1685 | 1077462 | 916.23% |
| 1676  | 56 | -370.4028 | 811  | -38.0000 | -386.1685 | 1048798 | 916.23% |
| 1677  | 58 | -377.8983 | 718  | -38.0000 | -386.1685 | 1057061 | 916.23% |
| 1680  | 69 | -377.3027 | 879  | -38.0000 | -386.1685 | 1098444 | 916.23% |
| 1682  | 73 | -377.2401 | 751  | -38.0000 | -386.1685 | 1119275 | 916.23% |
| 1687  | 64 | -366.9964 | 711  | -38.0000 | -386.1685 | 1081207 | 916.23% |

Elapsed time = 170.66 sec. (179644.29 ticks, tree = 0.33 MB, solutions = 5)

|      |     |           |     |          |           |         |         |
|------|-----|-----------|-----|----------|-----------|---------|---------|
| 1689 | 80  | -376.0566 | 805 | -38.0000 | -386.1685 | 1152637 | 916.23% |
| 1692 | 81  | -364.2601 | 795 | -38.0000 | -386.1685 | 1158452 | 916.23% |
| 1698 | 86  | -375.6997 | 713 | -38.0000 | -386.1685 | 1176524 | 916.23% |
| 1702 | 78  | -367.0278 | 782 | -38.0000 | -386.1685 | 1148330 | 916.23% |
| 1705 | 87  | -362.6076 | 808 | -38.0000 | -386.1685 | 1186831 | 916.23% |
| 1709 | 87  | -372.5778 | 688 | -38.0000 | -386.1685 | 1182617 | 916.23% |
| 1715 | 91  | -361.2418 | 775 | -38.0000 | -386.1685 | 1198439 | 916.23% |
| 1718 | 96  | -364.3288 | 787 | -38.0000 | -386.1685 | 1229751 | 916.23% |
| 1722 | 97  | -361.7048 | 671 | -38.0000 | -386.1685 | 1223041 | 916.23% |
| 1731 | 101 | -371.0484 | 819 | -38.0000 | -386.1685 | 1241877 | 916.23% |

Elapsed time = 181.55 sec. (190828.34 ticks, tree = 0.48 MB, solutions = 5)

|      |     |           |     |          |           |         |         |
|------|-----|-----------|-----|----------|-----------|---------|---------|
| 1738 | 101 | -352.9145 | 701 | -38.0000 | -386.1685 | 1224916 | 916.23% |
| 1747 | 105 | -348.2397 | 651 | -38.0000 | -386.1685 | 1226350 | 916.23% |
| 1751 | 92  | -355.5354 | 732 | -38.0000 | -386.1685 | 1201408 | 916.23% |
| 1753 | 98  | -363.3957 | 800 | -38.0000 | -386.1685 | 1236017 | 916.23% |
| 1760 | 109 | -360.8998 | 699 | -38.0000 | -386.1685 | 1258257 | 916.23% |
| 1766 | 106 | -362.0373 | 768 | -38.0000 | -386.1685 | 1251129 | 916.23% |
| 1770 | 138 | -369.8963 | 847 | -38.0000 | -386.1685 | 1315878 | 916.23% |
| 1776 | 157 | -359.2809 | 751 | -38.0000 | -386.1685 | 1371681 | 916.23% |
| 1780 | 143 | -372.8468 | 866 | -38.0000 | -386.1685 | 1336188 | 916.23% |
| 1788 | 159 | -357.3907 | 752 | -38.0000 | -386.1685 | 1376458 | 916.23% |

Elapsed time = 192.07 sec. (201530.64 ticks, tree = 1.48 MB, solutions = 5)

|      |     |           |     |          |           |         |         |
|------|-----|-----------|-----|----------|-----------|---------|---------|
| 1793 | 165 | -351.1548 | 720 | -38.0000 | -386.1685 | 1382812 | 916.23% |
| 1800 | 146 | -330.0804 | 647 | -38.0000 | -386.1685 | 1313355 | 916.23% |
| 1809 | 168 | -354.1876 | 662 | -38.0000 | -386.1685 | 1388199 | 916.23% |
| 1819 | 169 | -347.8706 | 660 | -38.0000 | -386.1685 | 1390338 | 916.23% |
| 1827 | 171 | -347.0562 | 700 | -38.0000 | -386.1685 | 1392341 | 916.23% |
| 1838 | 198 | -359.3410 | 735 | -38.0000 | -386.1685 | 1468649 | 916.23% |
| 1844 | 189 | -316.1421 | 609 | -38.0000 | -386.1685 | 1413172 | 916.23% |
| 1856 | 184 | -366.0754 | 822 | -38.0000 | -386.1685 | 1431628 | 916.23% |
| 1862 | 177 | -342.0989 | 643 | -38.0000 | -386.1685 | 1401987 | 916.23% |
| 1872 | 185 | -368.7856 | 775 | -38.0000 | -386.1685 | 1433055 | 916.23% |

Elapsed time = 202.84 sec. (212543.16 ticks, tree = 2.11 MB, solutions = 5)

|      |     |           |     |          |           |         |         |
|------|-----|-----------|-----|----------|-----------|---------|---------|
| 1886 | 204 | -348.5624 | 768 | -38.0000 | -386.1685 | 1470065 | 916.23% |
| 1896 | 187 | -367.8768 | 775 | -38.0000 | -386.1685 | 1439100 | 916.23% |
| 1910 | 263 | -366.6514 | 725 | -38.0000 | -386.1685 | 1563807 | 916.23% |
| 1917 | 226 | -366.2143 | 745 | -38.0000 | -386.1685 | 1526100 | 916.23% |
| 1936 | 223 | -329.7481 | 750 | -38.0000 | -386.1685 | 1508197 | 916.23% |



|   |      |           |      |          |           |         |         |
|---|------|-----------|------|----------|-----------|---------|---------|
| 1943  | 280  | -352.0908 | 798  | -38.0000 | -386.1685 | 1611855 | 916.23% |
| 1954  | 306  | -346.5994 | 704  | -38.0000 | -386.1685 | 1668764 | 916.23% |
| 1963  | 266  | -359.3957 | 727  | -38.0000 | -386.1685 | 1578568 | 916.23% |
| 1976  | 227  | -330.0316 | 709  | -38.0000 | -386.1685 | 1517288 | 916.23% |
| 1996  | 304  | -332.9077 | 756  | -38.0000 | -386.1685 | 1652826 | 916.23% |
| Elapsed time = 212.95 sec. (223101.71 ticks, tree = 5.77 MB, solutions = 5)   |      |           |      |          |           |         |         |
| 2005  | 237  | -359.0799 | 637  | -38.0000 | -386.1685 | 1547380 | 916.23% |
| 2023  | 289  | -351.0669 | 792  | -38.0000 | -386.1685 | 1631819 | 916.23% |
| 2045  | 312  | -332.4457 | 739  | -38.0000 | -386.1685 | 1662091 | 916.23% |
| 2068  | 366  | -350.4486 | 785  | -38.0000 | -386.1685 | 1774184 | 916.23% |
| 2081  | 393  | -327.5920 | 631  | -38.0000 | -386.1685 | 1810141 | 916.23% |
| 2099  | 326  | -322.0228 | 695  | -38.0000 | -386.1685 | 1696440 | 916.23% |
| 2119  | 349  | -325.3107 | 627  | -38.0000 | -386.1685 | 1722349 | 916.23% |
| 2140  | 448  | -321.3074 | 722  | -38.0000 | -386.1685 | 1913614 | 916.23% |
| 2160  | 460  | -315.9675 | 684  | -38.0000 | -386.1685 | 1927645 | 916.23% |
| 2227  | 375  | -329.5555 | 813  | -38.0000 | -386.1685 | 1801495 | 916.23% |
| Elapsed time = 225.67 sec. (235995.28 ticks, tree = 6.47 MB, solutions = 5)   |      |           |      |          |           |         |         |
| 2329  | 554  | -274.9106 | 575  | -38.0000 | -386.1685 | 2020145 | 916.23% |
| 2462  | 603  | -208.4551 | 608  | -38.0000 | -386.1685 | 2106858 | 916.23% |
| 2643  | 662  | -287.5155 | 621  | -38.0000 | -386.1685 | 2198449 | 916.23% |
| 2816  | 632  | -274.9940 | 683  | -38.0000 | -386.1685 | 2159172 | 916.23% |
| 2986  | 735  | -213.5904 | 523  | -38.0000 | -386.1685 | 2277454 | 916.23% |
| 3306  | 787  | -211.7584 | 632  | -38.0000 | -385.3111 | 2315535 | 913.98% |
| 3607  | 1286 | -201.8962 | 558  | -38.0000 | -385.3111 | 2674488 | 913.98% |
| 3977  | 1303 | -183.7525 | 692  | -38.0000 | -385.3111 | 2693379 | 913.98% |
| 4008  | 1540 | -376.5161 | 957  | -38.0000 | -385.3111 | 2835562 | 913.98% |
| 4055  | 1700 | -376.8232 | 922  | -38.0000 | -385.3111 | 2930975 | 913.98% |
| Elapsed time = 265.35 sec. (274668.79 ticks, tree = 65.53 MB, solutions = 5)  |      |           |      |          |           |         |         |
| 4113  | 1703 | -375.8357 | 891  | -38.0000 | -385.3111 | 2941519 | 913.98% |
| 4283  | 2263 | -129.2319 | 583  | -38.0000 | -384.4635 | 3322625 | 911.75% |
| 4472  | 2267 | -374.2307 | 1055 | -38.0000 | -384.4635 | 3388151 | 911.75% |
| 4510  | 2280 | -365.4293 | 795  | -38.0000 | -384.4635 | 3426661 | 911.75% |
| 4538  | 2416 | -346.9335 | 718  | -38.0000 | -381.9426 | 3507655 | 905.11% |
| 4576  | 2480 | -361.8407 | 815  | -38.0000 | -381.9426 | 3618609 | 905.11% |
| 4615  | 2528 | -373.4181 | 888  | -38.0000 | -381.9426 | 3742100 | 905.11% |
| 4658  | 2532 | -342.0634 | 836  | -38.0000 | -381.9426 | 3734502 | 905.11% |
| 4699  | 2533 | -365.4533 | 944  | -38.0000 | -381.9426 | 3763000 | 905.11% |
| 4747  | 2657 | -310.5418 | 677  | -38.0000 | -381.9426 | 4014791 | 905.11% |
| Elapsed time = 303.11 sec. (313289.88 ticks, tree = 111.76 MB, solutions = 5) |      |           |      |          |           |         |         |

|   |      |           |     |          |           |         |         |
|---|------|-----------|-----|----------|-----------|---------|---------|
| 4802  | 2620 | -349.3655 | 890 | -38.0000 | -381.9426 | 3957330 | 905.11% |
| 4871  | 2755 | -323.3668 | 697 | -38.0000 | -381.9426 | 4199276 | 905.11% |
| 4946  | 2741 | -290.9565 | 601 | -38.0000 | -381.9426 | 4189091 | 905.11% |
| 5043  | 2816 | -273.6839 | 761 | -38.0000 | -381.9426 | 4291508 | 905.11% |
| 5155  | 2962 | -201.2710 | 658 | -38.0000 | -381.9426 | 4460142 | 905.11% |
| 5291  | 2981 | -169.8593 | 604 | -38.0000 | -381.9426 | 4478921 | 905.11% |
| 5466  | 3076 | -203.9541 | 682 | -38.0000 | -381.9426 | 4584024 | 905.11% |
| 5694  | 3180 | -135.7850 | 678 | -38.0000 | -381.9426 | 4698677 | 905.11% |
| 6097  | 3555 | -75.2412  | 434 | -38.0000 | -381.9426 | 4847836 | 905.11% |
| 6335  | 3538 | -100.6562 | 464 | -38.0000 | -381.9426 | 4949312 | 905.11% |
| Elapsed time = 342.63 sec. (351762.11 ticks, tree = 158.31 MB, solutions = 5) |      |           |     |          |           |         |         |
| 6614  | 4051 | -82.9797  | 391 | -38.0000 | -381.9426 | 5198382 | 905.11% |
| 7157  | 4043 | -93.9551  | 441 | -38.0000 | -381.9426 | 5261948 | 905.11% |
| 7752  | 4029 | -193.8106 | 526 | -38.0000 | -381.9426 | 5254080 | 905.11% |
| 7876  | 4590 | -83.9348  | 406 | -38.0000 | -381.8931 | 5514496 | 904.98% |
| 7902  | 4881 | -379.3565 | 919 | -38.0000 | -381.8926 | 5595047 | 904.98% |
| 7940  | 5145 | -286.1287 | 658 | -38.0000 | -380.8071 | 5682204 | 902.12% |
| 8002  | 4691 | -379.3689 | 774 | -38.0000 | -380.6354 | 5544630 | 901.67% |
| 8035  | 5148 | -364.5840 | 753 | -38.0000 | -380.6354 | 5716992 | 901.67% |
| 8098  | 5346 | -324.6925 | 717 | -38.0000 | -379.9667 | 5809066 | 899.91% |
| 8209  | 5380 | -263.0652 | 689 | -38.0000 | -379.9667 | 5827011 | 899.91% |
| Elapsed time = 383.55 sec. (391445.00 ticks, tree = 250.41 MB, solutions = 5) |      |           |     |          |           |         |         |
| 8407  | 5393 | -359.8021 | 721 | -38.0000 | -379.9667 | 5914698 | 899.91% |
| 8481  | 5521 | -262.1683 | 689 | -38.0000 | -379.9667 | 6008749 | 899.91% |
| 8682  | 5483 | -357.5335 | 722 | -38.0000 | -379.9667 | 6039212 | 899.91% |
| 8840  | 5744 | -352.5118 | 627 | -38.0000 | -379.9667 | 6188503 | 899.91% |
| 9256  | 5975 | -93.5178  | 383 | -38.0000 | -379.9667 | 6283362 | 899.91% |
| 9630  | 6102 | -222.7763 | 518 | -38.0000 | -379.9667 | 6388913 | 899.91% |
| 9957  | 6395 | -332.9427 | 599 | -38.0000 | -379.9667 | 6566131 | 899.91% |
| 10206   | 6704 | -102.7602 | 493 | -38.0000 | -379.9667 | 6620570 | 899.91% |
| 10687   | 6744 | -356.8449 | 804 | -38.0000 | -379.9667 | 6676558 | 899.91% |
| 10892   | 7279 | -141.4255 | 485 | -38.0000 | -379.9667 | 6824257 | 899.91% |
| Elapsed time = 424.74 sec. (430070.66 ticks, tree = 348.74 MB, solutions = 5) |      |           |     |          |           |         |         |
| 11285   | 7549 | -266.8955 | 713 | -38.0000 | -379.9667 | 6935942 | 899.91% |
| 11952   | 8078 | -81.0221  | 475 | -38.0000 | -379.9667 | 7048892 | 899.91% |
| 12136   | 8219 | -376.5899 | 831 | -38.0000 | -379.7943 | 7146826 | 899.46% |
| 12316   | 8696 | -376.1854 | 831 | -38.0000 | -379.5824 | 7253016 | 898.90% |
| 12762   | 9331 | -109.6829 | 395 | -38.0000 | -379.5824 | 7366582 | 898.90% |
| 13127   | 9413 | -307.3537 | 678 | -38.0000 | -379.4554 | 7421367 | 898.57% |

|   |       |           |     |          |           |         |         |
|---|-------|-----------|-----|----------|-----------|---------|---------|
| 13190   | 9725  | -370.0417 | 752 | -38.0000 | -379.4554 | 7491216 | 898.57% |
| 13369   | 10087 | -365.0055 | 759 | -38.0000 | -379.4554 | 7647384 | 898.57% |
| 13522   | 9992  | -149.8716 | 574 | -38.0000 | -379.3906 | 7584555 | 898.40% |
| 13675   | 10455 | -169.6634 | 556 | -38.0000 | -379.3906 | 7707912 | 898.40% |
| Elapsed time = 472.46 sec. (468453.20 ticks, tree = 464.06 MB, solutions = 5) |       |           |     |          |           |         |         |
| 13959   | 10554 | -275.5156 | 638 | -38.0000 | -379.3906 | 7826355 | 898.40% |
| 14081   | 10676 | -330.6031 | 587 | -38.0000 | -379.3841 | 7853249 | 898.38% |
| 14380   | 10903 | -299.8063 | 554 | -38.0000 | -379.2996 | 7908540 | 898.16% |
| 14811   | 10991 | -84.2419  | 244 | -38.0000 | -379.2886 | 7914970 | 898.13% |
| 15473   | 11856 | -43.7849  | 209 | -38.0000 | -379.2886 | 8097559 | 898.13% |
| 15621   | 11659 | -375.0829 | 765 | -38.0000 | -379.2886 | 8079509 | 898.13% |
| 15745   | 12045 | -279.4488 | 234 | -38.0000 | -379.2886 | 8159239 | 898.13% |
| 16259   | 12480 | -122.9856 | 334 | -38.0000 | -379.2886 | 8247673 | 898.13% |
| 16560   | 12619 | -150.5545 | 539 | -38.0000 | -379.2386 | 8302917 | 898.00% |
| 16678   | 12987 | -260.3273 | 396 | -38.0000 | -378.8563 | 8406230 | 896.99% |
| Elapsed time = 525.90 sec. (506688.39 ticks, tree = 537.86 MB, solutions = 5) |       |           |     |          |           |         |         |
| 16832   | 13408 | -360.3564 | 681 | -38.0000 | -378.8563 | 8512516 | 896.99% |
| 17110   | 13421 | -347.1104 | 577 | -38.0000 | -378.7315 | 8526769 | 896.66% |
| 17190   | 13641 | -337.1913 | 715 | -38.0000 | -378.5983 | 8577198 | 896.31% |
| 17403   | 13718 | -266.2754 | 489 | -38.0000 | -378.5983 | 8642161 | 896.31% |
| 17723   | 13869 | -246.2897 | 615 | -38.0000 | -378.5983 | 8701973 | 896.31% |
| 17846   | 14453 | -147.7591 | 476 | -38.0000 | -378.5983 | 8901628 | 896.31% |
| 18013   | 14743 | -257.4287 | 619 | -38.0000 | -378.5983 | 9008331 | 896.31% |
| 18451   | 14774 | -193.0102 | 557 | -38.0000 | -378.5983 | 9013834 | 896.31% |
| 18659   | 14808 | -112.1777 | 501 | -38.0000 | -378.5983 | 9017455 | 896.31% |
| 18954   | 15194 | -365.5685 | 865 | -38.0000 | -378.5983 | 9123572 | 896.31% |
| Elapsed time = 577.52 sec. (546429.72 ticks, tree = 545.80 MB, solutions = 5) |       |           |     |          |           |         |         |
| 18993   | 14989 | -304.6462 | 216 | -38.0000 | -378.5190 | 9079117 | 896.10% |
| 19220   | 15840 | -359.2220 | 537 | -38.0000 | -378.5190 | 9298493 | 896.10% |
| 19362   | 15500 | -367.9160 | 862 | -38.0000 | -378.3778 | 9199784 | 895.73% |
| 19647   | 16099 | -337.1348 | 625 | -38.0000 | -378.2779 | 9416366 | 895.47% |
| 19967   | 16207 | -348.9415 | 288 | -38.0000 | -378.2779 | 9475112 | 895.47% |
| 20375   | 16345 | -375.7467 | 838 | -38.0000 | -378.2215 | 9569876 | 895.32% |
| 20568   | 16421 | -210.0809 | 171 | -38.0000 | -378.2029 | 9586501 | 895.27% |
| 20898   | 16905 | -48.9183  | 177 | -38.0000 | -378.1858 | 9664318 | 895.23% |
| 21209   | 17362 | -43.6742  | 267 | -38.0000 | -378.1858 | 9772573 | 895.23% |
| 21460   | 17380 | -195.1753 | 181 | -38.0000 | -378.1382 | 9776799 | 895.10% |
| Elapsed time = 628.76 sec. (585005.60 ticks, tree = 564.44 MB, solutions = 5) |       |           |     |          |           |         |         |
| 21731   | 17569 | -176.2266 | 368 | -38.0000 | -378.1382 | 9846289 | 895.10% |

|  |       |           |     |          |           |          |         |
|--|-------|-----------|-----|----------|-----------|----------|---------|
| 22006  | 18252 | -234.4369 | 589 | -38.0000 | -378.1353 | 10008342 | 895.09% |
| 22183  | 18306 | -306.6087 | 349 | -38.0000 | -378.1353 | 9991426  | 895.09% |
| 22423  | 18469 | -121.7009 | 505 | -38.0000 | -378.1353 | 10072247 | 895.09% |
| 22692  | 18987 | -121.6388 | 336 | -38.0000 | -378.1353 | 10213880 | 895.09% |
| 22850  | 19137 | -56.8695  | 394 | -38.0000 | -378.1353 | 10254885 | 895.09% |
| 22918  | 19013 | -364.3899 | 709 | -38.0000 | -378.0981 | 10236729 | 894.99% |
| 23147  | 19464 | -325.3539 | 713 | -38.0000 | -377.9287 | 10374695 | 894.55% |
| 23527  | 19550 | -169.3183 | 533 | -38.0000 | -377.9287 | 10393813 | 894.55% |
| 24049  | 19625 | -364.2002 | 903 | -38.0000 | -377.8836 | 10371003 | 894.43% |
| Elapsed time = 682.61 sec. (623723.92 ticks, tree = 682.22 MB, solutions = 5)  |       |           |     |          |           |          |         |
| 24686  | 20421 | -368.3340 | 750 | -38.0000 | -377.8294 | 10657403 | 894.29% |
| 25245  | 19621 | -341.1563 | 713 | -38.0000 | -377.8294 | 10466998 | 894.29% |
| 25810  | 20807 | -353.1728 | 676 | -38.0000 | -377.8294 | 10767293 | 894.29% |
| 26049  | 21383 | -358.5244 | 487 | -38.0000 | -377.8294 | 10845444 | 894.29% |
| 26370  | 21135 | -277.1734 | 655 | -38.0000 | -377.7041 | 10818422 | 893.96% |
| 26824  | 21172 | -182.8045 | 538 | -38.0000 | -377.6195 | 10821038 | 893.74% |
| 27218  | 22670 | -296.3888 | 360 | -38.0000 | -377.6195 | 11004288 | 893.74% |
| 27628  | 22783 | -189.3246 | 127 | -38.0000 | -377.6147 | 11054059 | 893.72% |
| 28136  | 22825 | -270.7104 | 612 | -38.0000 | -377.6147 | 11112939 | 893.72% |
| 28294  | 24138 | -209.7610 | 529 | -38.0000 | -377.6147 | 11307267 | 893.72% |
| Elapsed time = 734.91 sec. (662090.80 ticks, tree = 797.77 MB, solutions = 5)  |       |           |     |          |           |          |         |
| 28605  | 23711 | -234.1514 | 552 | -38.0000 | -377.6147 | 11253825 | 893.72% |
| 28840  | 24553 | -268.2504 | 475 | -38.0000 | -377.5816 | 11391896 | 893.64% |
| 29426  | 24982 | -166.5687 | 513 | -38.0000 | -377.5816 | 11485504 | 893.64% |
| 29687  | 25483 | -371.1550 | 894 | -38.0000 | -377.5816 | 11577943 | 893.64% |
| 30202  | 25692 | -274.5559 | 499 | -38.0000 | -377.4552 | 11622202 | 893.30% |
| 30909  | 25657 | -63.7559  | 371 | -38.0000 | -377.4257 | 11604346 | 893.23% |
| 31597  | 25853 | -118.5099 | 565 | -38.0000 | -377.4257 | 11717188 | 893.23% |
| 32092  | 26336 | -181.8973 | 511 | -38.0000 | -377.4257 | 11767598 | 893.23% |
| 33050  | 26745 | -46.3389  | 148 | -38.0000 | -377.4257 | 11832881 | 893.23% |
| 33558  | 27309 | -53.9421  | 87  | -38.0000 | -377.3971 | 11887058 | 893.15% |
| Elapsed time = 781.18 sec. (700363.36 ticks, tree = 1010.72 MB, solutions = 5) |       |           |     |          |           |          |         |
| 33666  | 27434 | -282.0341 | 190 | -38.0000 | -377.2214 | 11958972 | 892.69% |
| * 33853+29275  |       |           |     | -39.0000 | -377.1435 |          | 867.03% |
| 33922  | 29276 | -367.3141 | 816 | -39.0000 | -377.1435 | 12240781 | 867.03% |
| 33978  | 29609 | -373.9386 | 762 | -39.0000 | -377.1435 | 12286072 | 867.03% |
| 34107  | 29321 | -272.3192 | 625 | -39.0000 | -377.1435 | 12257306 | 867.03% |

GUB cover cuts applied: 745

```

Clique cuts applied: 45
Cover cuts applied: 3303
Implied bound cuts applied: 47
Flow cuts applied: 81
Mixed integer rounding cuts applied: 882
Zero-half cuts applied: 110
Lift and project cuts applied: 6
Gomory fractional cuts applied: 196

Root node processing (before b&c):
Real time          = 5.07 sec. (5253.09 ticks)
Parallel b&c, 8 threads:
Real time          = 792.79 sec. (713089.45 ticks)
Sync time (average) = 91.30 sec.
Wait time (average) = 0.07 sec.
-----
Total (root+branch&cut) = 797.86 sec. (718342.54 ticks)

-----

Iteration 6
Bounds on # of cuts = 8 with [3 3 2]
Error = 61 (out of 100 instances)
Accuracy = 39
Solving time = 13.297700484 min (minutes)
Accumulated time = 13.386493632 min (minutes)

Solution status code = 104
LB on error = -277.143152611
Relative objective gap = 8.670337246

Selected variables:
PEMLR (Categorical)
SS_YN (Categorical)

Number of selected variables = 2 (0 continuous + 2 categorical)
-----
Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d
CPXPARAM_MIP_Strategy_File          3
CPXPARAM_MIP_Limits_Solutions      1

```

|                                |                    |
|--------------------------------|--------------------|
| CPXPARAM_TimeLimit             | 85596.810382080075 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800             |

| Nodes  |       | Cuts/      |      |              |            |          |         |  |
|--|-------|------------|------|--------------|------------|----------|---------|--|
| Node   | Left  | Objective  | IInf | Best Integer | Best Bound | ItCnt    | Gap     |  |
| 34184  | 30011 | infeasible |      | -39.0000     | -377.1432  | 12462046 | 867.03% |  |
| Elapsed time = 0.56 sec. (7.69 ticks, tree = 1131.55 MB, solutions = 6)      |       |            |      |              |            |          |         |  |
| 34185  | 30011 | infeasible |      | -39.0000     | -377.1432  | 12463576 | 867.03% |  |
| 34186  | 30012 | -353.1274  | 307  | -39.0000     | -377.1432  | 12467117 | 867.03% |  |
| 34230  | 30050 | -240.2890  | 140  | -39.0000     | -377.1432  | 12469248 | 867.03% |  |
| 34284  | 30101 | -96.2412   | 68   | -39.0000     | -377.1432  | 12469654 | 867.03% |  |
| 34322  | 30026 | -310.4203  | 254  | -39.0000     | -377.1432  | 12474494 | 867.03% |  |
| 34358  | 30062 | -208.3211  | 168  | -39.0000     | -377.1432  | 12474783 | 867.03% |  |
| 34418  | 30117 | -61.5243   | 49   | -39.0000     | -377.1432  | 12474986 | 867.03% |  |
| 34429  | 30013 | -375.1626  | 767  | -39.0000     | -377.1432  | 12465551 | 867.03% |  |
| 34430  | 30013 | -368.5689  | 712  | -39.0000     | -377.1432  | 12480749 | 867.03% |  |
| 34467  | 30044 | -274.8883  | 182  | -39.0000     | -377.1369  | 12485663 | 867.02% |  |
| Elapsed time = 4.67 sec. (3790.87 ticks, tree = 1118.48 MB, solutions = 6)   |       |            |      |              |            |          |         |  |
| 34559  | 30016 | -375.0799  | 850  | -39.0000     | -377.1369  | 12488423 | 867.02% |  |
| 34566  | 30025 | -347.9018  | 626  | -39.0000     | -376.9781  | 12489041 | 866.61% |  |
| 34577  | 30032 | -332.5967  | 607  | -39.0000     | -376.9781  | 12490820 | 866.61% |  |
| 34601  | 30027 | -337.4018  | 605  | -39.0000     | -376.9781  | 12498141 | 866.61% |  |
| 34627  | 30041 | -305.9294  | 499  | -39.0000     | -376.9781  | 12501938 | 866.61% |  |
| 34686  | 30147 | -296.6126  | 233  | -39.0000     | -376.9781  | 12501312 | 866.61% |  |
| 34810  | 30028 | -351.9984  | 446  | -39.0000     | -376.9781  | 12506723 | 866.61% |  |
| 34871  | 30070 | -210.9115  | 477  | -39.0000     | -376.9781  | 12496496 | 866.61% |  |
| 34894  | 30030 | -347.0129  | 721  | -39.0000     | -376.9781  | 12516063 | 866.61% |  |
| 34921  | 30128 | -340.5311  | 403  | -39.0000     | -376.9781  | 12501487 | 866.61% |  |
| Elapsed time = 18.01 sec. (13637.71 ticks, tree = 1129.36 MB, solutions = 6) |       |            |      |              |            |          |         |  |
| 35000  | 30164 | -248.6996  | 190  | -39.0000     | -376.9781  | 12503763 | 866.61% |  |
| 35127  | 30084 | -205.3721  | 505  | -39.0000     | -376.9781  | 12522308 | 866.61% |  |
| 35293  | 30114 | -133.2772  | 471  | -39.0000     | -376.9781  | 12523058 | 866.61% |  |
| 35359  | 30236 | -342.9975  | 706  | -39.0000     | -376.9781  | 12518300 | 866.61% |  |
| 35553  | 30295 | -154.2894  | 114  | -39.0000     | -376.9781  | 12510201 | 866.61% |  |
| 35761  | 30483 | -66.1665   | 53   | -39.0000     | -376.9781  | 12512438 | 866.61% |  |
| 35798  | 30258 | -297.3622  | 651  | -39.0000     | -376.9781  | 12521841 | 866.61% |  |
| 35816  | 30266 | -281.3269  | 625  | -39.0000     | -376.9781  | 12523129 | 866.61% |  |
| 35843  | 30276 | -256.0856  | 595  | -39.0000     | -376.9744  | 12523344 | 866.60% |  |

|  |       |           |     |          |           |          |         |
|--|-------|-----------|-----|----------|-----------|----------|---------|
| 35885  | 30140 | -302.2962 | 240 | -39.0000 | -376.9744 | 12517050 | 866.60% |
| Elapsed time = 30.67 sec. (23289.65 ticks, tree = 1133.67 MB, solutions = 6) |       |           |     |          |           |          |         |
| 36002  | 30180 | -252.7491 | 441 | -39.0000 | -376.9744 | 12529649 | 866.60% |
| 36062  | 30299 | -206.5953 | 589 | -39.0000 | -376.9744 | 12527129 | 866.60% |
| 36101  | 30230 | -57.4126  | 281 | -39.0000 | -376.9744 | 12532623 | 866.60% |
| 36126  | 30319 | -159.6736 | 546 | -39.0000 | -376.9744 | 12528123 | 866.60% |
| 36145  | 30340 | -344.3312 | 457 | -39.0000 | -376.9744 | 12533604 | 866.60% |
| 36233  | 30409 | -163.6412 | 356 | -39.0000 | -376.9744 | 12535025 | 866.60% |
| 36303  | 30347 | -91.1935  | 479 | -39.0000 | -376.9744 | 12529582 | 866.60% |
| 36329  | 30235 | -375.3955 | 857 | -39.0000 | -376.9744 | 12539899 | 866.60% |
| 36545  | 30368 | cutoff    |     | -39.0000 | -376.9744 | 12531654 | 866.60% |
| 36575  | 30265 | -348.5818 | 255 | -39.0000 | -376.9744 | 12541452 | 866.60% |
| Elapsed time = 42.20 sec. (33038.41 ticks, tree = 1127.58 MB, solutions = 6) |       |           |     |          |           |          |         |
| 36709  | 30470 | -351.3221 | 624 | -39.0000 | -376.9744 | 12544142 | 866.60% |
| 36729  | 30559 | -215.9049 | 649 | -39.0000 | -376.9744 | 12544298 | 866.60% |
| 36812  | 30436 | -161.8911 | 120 | -39.0000 | -376.9744 | 12548856 | 866.60% |
| 36944  | 30486 | -328.9821 | 597 | -39.0000 | -376.9744 | 12550670 | 866.60% |
| 37174  | 30492 | -322.6494 | 608 | -39.0000 | -376.9744 | 12552363 | 866.60% |
| 37271  | 30718 | -149.7022 | 112 | -39.0000 | -376.9744 | 12556065 | 866.60% |
| 37335  | 30604 | -117.6572 | 523 | -39.0000 | -376.9744 | 12548367 | 866.60% |
| 37361  | 30612 | -97.8061  | 497 | -39.0000 | -376.9744 | 12549204 | 866.60% |
| 37508  | 30622 | -74.8865  | 483 | -39.0000 | -376.9744 | 12549545 | 866.60% |
| 37547  | 30284 | -269.1983 | 676 | -39.0000 | -376.9744 | 12570795 | 866.60% |
| Elapsed time = 56.00 sec. (42712.64 ticks, tree = 1132.84 MB, solutions = 6) |       |           |     |          |           |          |         |
| 37587  | 30639 | -46.6761  | 404 | -39.0000 | -376.9744 | 12551100 | 866.60% |
| 37639  | 30414 | -311.7083 | 637 | -39.0000 | -376.9744 | 12561840 | 866.60% |
| 37916  | 30226 | -75.1134  | 38  | -39.0000 | -376.9744 | 12586701 | 866.60% |
| 37975  | 30522 | -298.5992 | 190 | -39.0000 | -376.9744 | 12567952 | 866.60% |
| 38358  | 30734 | -49.6809  | 34  | -39.0000 | -376.9744 | 12573259 | 866.60% |
| 38425  | 30896 | -312.8846 | 395 | -39.0000 | -376.9744 | 12576993 | 866.60% |
| 38560  | 30651 | -351.1738 | 707 | -39.0000 | -376.9744 | 12567726 | 866.60% |
| 38703  | 30659 | -338.3736 | 682 | -39.0000 | -376.9744 | 12569044 | 866.60% |
| 38722  | 30923 | -251.4943 | 422 | -39.0000 | -376.9744 | 12578618 | 866.60% |
| 38807  | 30678 | -300.9916 | 641 | -39.0000 | -376.9744 | 12570330 | 866.60% |
| Elapsed time = 69.11 sec. (52474.66 ticks, tree = 1168.75 MB, solutions = 6) |       |           |     |          |           |          |         |
| 38865  | 30114 | -364.9152 | 785 | -39.0000 | -376.9744 | 12605868 | 866.60% |
| 39094  | 30118 | -364.5336 | 776 | -39.0000 | -376.9744 | 12608499 | 866.60% |
| 39163  | 30390 | -290.9313 | 188 | -39.0000 | -376.9744 | 12593666 | 866.60% |
| 39318  | 30330 | -128.7170 | 102 | -39.0000 | -376.9744 | 12608320 | 866.60% |

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 39378 | 30824 | -371.6508 | 666 | -39.0000 | -376.9744 | 12583385 | 866.60% |
| 39448 | 30859 | -235.6664 | 169 | -39.0000 | -376.9744 | 12587080 | 866.60% |
| 39572 | 30207 | -115.2196 | 106 | -39.0000 | -376.9744 | 12620071 | 866.60% |
| 39664 | 30963 | -184.5348 | 344 | -39.0000 | -376.9744 | 12600785 | 866.60% |
| 39767 | 30781 | -243.6394 | 154 | -39.0000 | -376.9744 | 12609310 | 866.60% |
| 39849 | 30937 | -367.9700 | 804 | -39.0000 | -376.9744 | 12597338 | 866.60% |

Elapsed time = 80.41 sec. (62223.15 ticks, tree = 1187.62 MB, solutions = 6)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 39854 | 30851 | -372.7405 | 686 | -39.0000 | -376.9744 | 12613720 | 866.60% |
| 39993 | 30935 | -102.8985 | 77  | -39.0000 | -376.9744 | 12616877 | 866.60% |
| 40140 | 30982 | -256.2504 | 319 | -39.0000 | -376.9744 | 12605444 | 866.60% |
| 40214 | 31050 | -74.6662  | 160 | -39.0000 | -376.9744 | 12606445 | 866.60% |
| 40237 | 30486 | -373.3192 | 818 | -39.0000 | -376.9744 | 12620511 | 866.60% |
| 40365 | 30487 | -371.8640 | 807 | -39.0000 | -376.9744 | 12623950 | 866.60% |
| 40369 | 31131 | -374.6936 | 763 | -39.0000 | -376.9744 | 12621218 | 866.60% |
| 40456 | 31135 | -198.9005 | 131 | -39.0000 | -376.9744 | 12617239 | 866.60% |
| 40555 | 30500 | -355.6002 | 607 | -39.0000 | -376.9744 | 12631140 | 866.60% |
| 40570 | 30508 | -331.8984 | 543 | -39.0000 | -376.9744 | 12632773 | 866.60% |

Elapsed time = 92.34 sec. (72321.10 ticks, tree = 1149.15 MB, solutions = 6)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 40596 | 30518 | -328.9640 | 539 | -39.0000 | -376.9744 | 12633058 | 866.60% |
| 40632 | 30271 | -259.0082 | 190 | -39.0000 | -376.9744 | 12650779 | 866.60% |
| 40800 | 31223 | -90.5794  | 81  | -39.0000 | -376.9744 | 12635395 | 866.60% |
| 41073 | 31344 | -64.5276  | 40  | -39.0000 | -376.9744 | 12637685 | 866.60% |
| 41160 | 30618 | -133.3406 | 487 | -39.0000 | -376.9744 | 12643767 | 866.60% |
| 41210 | 31110 | -356.1415 | 734 | -39.0000 | -376.9744 | 12623652 | 866.60% |
| 41230 | 30356 | -355.0434 | 236 | -39.0000 | -376.9744 | 12664838 | 866.60% |
| 41364 | 31124 | -323.7738 | 674 | -39.0000 | -376.9744 | 12626631 | 866.60% |
| 41379 | 31356 | -369.4440 | 735 | -39.0000 | -376.9744 | 12647780 | 866.60% |
| 41481 | 30734 | -138.1924 | 86  | -39.0000 | -376.9744 | 12656975 | 866.60% |

Elapsed time = 104.01 sec. (81980.95 ticks, tree = 1160.34 MB, solutions = 6)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 41544 | 30398 | -298.4723 | 615 | -39.0000 | -376.9744 | 12669908 | 866.60% |
| 41678 | 31417 | -241.3441 | 167 | -39.0000 | -376.9744 | 12654919 | 866.60% |
| 41866 | 31505 | -61.6078  | 64  | -39.0000 | -376.9744 | 12655794 | 866.60% |
| 41914 | 31163 | -244.9421 | 559 | -39.0000 | -376.9744 | 12639460 | 866.60% |
| 42050 | 31172 | -220.4289 | 522 | -39.0000 | -376.9744 | 12640470 | 866.60% |
| 42082 | 30440 | -203.7039 | 545 | -39.0000 | -376.9744 | 12674888 | 866.60% |
| 42117 | 30505 | -307.1978 | 643 | -39.0000 | -376.9744 | 12694878 | 866.60% |
| 42157 | 30458 | -162.6077 | 487 | -39.0000 | -376.9744 | 12676762 | 866.60% |
| 42257 | 31346 | -321.7987 | 248 | -39.0000 | -376.9744 | 12666744 | 866.60% |
| 42771 | 31228 | -124.3631 | 93  | -39.0000 | -376.9744 | 12686599 | 866.60% |



Elapsed time = 119.11 sec. (94489.24 ticks, tree = 1192.42 MB, solutions = 6)

|       |       |           |      |          |           |          |         |
|-------|-------|-----------|------|----------|-----------|----------|---------|
| 43224 | 31270 | -374.6367 | 958  | -39.0000 | -376.9744 | 12694136 | 866.60% |
| 43751 | 33045 | -161.2916 | 114  | -39.0000 | -376.9744 | 12987648 | 866.60% |
| 44530 | 30774 | -150.7804 | 111  | -39.0000 | -376.9744 | 12718084 | 866.60% |
| 44812 | 30814 | -374.2969 | 1033 | -39.0000 | -376.9744 | 12725929 | 866.60% |
| 45132 | 30671 | cutoff    |      | -39.0000 | -376.9744 | 12724888 | 866.60% |
| 45505 | 31494 | -360.9840 | 699  | -39.0000 | -376.9744 | 12709907 | 866.60% |
| 45992 | 31897 | -85.7831  | 53   | -39.0000 | -376.9744 | 12902866 | 866.60% |
| 46284 | 35065 | -111.8791 | 76   | -39.0000 | -376.9744 | 13253046 | 866.60% |
| 46578 | 31053 | -356.1008 | 650  | -39.0000 | -376.9744 | 12774822 | 866.60% |
| 46906 | 31958 | -274.4820 | 382  | -39.0000 | -376.9744 | 12935080 | 866.60% |

Elapsed time = 164.80 sec. (133139.60 ticks, tree = 1235.78 MB, solutions = 6)

|               |       |           |      |          |           |          |         |
|---------------|-------|-----------|------|----------|-----------|----------|---------|
| 47493         | 31337 | -291.1340 | 219  | -39.0000 | -376.9744 | 12792486 | 866.60% |
| 48138         | 31430 | -374.7112 | 1029 | -39.0000 | -376.9744 | 12799082 | 866.60% |
| 48546         | 32033 | -116.6233 | 179  | -39.0000 | -376.9194 | 12782627 | 866.46% |
| 49011         | 32202 | -357.4841 | 370  | -39.0000 | -376.9194 | 12958830 | 866.46% |
| 50019         | 32432 | -103.9418 | 68   | -39.0000 | -376.9194 | 12967930 | 866.46% |
| 50531         | 31080 | -370.9851 | 885  | -39.0000 | -376.9194 | 12828929 | 866.46% |
| * 50701+31549 |       |           |      | -40.0000 | -376.9194 |          | 842.30% |

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 51048 | 32626 | -160.4344 | 119 | -40.0000 | -376.9194 | 12988233 | 842.30% |
| 51323 | 33736 | -344.6369 | 244 | -40.0000 | -376.9194 | 13106949 | 842.30% |
| 51999 | 37235 | -345.6706 | 331 | -40.0000 | -376.9194 | 13626666 | 842.30% |
| 52188 | 31438 | -349.4261 | 701 | -40.0000 | -376.9194 | 12876494 | 842.30% |

Elapsed time = 209.24 sec. (171662.93 ticks, tree = 1199.03 MB, solutions = 7)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 52481 | 37432 | -201.6757 | 314 | -40.0000 | -376.9194 | 13648219 | 842.30% |
| 53422 | 35758 | -365.5130 | 684 | -40.0000 | -376.9194 | 13371629 | 842.30% |
| 53912 | 37682 | -130.6639 | 94  | -40.0000 | -376.9194 | 13667768 | 842.30% |
| 54122 | 34391 | -222.5263 | 261 | -40.0000 | -376.9194 | 13156341 | 842.30% |
| 54537 | 34575 | -118.8445 | 76  | -40.0000 | -376.9194 | 13161634 | 842.30% |
| 54944 | 32867 | -274.5121 | 285 | -40.0000 | -376.9194 | 13066188 | 842.30% |
| 55210 | 36351 | -126.9557 | 87  | -40.0000 | -376.9194 | 13427861 | 842.30% |
| 55473 | 36429 | -261.6947 | 186 | -40.0000 | -376.9194 | 13441222 | 842.30% |
| 55684 | 34630 | -361.6861 | 651 | -40.0000 | -376.9194 | 13188259 | 842.30% |
| 56056 | 31799 | -294.4002 | 652 | -40.0000 | -376.9194 | 12963851 | 842.30% |

Elapsed time = 253.04 sec. (209922.64 ticks, tree = 1190.36 MB, solutions = 7)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 56741 | 31813 | -374.9630 | 885 | -40.0000 | -376.9194 | 12984867 | 842.30% |
| 57071 | 36555 | -349.2594 | 626 | -40.0000 | -376.9194 | 13480838 | 842.30% |
| 57695 | 31966 | -342.6780 | 723 | -40.0000 | -376.9194 | 13006011 | 842.30% |
| 58149 | 32052 | -133.2492 | 96  | -40.0000 | -376.9194 | 13020291 | 842.30% |

|  |       |            |     |          |           |          |         |
|--|-------|------------|-----|----------|-----------|----------|---------|
| 58577  | 36670 | -319.4597  | 209 | -40.0000 | -376.9194 | 13512903 | 842.30% |
| 59334  | 38194 | infeasible |     | -40.0000 | -376.9194 | 13776794 | 842.30% |
| 59411  | 36778 | -351.9628  | 635 | -40.0000 | -376.9194 | 13531178 | 842.30% |
| 59775  | 33722 | -371.4617  | 918 | -40.0000 | -376.9194 | 13181426 | 842.30% |
| 59948  | 36900 | -366.2275  | 661 | -40.0000 | -376.9194 | 13549234 | 842.30% |
| 60447  | 32460 | -335.7909  | 735 | -40.0000 | -376.9194 | 13080118 | 842.30% |
| Elapsed time = 296.23 sec. (248581.39 ticks, tree = 1274.28 MB, solutions = 7) |       |            |     |          |           |          |         |
| 60791  | 37101 | -185.5764  | 181 | -40.0000 | -376.9194 | 13570876 | 842.30% |
| 61392  | 34217 | -374.0933  | 734 | -40.0000 | -376.9194 | 13219253 | 842.30% |
| 62039  | 36439 | -363.2180  | 698 | -40.0000 | -376.9194 | 13336882 | 842.30% |
| 62196  | 36566 | -46.5830   | 229 | -40.0000 | -376.9194 | 13345567 | 842.30% |
| 62482  | 34472 | -340.0144  | 758 | -40.0000 | -376.9194 | 13248238 | 842.30% |

Began writing nodes to disk (directory ./cpxhGkJOU created)

GUB cover cuts applied: 872  
 Clique cuts applied: 53  
 Cover cuts applied: 3794  
 Implied bound cuts applied: 59  
 Flow cuts applied: 95  
 Mixed integer rounding cuts applied: 1264  
 Zero-half cuts applied: 118  
 Lift and project cuts applied: 8  
 Gomory fractional cuts applied: 197

Root node processing (before b&c):

|           |   |                        |
|-----------|---|------------------------|
| Real time | = | 0.00 sec. (0.68 ticks) |
|-----------|---|------------------------|

Parallel b&c, 8 threads:

|                     |   |                               |
|---------------------|---|-------------------------------|
| Real time           | = | 316.13 sec. (270209.62 ticks) |
| Sync time (average) | = | 21.13 sec.                    |
| Wait time (average) | = | 0.00 sec.                     |

-----

Total (root+branch&cut) = 316.14 sec. (270210.30 ticks)

-----

Iteration 7

Bounds on # of cuts = 8 with [3 3 2]

Error = 60 (out of 100 instances)

Accuracy = 40

Solving time = 5.268966785 min (minutes)

Accumulated time = 18.655460417 min (minutes)

Solution status code = 104

LB on error = -276.833555011

Relative objective gap = 8.420838875

Selected variables:

PEMLR (Categorical)

SS\_YN (Categorical)

Number of selected variables = 2 (0 continuous + 2 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |                    |
|--------------------------------|--------------------|
| CPXPARAM_MIP_Strategy_File     | 3                  |
| CPXPARAM_MIP_Limits_Solutions  | 1                  |
| CPXPARAM_TimeLimit             | 85280.672374999995 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800             |

| Nodes  |       |            |      | Cuts/        |            |          |         |  |
|--|-------|------------|------|--------------|------------|----------|---------|--|
| Node   | Left  | Objective  | IInf | Best Integer | Best Bound | ItCnt    | Gap     |  |
| 62493  | 56328 | -371.5512  | 875  | -40.0000     | -376.8336  | 16793405 | 842.08% |  |
| Elapsed time = 1.28 sec. (381.47 ticks, tree = 2553.13 MB, solutions = 7)  |       |            |      |              |            |          |         |  |
| Nodefile size = 505.19 MB (457.73 MB after compression)                    |       |            |      |              |            |          |         |  |
| 62494  | 56329 | -371.1453  | 802  | -40.0000     | -376.8336  | 16795022 | 842.08% |  |
| 62497  | 56331 | -371.0317  | 798  | -40.0000     | -376.8336  | 16796271 | 842.08% |  |
| 62498  | 56328 | -368.1504  | 812  | -40.0000     | -376.8336  | 16797169 | 842.08% |  |
| 62512  | 56334 | -374.4435  | 690  | -40.0000     | -376.8336  | 16798167 | 842.08% |  |
| 62525  | 56343 | -367.3256  | 732  | -40.0000     | -376.8336  | 16801668 | 842.08% |  |
| 62532  | 56335 | -369.7631  | 729  | -40.0000     | -376.8336  | 16799811 | 842.08% |  |
| 62542  | 56346 | infeasible |      | -40.0000     | -376.8336  | 16803611 | 842.08% |  |
| 62547  | 56350 | -365.8593  | 652  | -40.0000     | -376.8336  | 16804496 | 842.08% |  |
| 62560  | 56356 | -364.8589  | 634  | -40.0000     | -376.8336  | 16805402 | 842.08% |  |
| 62618  | 56340 | -373.4930  | 705  | -40.0000     | -376.8336  | 16804652 | 842.08% |  |
| Elapsed time = 5.50 sec. (4460.10 ticks, tree = 2546.50 MB, solutions = 7) |       |            |      |              |            |          |         |  |
| Nodefile size = 505.19 MB (457.73 MB after compression)                    |       |            |      |              |            |          |         |  |
| 62639  | 56342 | -376.2051  | 828  | -40.0000     | -376.8205  | 16808904 | 842.05% |  |
| 62665  | 56385 | -373.6476  | 439  | -40.0000     | -376.8205  | 16811958 | 842.05% |  |
| 62722  | 56376 | -285.1413  | 212  | -40.0000     | -376.8205  | 16814049 | 842.05% |  |

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 62904 | 56365 | -320.2108 | 319 | -40.0000 | -376.8205 | 16832674 | 842.05% |
| 62969 | 56414 | -207.5316 | 159 | -40.0000 | -376.8205 | 16836614 | 842.05% |
| 63094 | 56358 | -361.8225 | 455 | -40.0000 | -376.8205 | 16829520 | 842.05% |
| 63139 | 56390 | -350.5564 | 411 | -40.0000 | -376.8205 | 16833177 | 842.05% |
| 63164 | 56347 | -366.7584 | 820 | -40.0000 | -376.8205 | 16827937 | 842.05% |
| 63232 | 56547 | -261.9177 | 265 | -40.0000 | -376.8205 | 16828650 | 842.05% |
| 63383 | 56506 | -372.3550 | 659 | -40.0000 | -376.8205 | 16845155 | 842.05% |

Elapsed time = 17.85 sec. (15002.70 ticks, tree = 2538.21 MB, solutions = 7)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |            |     |          |           |          |         |
|-------|-------|------------|-----|----------|-----------|----------|---------|
| 63431 | 56370 | -361.1593  | 662 | -40.0000 | -376.8205 | 16836599 | 842.05% |
| 63518 | 56528 | -366.3616  | 580 | -40.0000 | -376.8205 | 16851365 | 842.05% |
| 63551 | 56668 | -372.7898  | 614 | -40.0000 | -376.8205 | 16838522 | 842.05% |
| 63617 | 56356 | infeasible |     | -40.0000 | -376.8205 | 16847550 | 842.05% |
| 63657 | 56433 | -373.2525  | 857 | -40.0000 | -376.5778 | 16842129 | 841.44% |
| 63720 | 56584 | infeasible |     | -40.0000 | -376.5778 | 16866006 | 841.44% |
| 63742 | 56708 | -347.8130  | 343 | -40.0000 | -376.5778 | 16851562 | 841.44% |
| 63817 | 56407 | -372.9694  | 713 | -40.0000 | -376.5778 | 16853277 | 841.44% |
| 63875 | 56438 | -336.4001  | 379 | -40.0000 | -376.5778 | 16856671 | 841.44% |
| 63937 | 56457 | -370.4856  | 719 | -40.0000 | -376.5778 | 16855716 | 841.44% |

Elapsed time = 29.24 sec. (24884.76 ticks, tree = 2542.06 MB, solutions = 7)

Nodefile size = 505.19 MB (457.73 MB after compression)

|               |       |           |     |          |           |          |         |
|---------------|-------|-----------|-----|----------|-----------|----------|---------|
| 63986         | 56760 | -361.2265 | 352 | -40.0000 | -376.5778 | 16863808 | 841.44% |
| * 64088+56788 |       |           |     | -42.0000 | -376.5778 |          | 796.61% |
| 64161         | 56427 | -308.4527 | 287 | -42.0000 | -376.5778 | 16861750 | 796.61% |
| 64305         | 56426 | -364.4031 | 448 | -42.0000 | -376.5778 | 16867050 | 796.61% |
| 64344         | 56429 | cutoff    |     | -42.0000 | -376.5778 | 16870294 | 796.61% |
| 64408         | 56433 | -361.1858 | 402 | -42.0000 | -376.5778 | 16864366 | 796.61% |
| 64514         | 56592 | -369.9594 | 867 | -42.0000 | -376.5778 | 16880737 | 796.61% |
| 64661         | 56555 | -117.7107 | 86  | -42.0000 | -376.5778 | 16881851 | 796.61% |
| 64713         | 56603 | -366.8417 | 779 | -42.0000 | -376.5778 | 16886930 | 796.61% |
| 64780         | 56605 | -366.4698 | 401 | -42.0000 | -376.5778 | 16885487 | 796.61% |
| 64920         | 56444 | -257.3129 | 304 | -42.0000 | -376.5778 | 16880818 | 796.61% |

Elapsed time = 40.45 sec. (34952.40 ticks, tree = 2527.61 MB, solutions = 8)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 65008 | 56483 | -373.2735 | 748 | -42.0000 | -376.5778 | 16879719 | 796.61% |
| 65038 | 56496 | -371.2082 | 756 | -42.0000 | -376.5778 | 16884054 | 796.61% |
| 65110 | 56516 | -350.0730 | 368 | -42.0000 | -376.5778 | 16888980 | 796.61% |
| 65158 | 56558 | -235.2681 | 191 | -42.0000 | -376.5778 | 16892346 | 796.61% |
| 65285 | 56665 | -371.7312 | 780 | -42.0000 | -376.5778 | 16902786 | 796.61% |

|       |       |           |      |          |           |          |         |
|-------|-------|-----------|------|----------|-----------|----------|---------|
| 65319 | 56612 | -366.8891 | 1013 | -42.0000 | -376.5778 | 16899193 | 796.61% |
| 65328 | 56515 | -369.2649 | 813  | -42.0000 | -376.5778 | 16898243 | 796.61% |
| 65349 | 56619 | -365.9130 | 961  | -42.0000 | -376.5778 | 16903443 | 796.61% |
| 65377 | 56656 | -374.9636 | 869  | -42.0000 | -376.5778 | 16903553 | 796.61% |
| 65461 | 56566 | -354.8815 | 435  | -42.0000 | -376.5778 | 16906832 | 796.61% |

Elapsed time = 51.75 sec. (45094.74 ticks, tree = 2537.59 MB, solutions = 8)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |           |      |          |           |          |         |
|-------|-------|-----------|------|----------|-----------|----------|---------|
| 65538 | 56652 | -352.6881 | 414  | -42.0000 | -376.5778 | 16912258 | 796.61% |
| 65579 | 56663 | -373.6537 | 807  | -42.0000 | -376.5778 | 16911756 | 796.61% |
| 65603 | 56591 | -375.1709 | 881  | -42.0000 | -376.5778 | 16912590 | 796.61% |
| 65614 | 56685 | -368.6663 | 587  | -42.0000 | -376.5778 | 16926075 | 796.61% |
| 65654 | 56606 | -326.8965 | 270  | -42.0000 | -376.5778 | 16919118 | 796.61% |
| 65840 | 56689 | -344.0531 | 352  | -42.0000 | -376.5778 | 16932035 | 796.61% |
| 65863 | 56702 | -353.1667 | 420  | -42.0000 | -376.5778 | 16935329 | 796.61% |
| 65889 | 56719 | -319.7314 | 372  | -42.0000 | -376.5778 | 16938567 | 796.61% |
| 65911 | 56725 | -322.5031 | 341  | -42.0000 | -376.5778 | 16941732 | 796.61% |
| 65958 | 56694 | -373.2894 | 1005 | -42.0000 | -376.5778 | 16931254 | 796.61% |

Elapsed time = 62.90 sec. (55166.59 ticks, tree = 2544.63 MB, solutions = 8)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 65997 | 56768 | -253.7349 | 280 | -42.0000 | -376.5778 | 16947850 | 796.61% |
| 66033 | 56799 | -200.2774 | 224 | -42.0000 | -376.5778 | 16951162 | 796.61% |
| 66088 | 56579 | -363.1327 | 912 | -42.0000 | -376.5778 | 16939742 | 796.61% |
| 66104 | 56529 | -366.7705 | 832 | -42.0000 | -376.5778 | 16919965 | 796.61% |
| 66121 | 56540 | -363.5003 | 629 | -42.0000 | -376.5778 | 16923506 | 796.61% |
| 66256 | 56603 | -333.1568 | 482 | -42.0000 | -376.5778 | 16927307 | 796.61% |
| 66353 | 56781 | -358.3175 | 407 | -42.0000 | -376.5778 | 16950761 | 796.61% |
| 66420 | 56807 | -333.2784 | 378 | -42.0000 | -376.5778 | 16954452 | 796.61% |
| 66540 | 56939 | -273.2919 | 280 | -42.0000 | -376.5778 | 16973671 | 796.61% |
| 66663 | 56741 | -346.7942 | 445 | -42.0000 | -376.5778 | 16960552 | 796.61% |

Elapsed time = 74.45 sec. (65498.15 ticks, tree = 2558.25 MB, solutions = 8)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 66746 | 56738 | -367.2268 | 477 | -42.0000 | -376.5778 | 16960134 | 796.61% |
| 67127 | 56776 | -342.2970 | 517 | -42.0000 | -376.5778 | 16968251 | 796.61% |
| 67238 | 56999 | -371.4690 | 752 | -42.0000 | -376.5778 | 16983874 | 796.61% |
| 67266 | 57021 | -333.9642 | 341 | -42.0000 | -376.5778 | 16987177 | 796.61% |
| 67424 | 56898 | -76.4479  | 160 | -42.0000 | -376.5778 | 16978530 | 796.61% |
| 67530 | 57053 | -373.1439 | 621 | -42.0000 | -376.5778 | 16993918 | 796.61% |
| 67784 | 57039 | -91.9323  | 75  | -42.0000 | -376.5778 | 16976965 | 796.61% |
| 67923 | 57209 | -374.6908 | 824 | -42.0000 | -376.5778 | 17000708 | 796.61% |

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 67941 | 56855 | -372.2216 | 428 | -42.0000 | -376.5778 | 16977830 | 796.61% |
| 68103 | 56928 | -331.4462 | 469 | -42.0000 | -376.5778 | 16990292 | 796.61% |

Elapsed time = 85.79 sec. (75199.50 ticks, tree = 2566.21 MB, solutions = 8)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |            |      |          |           |          |         |
|-------|-------|------------|------|----------|-----------|----------|---------|
| 68294 | 56955 | -247.9800  | 326  | -42.0000 | -376.5778 | 16984262 | 796.61% |
| 68361 | 56926 | infeasible |      | -42.0000 | -376.5778 | 16995251 | 796.61% |
| 68454 | 56941 | -342.9196  | 259  | -42.0000 | -376.5778 | 16998376 | 796.61% |
| 68580 | 56992 | -249.5999  | 176  | -42.0000 | -376.5778 | 17002343 | 796.61% |
| 68785 | 57111 | -334.3761  | 321  | -42.0000 | -376.5778 | 16998461 | 796.61% |
| 68946 | 56636 | -370.2219  | 1051 | -42.0000 | -376.5778 | 16959597 | 796.61% |
| 68960 | 57248 | infeasible |      | -42.0000 | -376.5778 | 17004796 | 796.61% |
| 69028 | 57254 | infeasible |      | -42.0000 | -376.5778 | 17007632 | 796.61% |
| 69137 | 57046 | cutoff     |      | -42.0000 | -376.5778 | 17011825 | 796.61% |
| 69146 | 57258 | -374.6623  | 732  | -42.0000 | -376.5778 | 17013586 | 796.61% |

Elapsed time = 96.76 sec. (84893.06 ticks, tree = 2553.89 MB, solutions = 8)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |            |     |          |           |          |         |
|-------|-------|------------|-----|----------|-----------|----------|---------|
| 69174 | 57079 | -374.6247  | 714 | -42.0000 | -376.5778 | 17010021 | 796.61% |
| 69379 | 57535 | -154.2234  | 96  | -42.0000 | -376.5778 | 17040415 | 796.61% |
| 69542 | 57048 | -351.2630  | 495 | -42.0000 | -376.5778 | 17024459 | 796.61% |
| 69611 | 57092 | -249.8471  | 236 | -42.0000 | -376.5778 | 17027482 | 796.61% |
| 69791 | 57123 | -266.5293  | 180 | -42.0000 | -376.5778 | 17021100 | 796.61% |
| 69896 | 57588 | infeasible |     | -42.0000 | -376.5778 | 17051599 | 796.61% |
| 69900 | 57201 | -372.7224  | 744 | -42.0000 | -376.5778 | 17026463 | 796.61% |
| 69921 | 57253 | -355.6185  | 324 | -42.0000 | -376.5778 | 17037474 | 796.61% |
| 70000 | 57290 | -294.2659  | 218 | -42.0000 | -376.5778 | 17038577 | 796.61% |
| 70742 | 57498 | -268.3576  | 172 | -42.0000 | -376.5778 | 17052046 | 796.61% |

Elapsed time = 111.68 sec. (97530.70 ticks, tree = 2556.97 MB, solutions = 9)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |           |      |          |           |          |         |
|-------|-------|-----------|------|----------|-----------|----------|---------|
| 71350 | 57728 | -348.3798 | 248  | -42.0000 | -376.5778 | 17063553 | 796.61% |
| 71743 | 57460 | -373.4932 | 966  | -42.0000 | -376.5778 | 17049682 | 796.61% |
| 71755 | 57653 | -370.4464 | 636  | -42.0000 | -376.5778 | 17078692 | 796.61% |
| 72187 | 57551 | -215.6947 | 184  | -42.0000 | -376.5778 | 17066389 | 796.61% |
| 72276 | 57850 | -367.7073 | 661  | -42.0000 | -376.5778 | 17096223 | 796.61% |
| 72618 | 57937 | -157.8367 | 118  | -42.0000 | -376.5778 | 17107344 | 796.61% |
| 73589 | 58103 | -366.4535 | 645  | -42.0000 | -376.5778 | 17117318 | 796.61% |
| 74114 | 58372 | -220.1499 | 157  | -42.0000 | -376.5778 | 17127622 | 796.61% |
| 74271 | 57688 | -366.0440 | 1022 | -42.0000 | -376.5778 | 17107476 | 796.61% |
| 74330 | 58468 | -278.5357 | 406  | -42.0000 | -376.5778 | 17158803 | 796.61% |

Elapsed time = 151.49 sec. (136817.80 ticks, tree = 2572.25 MB, solutions = 9)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 74466 | 57137 | -373.4744 | 786 | -42.0000 | -376.5778 | 17075738 | 796.61% |
| 74579 | 57229 | -125.4892 | 163 | -42.0000 | -376.5778 | 17083210 | 796.61% |
| 74997 | 58823 | -124.1569 | 77  | -42.0000 | -376.5778 | 17191261 | 796.61% |
| 75138 | 57699 | -351.9220 | 642 | -42.0000 | -376.5778 | 17150191 | 796.61% |
| 75183 | 57727 | -312.4915 | 310 | -42.0000 | -376.5778 | 17159655 | 796.61% |
| 75598 | 57528 | cutoff    |     | -42.0000 | -376.5778 | 17113472 | 796.61% |
| 75757 | 57645 | -372.7641 | 917 | -42.0000 | -376.5778 | 17123059 | 796.61% |
| 75781 | 57652 | -363.8514 | 654 | -42.0000 | -376.5778 | 17133198 | 796.61% |
| 75914 | 57770 | -368.0621 | 641 | -42.0000 | -376.5778 | 17141831 | 796.61% |
| 76307 | 57888 | -367.1160 | 710 | -42.0000 | -376.5778 | 17151066 | 796.61% |

Elapsed time = 182.24 sec. (176632.97 ticks, tree = 2640.89 MB, solutions = 10)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |           |      |          |           |          |         |
|-------|-------|-----------|------|----------|-----------|----------|---------|
| 76625 | 58372 | -276.7328 | 275  | -42.0000 | -376.5778 | 17215778 | 796.61% |
| 76896 | 58881 | -363.3072 | 789  | -42.0000 | -376.5778 | 17266359 | 796.61% |
| 77088 | 58341 | -205.9310 | 178  | -42.0000 | -376.5778 | 17178206 | 796.61% |
| 77452 | 58913 | -289.3936 | 190  | -42.0000 | -376.5778 | 17282930 | 796.61% |
| 77896 | 58805 | -59.1187  | 71   | -42.0000 | -376.5778 | 17249555 | 796.61% |
| 78198 | 58777 | -104.5215 | 100  | -42.0000 | -376.5778 | 17202653 | 796.61% |
| 78213 | 58926 | -368.4008 | 652  | -42.0000 | -376.5778 | 17267554 | 796.61% |
| 78401 | 58786 | -372.5803 | 1028 | -42.0000 | -376.5778 | 17218675 | 796.61% |
| 78547 | 59186 | -304.1862 | 222  | -42.0000 | -376.5778 | 17287687 | 796.61% |
| 78819 | 59304 | -355.0582 | 246  | -42.0000 | -376.5778 | 17297787 | 796.61% |

Elapsed time = 213.20 sec. (216193.23 ticks, tree = 2715.45 MB, solutions = 11)

Nodefile size = 505.19 MB (457.73 MB after compression)

|               |       |            |     |          |           |          |         |
|---------------|-------|------------|-----|----------|-----------|----------|---------|
| * 78861+59332 |       |            |     | -43.0000 | -376.5778 |          | 775.76% |
| 78863         | 58919 | -372.1730  | 923 | -43.0000 | -376.5778 | 17245546 | 775.76% |
| 78865         | 58921 | -362.0419  | 695 | -43.0000 | -376.5778 | 17262028 | 775.76% |
| 78908         | 58961 | -287.4919  | 224 | -43.0000 | -376.5778 | 17274297 | 775.76% |
| 79046         | 59079 | -351.1997  | 373 | -43.0000 | -376.5778 | 17285981 | 775.76% |
| 79251         | 59269 | -136.6352  | 93  | -43.0000 | -376.5778 | 17296280 | 775.76% |
| 79485         | 59473 | -331.8259  | 277 | -43.0000 | -376.5778 | 17304844 | 775.76% |
| 79610         | 59575 | -368.4471  | 613 | -43.0000 | -376.5778 | 17311192 | 775.76% |
| 79779         | 59736 | -235.4136  | 155 | -43.0000 | -376.5778 | 17320410 | 775.76% |
| 79874         | 59817 | infeasible |     | -43.0000 | -376.5778 | 17331372 | 775.76% |
| 79976         | 59913 | -352.6447  | 359 | -43.0000 | -376.5778 | 17343498 | 775.76% |

Elapsed time = 240.73 sec. (260469.65 ticks, tree = 2807.01 MB, solutions = 12)

Nodefile size = 505.19 MB (457.73 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 80225 | 60135 | -351.0370 | 334 | -43.0000 | -376.5778 | 17359520 | 775.76% |
|-------|-------|-----------|-----|----------|-----------|----------|---------|

|       |       |            |      |          |           |          |         |
|-------|-------|------------|------|----------|-----------|----------|---------|
| 80482 | 60367 | -372.6844  | 1128 | -43.0000 | -376.5778 | 17379949 | 775.76% |
| 80486 | 60371 | -370.6348  | 854  | -43.0000 | -376.5778 | 17391940 | 775.76% |
| 80489 | 60374 | -366.6817  | 652  | -43.0000 | -376.5778 | 17402505 | 775.76% |
| 80618 | 60496 | -366.6781  | 671  | -43.0000 | -376.5778 | 17414997 | 775.76% |
| 80896 | 60756 | cutoff     |      | -43.0000 | -376.5778 | 17426348 | 775.76% |
| 81024 | 60865 | -368.8018  | 769  | -43.0000 | -376.5778 | 17439191 | 775.76% |
| 81161 | 60978 | infeasible |      | -43.0000 | -376.5778 | 17452029 | 775.76% |
| 81372 | 61172 | -368.2417  | 708  | -43.0000 | -376.5778 | 17463161 | 775.76% |

GUB cover cuts applied: 916

Clique cuts applied: 53

Cover cuts applied: 3875

Implied bound cuts applied: 59

Flow cuts applied: 100

Mixed integer rounding cuts applied: 1398

Zero-half cuts applied: 121

Lift and project cuts applied: 9

Gomory fractional cuts applied: 198

Root node processing (before b&c):

Real time = 0.00 sec. (0.97 ticks)

Parallel b&c, 8 threads:

Real time = 278.62 sec. (311816.15 ticks)

Sync time (average) = 11.93 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 278.62 sec. (311817.12 ticks)

-----

Iteration 8

Bounds on # of cuts = 8 with [3 3 2]

Error = 57 (out of 100 instances)

Accuracy = 43

Solving time = 4.643691231 min (minutes)

Accumulated time = 23.299151648 min (minutes)

Solution status code = 104

LB on error = -276.380316895

Relative objective gap = 7.753030625



Selected variables:

PEMLR (Categorical)

SS\_YN (Categorical)

Number of selected variables = 2 (0 continuous + 2 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |                    |
|--------------------------------|--------------------|
| CPXPARAM_MIP_Strategy_File     | 3                  |
| CPXPARAM_MIP_Limits_Solutions  | 1                  |
| CPXPARAM_TimeLimit             | 85002.050901123046 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800             |

| Nodes   |       | Cuts/     |      |              |            |          |         |
|---|-------|-----------|------|--------------|------------|----------|---------|
| Node  | Left  | Objective | IInf | Best Integer | Best Bound | ItCnt    | Gap     |
| 81435   | 71926 | -369.0867 | 475  | -43.0000     | -376.3803  | 19472128 | 775.30% |
| Elapsed time = 3.10 sec. (2384.36 ticks, tree = 3375.96 MB, solutions = 13) |       |           |      |              |            |          |         |
| Nodefile size = 1328.84 MB (1208.58 MB after compression)                   |       |           |      |              |            |          |         |
| 81438   | 71929 | -351.7855 | 242  | -43.0000     | -376.3803  | 19472768 | 775.30% |
| 81471   | 71961 | -270.8111 | 173  | -43.0000     | -376.3803  | 19473216 | 775.30% |
| 81515   | 72001 | -157.5837 | 98   | -43.0000     | -376.3803  | 19473641 | 775.30% |
| 81563   | 71926 | -374.3382 | 753  | -43.0000     | -376.3803  | 19473609 | 775.30% |
| 81564   | 71928 | -372.4402 | 715  | -43.0000     | -376.3803  | 19481748 | 775.30% |
| 81567   | 71930 | -371.4346 | 663  | -43.0000     | -376.3803  | 19482880 | 775.30% |
| 81571   | 71933 | -371.2108 | 644  | -43.0000     | -376.3803  | 19483675 | 775.30% |
| 81572   | 71934 | -370.7107 | 636  | -43.0000     | -376.3803  | 19484433 | 775.30% |
| 81576   | 71931 | -360.4175 | 763  | -43.0000     | -376.3803  | 19502020 | 775.30% |
| 81661   | 72012 | -144.5408 | 107  | -43.0000     | -376.3803  | 19488685 | 775.30% |
| Elapsed time = 9.37 sec. (7373.28 ticks, tree = 3370.21 MB, solutions = 13) |       |           |      |              |            |          |         |
| Nodefile size = 1328.84 MB (1208.58 MB after compression)                   |       |           |      |              |            |          |         |
| 81706   | 72044 | -358.3163 | 625  | -43.0000     | -376.3803  | 19488229 | 775.30% |
| 81757   | 72071 | -303.3940 | 260  | -43.0000     | -376.3803  | 19492258 | 775.30% |
| 82046   | 72027 | -154.9862 | 247  | -43.0000     | -376.3803  | 19515571 | 775.30% |
| 82190   | 72089 | -266.6773 | 179  | -43.0000     | -376.3803  | 19502642 | 775.30% |
| 82339   | 72085 | -249.3634 | 162  | -43.0000     | -376.3803  | 19503964 | 775.30% |
| 82548   | 71934 | -359.2701 | 768  | -43.0000     | -376.3803  | 19543860 | 775.30% |
| 82551   | 71937 | -357.5116 | 530  | -43.0000     | -376.3803  | 19547438 | 775.30% |
| 82574   | 71952 | -339.6193 | 324  | -43.0000     | -376.3803  | 19550709 | 775.30% |

|   |       |            |     |          |           |          |         |
|---|-------|------------|-----|----------|-----------|----------|---------|
| 82657   | 72026 | -155.4003  | 164 | -43.0000 | -376.3803 | 19552766 | 775.30% |
| 82707   | 72064 | -355.4909  | 247 | -43.0000 | -376.3803 | 19555144 | 775.30% |
| Elapsed time = 23.10 sec. (18322.56 ticks, tree = 3345.19 MB, solutions = 13) |       |            |     |          |           |          |         |
| Nodefile size = 1328.84 MB (1208.58 MB after compression)                     |       |            |     |          |           |          |         |
| 82804   | 72154 | -136.7153  | 96  | -43.0000 | -376.3527 | 19557777 | 775.24% |
| 82850   | 72307 | -360.9410  | 741 | -43.0000 | -376.3527 | 19521065 | 775.24% |
| 82855   | 72311 | -342.6034  | 249 | -43.0000 | -376.1368 | 19523927 | 774.74% |
| 82983   | 71936 | -362.8146  | 626 | -43.0000 | -376.1368 | 19553992 | 774.74% |
| 82985   | 72161 | -371.0562  | 970 | -43.0000 | -376.1368 | 19520957 | 774.74% |
| 82987   | 72193 | -374.9001  | 951 | -43.0000 | -376.1368 | 19562191 | 774.74% |
| 82993   | 71941 | -358.9686  | 430 | -43.0000 | -376.1368 | 19567870 | 774.74% |
| 82999   | 71946 | -348.8783  | 255 | -43.0000 | -376.1368 | 19572436 | 774.74% |
| 83050   | 71987 | -258.2577  | 225 | -43.0000 | -376.1368 | 19574685 | 774.74% |
| 83115   | 72047 | -106.9395  | 149 | -43.0000 | -376.1368 | 19575766 | 774.74% |
| Elapsed time = 35.85 sec. (28977.15 ticks, tree = 3351.66 MB, solutions = 13) |       |            |     |          |           |          |         |
| Nodefile size = 1328.84 MB (1208.58 MB after compression)                     |       |            |     |          |           |          |         |
| 83146   | 72066 | infeasible |     | -43.0000 | -376.1368 | 19578155 | 774.74% |
| 83150   | 72197 | -355.5337  | 338 | -43.0000 | -376.1368 | 19576926 | 774.74% |
| 83255   | 72221 | -222.3896  | 129 | -43.0000 | -376.1368 | 19540293 | 774.74% |
| 83429   | 72318 | cutoff     |     | -43.0000 | -376.1368 | 19579829 | 774.74% |
| 83434   | 72191 | -359.3736  | 818 | -43.0000 | -376.1368 | 19542416 | 774.74% |
| 83449   | 72287 | -371.6337  | 619 | -43.0000 | -376.1368 | 19550427 | 774.74% |
| 83487   | 72317 | -265.8980  | 174 | -43.0000 | -376.1368 | 19553782 | 774.74% |
| 83744   | 72447 | -333.6008  | 253 | -43.0000 | -376.1368 | 19553268 | 774.74% |
| 83839   | 72511 | -194.0038  | 122 | -43.0000 | -376.1368 | 19554512 | 774.74% |
| 83950   | 72252 | -192.8584  | 143 | -43.0000 | -376.1368 | 19555244 | 774.74% |
| Elapsed time = 48.25 sec. (39354.87 ticks, tree = 3364.70 MB, solutions = 13) |       |            |     |          |           |          |         |
| Nodefile size = 1328.84 MB (1208.58 MB after compression)                     |       |            |     |          |           |          |         |
| 84017   | 72081 | -354.4707  | 699 | -43.0000 | -376.1368 | 19578452 | 774.74% |
| 84023   | 72069 | -366.0459  | 957 | -43.0000 | -376.1368 | 19597048 | 774.74% |
| 84036   | 71956 | -348.2522  | 252 | -43.0000 | -376.1368 | 19588460 | 774.74% |
| 84184   | 72414 | -333.2872  | 216 | -43.0000 | -376.1368 | 19572926 | 774.74% |
| 84316   | 72094 | -351.1716  | 513 | -43.0000 | -376.1368 | 19591693 | 774.74% |
| 84492   | 72137 | -253.3089  | 162 | -43.0000 | -376.1368 | 19595305 | 774.74% |
| 84589   | 72520 | -372.8630  | 619 | -43.0000 | -376.1368 | 19581721 | 774.74% |
| 84631   | 72559 | -273.3236  | 176 | -43.0000 | -376.1368 | 19584387 | 774.74% |
| 84755   | 72337 | -342.0960  | 228 | -43.0000 | -376.1368 | 19606229 | 774.74% |
| 84999   | 72657 | -350.7128  | 344 | -43.0000 | -376.1368 | 19589927 | 774.74% |
| Elapsed time = 59.71 sec. (49483.74 ticks, tree = 3372.85 MB, solutions = 13) |       |            |     |          |           |          |         |

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|       |       |            |     |          |           |          |         |
|-------|-------|------------|-----|----------|-----------|----------|---------|
| 85177 | 72284 | -200.4956  | 128 | -43.0000 | -376.1368 | 19608089 | 774.74% |
| 85252 | 72564 | -366.6790  | 841 | -43.0000 | -376.1368 | 19577339 | 774.74% |
| 85269 | 72536 | infeasible |     | -43.0000 | -376.1368 | 19591276 | 774.74% |
| 85318 | 72802 | -272.0554  | 179 | -43.0000 | -376.1368 | 19598160 | 774.74% |
| 85458 | 72106 | -271.7240  | 204 | -43.0000 | -376.1368 | 19630436 | 774.74% |
| 85583 | 72343 | -369.7473  | 635 | -43.0000 | -376.1368 | 19620884 | 774.74% |
| 85753 | 72537 | -368.2100  | 867 | -43.0000 | -376.1368 | 19598411 | 774.74% |
| 85869 | 72101 | -319.9908  | 214 | -43.0000 | -376.1368 | 19628379 | 774.74% |
| 86144 | 72573 | -271.7490  | 196 | -43.0000 | -376.1368 | 19604341 | 774.74% |
| 86291 | 72116 | -306.6315  | 350 | -43.0000 | -376.1368 | 19628397 | 774.74% |

Elapsed time = 72.00 sec. (59610.39 ticks, tree = 3339.28 MB, solutions = 13)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 86447 | 72541 | -125.2543 | 65  | -43.0000 | -376.1368 | 19631988 | 774.74% |
| 86788 | 72227 | -46.0606  | 174 | -43.0000 | -376.1368 | 19635812 | 774.74% |
| 86904 | 72855 | -90.1545  | 54  | -43.0000 | -376.1368 | 19614400 | 774.74% |
| 86987 | 72371 | -183.6352 | 116 | -43.0000 | -376.1368 | 19641703 | 774.74% |
| 87059 | 72230 | -371.5048 | 694 | -43.0000 | -376.1368 | 19641837 | 774.74% |
| 87140 | 72762 | -210.2776 | 139 | -43.0000 | -376.1368 | 19616474 | 774.74% |
| 87328 | 72220 | -366.7426 | 657 | -43.0000 | -376.1368 | 19654622 | 774.74% |
| 87338 | 72227 | -342.5130 | 261 | -43.0000 | -376.1368 | 19658216 | 774.74% |
| 87497 | 73022 | -331.2281 | 315 | -43.0000 | -376.1368 | 19630982 | 774.74% |
| 87569 | 73080 | -184.5925 | 181 | -43.0000 | -376.1368 | 19631567 | 774.74% |

Elapsed time = 83.56 sec. (69415.07 ticks, tree = 3374.71 MB, solutions = 13)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 87722 | 72426 | -196.0292 | 354 | -43.0000 | -376.1368 | 19658817 | 774.74% |
| 87813 | 72470 | -313.7015 | 224 | -43.0000 | -376.1368 | 19657117 | 774.74% |
| 88010 | 73139 | -332.3763 | 232 | -43.0000 | -376.1368 | 19638071 | 774.74% |
| 88193 | 72344 | -369.2216 | 688 | -43.0000 | -376.1368 | 19671787 | 774.74% |
| 88226 | 72439 | -344.1819 | 306 | -43.0000 | -376.1368 | 19663453 | 774.74% |
| 88382 | 73331 | -108.0697 | 65  | -43.0000 | -376.1368 | 19645596 | 774.74% |
| 88585 | 72524 | -154.1781 | 103 | -43.0000 | -376.1368 | 19666440 | 774.74% |
| 88643 | 72580 | -341.4974 | 385 | -43.0000 | -376.1368 | 19679295 | 774.74% |
| 88686 | 72613 | -276.5086 | 221 | -43.0000 | -376.1368 | 19683720 | 774.74% |
| 88853 | 73404 | -204.9500 | 146 | -43.0000 | -376.1368 | 19657466 | 774.74% |

Elapsed time = 96.42 sec. (79164.76 ticks, tree = 3376.03 MB, solutions = 13)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 88930 | 72572 | -371.0431 | 728 | -43.0000 | -376.1368 | 19675302 | 774.74% |
| 88947 | 72490 | -365.6207 | 494 | -43.0000 | -376.1368 | 19682400 | 774.74% |

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 89059 | 72630 | -210.4036 | 137 | -43.0000 | -376.1368 | 19680104 | 774.74% |
| 89353 | 73556 | -174.7126 | 116 | -43.0000 | -376.1368 | 19669157 | 774.74% |
| 89437 | 72881 | -348.1156 | 280 | -43.0000 | -376.1368 | 19641906 | 774.74% |
| 89803 | 72768 | -138.0596 | 89  | -43.0000 | -376.1368 | 19686828 | 774.74% |
| 90099 | 73621 | -369.2874 | 668 | -43.0000 | -376.1368 | 19676578 | 774.74% |
| 90187 | 72870 | -145.8195 | 96  | -43.0000 | -376.1368 | 19692884 | 774.74% |
| 90391 | 72907 | -350.2219 | 270 | -43.0000 | -376.1368 | 19696002 | 774.74% |
| 90568 | 72953 | -260.3118 | 162 | -43.0000 | -376.1368 | 19699570 | 774.74% |

Elapsed time = 107.23 sec. (88918.59 ticks, tree = 3355.42 MB, solutions = 13)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 90747 | 73000 | -232.2603 | 144 | -43.0000 | -376.1368 | 19670487 | 774.74% |
| 90865 | 73685 | -212.0829 | 144 | -43.0000 | -376.1368 | 19685798 | 774.74% |
| 91021 | 73711 | -147.6431 | 128 | -43.0000 | -376.1368 | 19686698 | 774.74% |
| 91106 | 73041 | -279.0274 | 184 | -43.0000 | -376.1368 | 19662197 | 774.74% |
| 91217 | 72694 | -367.0982 | 639 | -43.0000 | -376.1368 | 19714979 | 774.74% |
| 91226 | 72696 | -364.1187 | 634 | -43.0000 | -376.1368 | 19718381 | 774.74% |
| 91279 | 73087 | -334.1832 | 285 | -43.0000 | -376.1368 | 19684478 | 774.74% |
| 91581 | 72886 | -239.2958 | 177 | -43.0000 | -376.1368 | 19731529 | 774.74% |
| 91880 | 72773 | -172.1287 | 147 | -43.0000 | -376.1368 | 19724728 | 774.74% |
| 92103 | 72979 | -318.1041 | 204 | -43.0000 | -376.1368 | 19741671 | 774.74% |

Elapsed time = 122.50 sec. (101620.07 ticks, tree = 3349.38 MB, solutions = 13)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 92488 | 73193 | -370.3096 | 645 | -43.0000 | -376.1368 | 19705612 | 774.74% |
| 92693 | 73253 | -263.1795 | 257 | -43.0000 | -376.1368 | 19716357 | 774.74% |
| 93074 | 72883 | -356.9105 | 851 | -43.0000 | -376.1368 | 19744324 | 774.74% |
| 93449 | 72909 | -298.8729 | 213 | -43.0000 | -376.1368 | 19753841 | 774.74% |
| 94224 | 73670 | -245.3925 | 164 | -43.0000 | -376.1368 | 19727039 | 774.74% |
| 95151 | 73027 | -142.9352 | 102 | -43.0000 | -376.1368 | 19773585 | 774.74% |
| 96004 | 73918 | -234.3377 | 168 | -43.0000 | -376.1368 | 19744955 | 774.74% |
| 96537 | 75077 | -76.1794  | 41  | -43.0000 | -376.1368 | 19787753 | 774.74% |
| 97188 | 73361 | -339.1905 | 244 | -43.0000 | -376.1368 | 19803446 | 774.74% |
| 97957 | 73408 | -98.3815  | 50  | -43.0000 | -376.1368 | 19811535 | 774.74% |

Elapsed time = 169.17 sec. (140231.77 ticks, tree = 3363.58 MB, solutions = 13)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|       |       |           |     |          |           |          |         |
|-------|-------|-----------|-----|----------|-----------|----------|---------|
| 98359 | 73123 | -368.1863 | 739 | -43.0000 | -376.1368 | 19803156 | 774.74% |
| 99166 | 73425 | -362.4546 | 512 | -43.0000 | -376.1368 | 19828990 | 774.74% |
| 99573 | 74050 | -348.9752 | 262 | -43.0000 | -376.1368 | 19832253 | 774.74% |

|               |  |  |  |          |           |  |         |
|---------------|--|--|--|----------|-----------|--|---------|
| *100206+75506 |  |  |  | -44.0000 | -376.1368 |  | 754.86% |
|---------------|--|--|--|----------|-----------|--|---------|

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 100260 | 74255 | -187.1122 | 111 | -44.0000 | -376.1368 | 19841225 | 754.86% |
|--------|-------|-----------|-----|----------|-----------|----------|---------|

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 100755 | 73923 | -141.6525 | 76  | -44.0000 | -376.1368 | 19855053 | 754.86% |
| 101360 | 74183 | -254.1317 | 165 | -44.0000 | -376.1368 | 19869790 | 754.86% |
| 101983 | 74396 | -365.9683 | 679 | -44.0000 | -376.1368 | 19880718 | 754.86% |
| 102256 | 73251 | -358.7644 | 844 | -44.0000 | -376.1368 | 19850813 | 754.86% |
| 102534 | 74551 | -369.3515 | 969 | -44.0000 | -376.1368 | 19886540 | 754.86% |
| 102636 | 74685 | -201.0157 | 189 | -44.0000 | -376.1368 | 19906540 | 754.86% |

Elapsed time = 213.97 sec. (178886.70 ticks, tree = 3369.28 MB, solutions = 14)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 103075 | 74690 | -137.0039 | 86  | -44.0000 | -376.1368 | 19858793 | 754.86% |
| 103324 | 74781 | -259.5830 | 176 | -44.0000 | -376.1368 | 19870758 | 754.86% |
| 103868 | 73707 | -357.3355 | 710 | -44.0000 | -376.1368 | 19916863 | 754.86% |
| 104488 | 74966 | -156.8062 | 105 | -44.0000 | -376.1368 | 19935045 | 754.86% |
| 104840 | 73993 | -298.3118 | 195 | -44.0000 | -376.1368 | 19937028 | 754.86% |
| 105230 | 74463 | -370.2003 | 680 | -44.0000 | -376.1368 | 19945863 | 754.86% |
| 106185 | 75111 | -328.7164 | 230 | -44.0000 | -376.1368 | 19921098 | 754.86% |
| 106948 | 74994 | -64.9639  | 51  | -44.0000 | -376.1368 | 19976173 | 754.86% |
| 107545 | 75108 | -275.3044 | 179 | -44.0000 | -376.1368 | 19985828 | 754.86% |
| 108190 | 74573 | -122.1881 | 75  | -44.0000 | -376.1368 | 19949611 | 754.86% |

Elapsed time = 255.53 sec. (217150.33 ticks, tree = 3470.33 MB, solutions = 15)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 108890 | 74604 | -302.1580 | 203 | -44.0000 | -376.1368 | 19988782 | 754.86% |
| 109683 | 74939 | -72.1704  | 42  | -44.0000 | -376.1368 | 19996434 | 754.86% |
| 110213 | 75844 | -152.6764 | 113 | -44.0000 | -376.1368 | 20025497 | 754.86% |
| 110687 | 74738 | -372.4462 | 654 | -44.0000 | -376.1368 | 19979491 | 754.86% |
| 111104 | 75218 | -255.9594 | 181 | -44.0000 | -376.1368 | 20021953 | 754.86% |
| 111226 | 75914 | -280.6563 | 210 | -44.0000 | -376.1368 | 20052210 | 754.86% |
| 111818 | 75067 | -108.0074 | 75  | -44.0000 | -376.1368 | 20004989 | 754.86% |
| 112086 | 74183 | -175.7369 | 112 | -44.0000 | -376.1368 | 20000307 | 754.86% |
| 112565 | 76266 | -241.4723 | 169 | -44.0000 | -376.1368 | 20079748 | 754.86% |
| 113030 | 76439 | -164.3090 | 212 | -44.0000 | -376.1368 | 20090558 | 754.86% |

Elapsed time = 300.62 sec. (255370.86 ticks, tree = 3493.07 MB, solutions = 16)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 113440 | 75423 | -356.3437 | 390 | -44.0000 | -376.1368 | 20066747 | 754.86% |
| 113846 | 75655 | -329.7125 | 232 | -44.0000 | -376.1368 | 20074973 | 754.86% |
| 114376 | 76956 | -372.7014 | 765 | -44.0000 | -376.1368 | 20119752 | 754.86% |
| 114992 | 75269 | -357.7460 | 861 | -44.0000 | -376.1368 | 20084688 | 754.86% |
| 115064 | 75899 | -244.1868 | 170 | -44.0000 | -376.1368 | 20104973 | 754.86% |
| 115422 | 75281 | -356.3431 | 761 | -44.0000 | -376.1368 | 20099647 | 754.86% |
| 115659 | 77257 | -354.9574 | 229 | -44.0000 | -376.1368 | 20156509 | 754.86% |

|   |       |           |     |          |           |          |         |
|---|-------|-----------|-----|----------|-----------|----------|---------|
| 116481  | 77486 | -350.4063 | 259 | -44.0000 | -376.1368 | 20166270 | 754.86% |
| 117012  | 74851 | -338.6518 | 338 | -44.0000 | -376.1368 | 20099673 | 754.86% |
| 117672  | 76593 | -73.3108  | 55  | -44.0000 | -376.1368 | 20139708 | 754.86% |
| Elapsed time = 340.22 sec. (294342.29 ticks, tree = 3590.75 MB, solutions = 16) |       |           |     |          |           |          |         |
| Nodefile size = 1328.84 MB (1208.58 MB after compression)                       |       |           |     |          |           |          |         |
| 118392  | 76837 | -340.1003 | 223 | -44.0000 | -376.1368 | 20149430 | 754.86% |
| 118661  | 76951 | -338.5554 | 252 | -44.0000 | -376.1368 | 20159026 | 754.86% |
| 119232  | 78202 | -370.3891 | 879 | -44.0000 | -376.1368 | 20206881 | 754.86% |
| 119504  | 78208 | -365.8875 | 675 | -44.0000 | -376.1368 | 20215279 | 754.86% |
| 120370  | 78339 | -294.4108 | 228 | -44.0000 | -376.1368 | 20224887 | 754.86% |
| 120736  | 77663 | -371.1597 | 751 | -44.0000 | -376.1368 | 20197661 | 754.86% |
| 121137  | 78468 | -263.1958 | 171 | -44.0000 | -376.1368 | 20240044 | 754.86% |
| 121380  | 76760 | -361.0483 | 578 | -44.0000 | -376.1368 | 20206996 | 754.86% |
| 121504  | 78546 | -372.0299 | 951 | -44.0000 | -376.1368 | 20254287 | 754.86% |
| 121709  | 77052 | -189.2273 | 149 | -44.0000 | -376.1368 | 20224660 | 754.86% |
| Elapsed time = 369.68 sec. (333296.33 ticks, tree = 3591.38 MB, solutions = 17) |       |           |     |          |           |          |         |
| Nodefile size = 1328.84 MB (1208.58 MB after compression)                       |       |           |     |          |           |          |         |
| 121787  | 77894 | -347.8439 | 314 | -44.0000 | -376.1368 | 20232409 | 754.86% |
| 121944  | 78563 | -362.8561 | 674 | -44.0000 | -376.1368 | 20281358 | 754.86% |
| 122228  | 78030 | -369.6159 | 952 | -44.0000 | -376.1368 | 20251103 | 754.86% |
| 122239  | 78035 | -365.2604 | 668 | -44.0000 | -376.1368 | 20260623 | 754.86% |
| 122604  | 79033 | -116.1095 | 76  | -44.0000 | -376.1368 | 20304884 | 754.86% |
| 122641  | 77112 | -360.7584 | 740 | -44.0000 | -376.1368 | 20264111 | 754.86% |
| 122909  | 79061 | -359.0364 | 761 | -44.0000 | -376.1368 | 20328240 | 754.86% |
| 122912  | 79064 | -345.4132 | 728 | -44.0000 | -376.1368 | 20339694 | 754.86% |
| 123088  | 79214 | -340.4910 | 331 | -44.0000 | -376.1368 | 20349332 | 754.86% |
| 123335  | 79434 | -366.9963 | 736 | -44.0000 | -376.1368 | 20359227 | 754.86% |
| Elapsed time = 386.93 sec. (378266.74 ticks, tree = 3689.23 MB, solutions = 18) |       |           |     |          |           |          |         |
| Nodefile size = 1328.84 MB (1208.58 MB after compression)                       |       |           |     |          |           |          |         |
| 123606  | 77360 | -367.9078 | 813 | -44.0000 | -376.1368 | 20304015 | 754.86% |
| 123789  | 77402 | -270.6668 | 213 | -44.0000 | -376.1368 | 20313171 | 754.86% |
| 124252  | 77565 | -147.9091 | 111 | -44.0000 | -376.1368 | 20322273 | 754.86% |
| 124710  | 80275 | -339.1575 | 259 | -44.0000 | -376.1368 | 20399552 | 754.86% |
| 125071  | 80455 | -130.4602 | 96  | -44.0000 | -376.1368 | 20407189 | 754.86% |
| 125120  | 80488 | -364.5023 | 979 | -44.0000 | -376.1368 | 20414180 | 754.86% |
| 125393  | 78074 | -67.5268  | 51  | -44.0000 | -376.1368 | 20356949 | 754.86% |
| 125548  | 78206 | -61.4737  | 25  | -44.0000 | -376.1368 | 20365875 | 754.86% |
| 125824  | 80617 | -365.8242 | 646 | -44.0000 | -376.1368 | 20434361 | 754.86% |
| 126311  | 80820 | -149.0581 | 106 | -44.0000 | -376.1368 | 20445898 | 754.86% |

Elapsed time = 402.92 sec. (417930.32 ticks, tree = 3750.55 MB, solutions = 18)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|        |       |            |     |          |           |          |         |
|--------|-------|------------|-----|----------|-----------|----------|---------|
| 126818 | 78688 | -359.1233  | 621 | -44.0000 | -376.1368 | 20397046 | 754.86% |
| 127130 | 78818 | -361.6743  | 326 | -44.0000 | -376.1368 | 20405785 | 754.86% |
| 127645 | 81464 | infeasible |     | -44.0000 | -376.1368 | 20480980 | 754.86% |
| 127773 | 79050 | -370.5096  | 967 | -44.0000 | -376.1368 | 20420424 | 754.86% |
| 128047 | 79052 | -369.8842  | 919 | -44.0000 | -376.1368 | 20426470 | 754.86% |
| 128292 | 82017 | -100.5857  | 62  | -44.0000 | -376.1368 | 20513017 | 754.86% |
| 128338 | 82042 | -364.7610  | 328 | -44.0000 | -376.1368 | 20523898 | 754.86% |
| 128527 | 79071 | -360.6063  | 650 | -44.0000 | -376.1368 | 20446426 | 754.86% |
| 128837 | 82360 | -201.0485  | 146 | -44.0000 | -376.1368 | 20543286 | 754.86% |
| 129157 | 82638 | -369.1021  | 836 | -44.0000 | -376.1368 | 20553236 | 754.86% |

Elapsed time = 433.80 sec. (460667.96 ticks, tree = 3767.71 MB, solutions = 19)

Nodefile size = 1328.84 MB (1208.58 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 129298 | 82771 | -49.6236  | 49  | -44.0000 | -376.1368 | 20560041 | 754.86% |
| 129563 | 83000 | -360.7373 | 441 | -44.0000 | -376.1368 | 20569164 | 754.86% |
| 129908 | 83292 | -150.2737 | 107 | -44.0000 | -376.1368 | 20580126 | 754.86% |
| 130141 | 83494 | -240.2222 | 141 | -44.0000 | -376.1368 | 20590944 | 754.86% |
| 130362 | 83680 | -370.2243 | 736 | -44.0000 | -376.1368 | 20601487 | 754.86% |
| 130505 | 83814 | -359.7878 | 388 | -44.0000 | -376.1368 | 20614667 | 754.86% |
| 130871 | 84128 | -128.4628 | 80  | -44.0000 | -376.1368 | 20623685 | 754.86% |

GUB cover cuts applied: 1043

Clique cuts applied: 57

Cover cuts applied: 4277

Implied bound cuts applied: 68

Flow cuts applied: 118

Mixed integer rounding cuts applied: 1735

Zero-half cuts applied: 125

Lift and project cuts applied: 9

Gomory fractional cuts applied: 199

Root node processing (before b&c):

Real time = 0.00 sec. (1.39 ticks)

Parallel b&c, 8 threads:

Real time = 460.44 sec. (493387.72 ticks)

Sync time (average) = 9.29 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 460.44 sec. (493389.11 ticks)

-----

Iteration 9

Bounds on # of cuts = 8 with [3 3 2]

Error = 56 (out of 100 instances)

Accuracy = 44

Solving time = 7.674096716 min (minutes)

Accumulated time = 30.973248364 min (minutes)

Solution status code = 104

LB on error = -275.942710447

Relative objective gap = 7.54415251

Selected variables:

PEMLR (Categorical)

SS\_YN (Categorical)

Number of selected variables = 2 (0 continuous + 2 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |                   |
|--------------------------------|-------------------|
| CPXPARAM_MIP_Strategy_File     | 3                 |
| CPXPARAM_MIP_Limits_Solutions  | 1                 |
| CPXPARAM_TimeLimit             | 84541.60509814453 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800            |

| Nodes   |        |            |      | Cuts/        |            |          |         |
|---|--------|------------|------|--------------|------------|----------|---------|
| Node  | Left   | Objective  | IInf | Best Integer | Best Bound | ItCnt    | Gap     |
| 130908  | 115417 | infeasible |      | -44.0000     | -375.9427  | 24852547 | 754.42% |
| Elapsed time = 0.21 sec. (11.76 ticks, tree = 4875.97 MB, solutions = 20) |        |            |      |              |            |          |         |
| Nodefile size = 2828.82 MB (2551.19 MB after compression)                 |        |            |      |              |            |          |         |
| 130946  | 115453 | -75.7118   | 39   | -44.0000     | -375.9427  | 24852830 | 754.42% |
| 130960  | 115461 | infeasible |      | -44.0000     | -375.9427  | 24854245 | 754.42% |
| 130961  | 115417 | infeasible |      | -44.0000     | -375.9427  | 24855273 | 754.42% |
| 130962  | 115419 | -375.5477  | 854  | -44.0000     | -375.9427  | 24854727 | 754.42% |
| 130963  | 115462 | -374.5850  | 952  | -44.0000     | -375.9427  | 24856324 | 754.42% |
| 130964  | 115419 | -374.8863  | 762  | -44.0000     | -375.9239  | 24859471 | 754.37% |
| 130966  | 115420 | -370.7308  | 599  | -44.0000     | -375.9239  | 24861461 | 754.37% |



|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 130970 | 115420 | -365.1263 | 677 | -44.0000 | -375.9239 | 24865366 | 754.37% |
| 130974 | 115425 | -353.5129 | 272 | -44.0000 | -375.9239 | 24863328 | 754.37% |
| 131072 | 115431 | -318.7079 | 260 | -44.0000 | -375.9239 | 24868843 | 754.37% |

Elapsed time = 6.88 sec. (4499.63 ticks, tree = 4853.98 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 131222 | 115489 | -186.2469 | 144 | -44.0000 | -375.9239 | 24869233 | 754.37% |
| 131419 | 115588 | -227.5296 | 151 | -44.0000 | -375.9064 | 24867646 | 754.33% |
| 131578 | 115473 | -365.3839 | 660 | -44.0000 | -375.9064 | 24885085 | 754.33% |
| 131721 | 115419 | -364.6390 | 889 | -44.0000 | -375.9064 | 24870560 | 754.33% |
| 131724 | 115420 | -363.4877 | 908 | -44.0000 | -375.9064 | 24872570 | 754.33% |
| 131728 | 115601 | -368.4619 | 691 | -44.0000 | -375.9064 | 24886633 | 754.33% |
| 131749 | 115614 | -344.4963 | 237 | -44.0000 | -375.9064 | 24889538 | 754.33% |
| 131877 | 115538 | -365.3678 | 477 | -44.0000 | -375.9064 | 24884596 | 754.33% |
| 131914 | 115567 | -282.2076 | 191 | -44.0000 | -375.9064 | 24887643 | 754.33% |
| 132035 | 115773 | -357.5782 | 691 | -44.0000 | -375.9064 | 24887689 | 754.33% |

Elapsed time = 20.65 sec. (15475.37 ticks, tree = 4891.62 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 132298 | 115478 | -363.3619 | 938 | -44.0000 | -375.9064 | 24905374 | 754.33% |
| 132305 | 115885 | -365.9278 | 666 | -44.0000 | -375.9064 | 24893668 | 754.33% |
| 132438 | 115476 | -371.2272 | 830 | -44.0000 | -375.9064 | 24902926 | 754.33% |
| 132450 | 115660 | -367.9299 | 777 | -44.0000 | -375.6031 | 24899669 | 753.64% |
| 132461 | 115721 | -365.2211 | 688 | -44.0000 | -375.6031 | 24906865 | 753.64% |
| 132632 | 115757 | -133.2122 | 81  | -44.0000 | -375.6031 | 24904356 | 753.64% |
| 132765 | 115485 | -337.9961 | 301 | -44.0000 | -375.6031 | 24920324 | 753.64% |
| 132903 | 115483 | -354.2930 | 485 | -44.0000 | -375.6031 | 24918321 | 753.64% |
| 132974 | 115524 | -276.5625 | 264 | -44.0000 | -375.6031 | 24920543 | 753.64% |
| 133138 | 116022 | -319.0843 | 203 | -44.0000 | -375.6031 | 24912566 | 753.64% |

Elapsed time = 33.13 sec. (25766.01 ticks, tree = 4914.84 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 133451 | 115867 | -144.2583 | 99  | -44.0000 | -375.6031 | 24916493 | 753.64% |
| 133606 | 116211 | -45.0030  | 24  | -44.0000 | -375.6031 | 24916465 | 753.64% |
| 133745 | 115906 | -235.1235 | 148 | -44.0000 | -375.6031 | 24924857 | 753.64% |
| 134004 | 115642 | -254.9202 | 165 | -44.0000 | -375.6031 | 24933906 | 753.64% |
| 134329 | 115597 | -79.8389  | 61  | -44.0000 | -375.6031 | 24927955 | 753.64% |
| 134423 | 116045 | -141.1138 | 100 | -44.0000 | -375.6031 | 24933151 | 753.64% |
| 134467 | 115718 | -373.6129 | 866 | -44.0000 | -375.6031 | 24938524 | 753.64% |
| 134536 | 115666 | -199.6527 | 129 | -44.0000 | -375.6031 | 24932904 | 753.64% |
| 134612 | 115721 | -354.9792 | 377 | -44.0000 | -375.6031 | 24943712 | 753.64% |
| 134717 | 116230 | -335.6979 | 239 | -44.0000 | -375.6031 | 24937404 | 753.64% |

Elapsed time = 44.97 sec. (35418.05 ticks, tree = 4934.31 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 135026 | 115538 | -238.0279 | 154 | -44.0000 | -375.6031 | 24941038 | 753.64% |
| 135204 | 115612 | -369.4843 | 771 | -44.0000 | -375.6031 | 24941848 | 753.64% |
| 135514 | 116263 | -248.8541 | 173 | -44.0000 | -375.6031 | 24945872 | 753.64% |
| 135735 | 115696 | -158.7882 | 110 | -44.0000 | -375.6031 | 24946026 | 753.64% |
| 135885 | 116414 | -164.6318 | 107 | -44.0000 | -375.6031 | 24949736 | 753.64% |
| 136157 | 115950 | -98.4789  | 83  | -44.0000 | -375.6031 | 24954128 | 753.64% |
| 136177 | 116049 | -371.4216 | 844 | -44.0000 | -375.6031 | 24942096 | 753.64% |
| 136184 | 115729 | -359.2447 | 647 | -44.0000 | -375.6031 | 24956224 | 753.64% |
| 136316 | 116080 | -98.6373  | 67  | -44.0000 | -375.6031 | 24961109 | 753.64% |
| 136393 | 116100 | -349.1181 | 249 | -44.0000 | -375.6031 | 24963534 | 753.64% |

Elapsed time = 57.63 sec. (45651.53 ticks, tree = 4905.68 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 136849 | 115888 | -253.3435 | 164 | -44.0000 | -375.6031 | 24959565 | 753.64% |
| 137050 | 116213 | -367.0710 | 403 | -44.0000 | -375.6031 | 24967308 | 753.64% |
| 137303 | 115892 | -370.9447 | 739 | -44.0000 | -375.6031 | 24969401 | 753.64% |
| 137389 | 116655 | -171.9714 | 119 | -44.0000 | -375.6031 | 24969048 | 753.64% |
| 137495 | 115924 | -298.0111 | 212 | -44.0000 | -375.6031 | 24973699 | 753.64% |
| 137631 | 115998 | -263.0363 | 183 | -44.0000 | -375.6031 | 24969968 | 753.64% |
| 137795 | 116758 | -248.3035 | 154 | -44.0000 | -375.6031 | 24976581 | 753.64% |
| 137891 | 116269 | -369.5074 | 798 | -44.0000 | -375.6031 | 24966502 | 753.64% |
| 137901 | 115848 | -360.4711 | 938 | -44.0000 | -375.5768 | 24990340 | 753.58% |
| 137906 | 116274 | -365.3659 | 725 | -44.0000 | -375.5768 | 24971064 | 753.58% |

Elapsed time = 70.87 sec. (56061.54 ticks, tree = 4932.76 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 137960 | 116487 | -316.4243 | 288 | -44.0000 | -375.5768 | 24985812 | 753.58% |
| 138142 | 116067 | -228.0601 | 154 | -44.0000 | -375.5768 | 24985266 | 753.58% |
| 138227 | 115731 | -362.3989 | 865 | -44.0000 | -375.5768 | 24979413 | 753.58% |
| 138244 | 116283 | -344.5858 | 239 | -44.0000 | -375.5768 | 24983061 | 753.58% |
| 138307 | 115736 | -359.8629 | 779 | -44.0000 | -375.5768 | 24983469 | 753.58% |
| 138489 | 115938 | -175.9894 | 129 | -44.0000 | -375.5768 | 25004586 | 753.58% |
| 138590 | 115775 | -255.4406 | 180 | -44.0000 | -375.5768 | 24988921 | 753.58% |
| 138814 | 116345 | -359.1724 | 760 | -44.0000 | -375.5768 | 24995243 | 753.58% |
| 139074 | 115974 | -105.0916 | 65  | -44.0000 | -375.5768 | 24992675 | 753.58% |
| 139113 | 116128 | -374.1367 | 970 | -44.0000 | -375.5768 | 24991767 | 753.58% |

Elapsed time = 82.98 sec. (65890.40 ticks, tree = 4914.26 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |        |  |          |           |          |         |
|--------|--------|--------|--|----------|-----------|----------|---------|
| 139288 | 116450 | cutoff |  | -44.0000 | -375.5768 | 25002072 | 753.58% |
|--------|--------|--------|--|----------|-----------|----------|---------|

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 139503 | 116586 | -365.1134 | 478 | -44.0000 | -375.5768 | 25000336 | 753.58% |
| 139743 | 116674 | -294.4688 | 225 | -44.0000 | -375.5768 | 24997586 | 753.58% |
| 139909 | 116748 | -108.7938 | 89  | -44.0000 | -375.5768 | 24997959 | 753.58% |
| 139971 | 116095 | -335.3009 | 237 | -44.0000 | -375.5768 | 25004249 | 753.58% |
| 140220 | 116203 | -69.1186  | 46  | -44.0000 | -375.5768 | 25004973 | 753.58% |
| 140240 | 116121 | -362.5128 | 582 | -44.0000 | -375.5768 | 25007014 | 753.58% |
| 140401 | 116148 | -303.0626 | 212 | -44.0000 | -375.5768 | 25009101 | 753.58% |
| 140517 | 116574 | -348.2827 | 284 | -44.0000 | -375.5768 | 25019146 | 753.58% |
| 140699 | 116276 | -258.9445 | 196 | -44.0000 | -375.5768 | 25012673 | 753.58% |

Elapsed time = 94.85 sec. (75581.51 ticks, tree = 4917.26 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 140877 | 116078 | -121.0623 | 82  | -44.0000 | -375.5768 | 25036048 | 753.58% |
| 140925 | 116350 | -343.0377 | 230 | -44.0000 | -375.5768 | 25017733 | 753.58% |
| 141100 | 116151 | -232.2341 | 177 | -44.0000 | -375.5768 | 25039954 | 753.58% |
| 141253 | 117269 | -234.1615 | 167 | -44.0000 | -375.5768 | 25034933 | 753.58% |
| 141416 | 116174 | -281.4930 | 181 | -44.0000 | -375.5768 | 25019843 | 753.58% |
| 141745 | 116720 | -364.4253 | 455 | -44.0000 | -375.5768 | 25034074 | 753.58% |
| 141861 | 116802 | -175.3061 | 289 | -44.0000 | -375.5768 | 25036560 | 753.58% |
| 142147 | 116886 | -280.5945 | 190 | -44.0000 | -375.5768 | 25034867 | 753.58% |
| 142406 | 117437 | -150.9468 | 103 | -44.0000 | -375.5768 | 25044378 | 753.58% |
| 142489 | 116212 | -373.2448 | 888 | -44.0000 | -375.5768 | 25048786 | 753.58% |

Elapsed time = 106.60 sec. (85221.60 ticks, tree = 4909.58 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 142508 | 117488 | -336.2286 | 214 | -44.0000 | -375.5768 | 25048940 | 753.58% |
| 142640 | 116225 | -363.3862 | 631 | -44.0000 | -375.5768 | 25033233 | 753.58% |
| 142775 | 116458 | -157.0598 | 131 | -44.0000 | -375.5768 | 25036898 | 753.58% |
| 142949 | 117590 | -353.3226 | 361 | -44.0000 | -375.5768 | 25056638 | 753.58% |
| 143076 | 116219 | -361.4628 | 313 | -44.0000 | -375.5768 | 25060174 | 753.58% |
| 143254 | 118022 | -345.2241 | 249 | -44.0000 | -375.5297 | 25176661 | 753.48% |
| 143691 | 116631 | -45.6814  | 55  | -44.0000 | -375.5297 | 25047642 | 753.48% |
| 143831 | 116896 | -258.8147 | 156 | -44.0000 | -375.5297 | 25056621 | 753.48% |
| 143932 | 117151 | -370.4339 | 702 | -44.0000 | -375.5297 | 25050563 | 753.48% |
| 144503 | 116351 | -361.2385 | 431 | -44.0000 | -375.5297 | 25058610 | 753.48% |

Elapsed time = 124.41 sec. (98029.26 ticks, tree = 4935.34 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 145598 | 118282 | -84.7192  | 45  | -44.0000 | -375.5297 | 25200709 | 753.48% |
| 146286 | 116663 | -146.1327 | 110 | -44.0000 | -375.5297 | 25086583 | 753.48% |
| 146983 | 118364 | -196.2860 | 147 | -44.0000 | -375.5297 | 25217258 | 753.48% |
| 147695 | 116842 | -288.8602 | 173 | -44.0000 | -375.5297 | 25106005 | 753.48% |

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 148179 | 118682 | -364.6394 | 681 | -44.0000 | -375.5297 | 25235746 | 753.48% |
| 148895 | 118808 | -45.9513  | 35  | -44.0000 | -375.5297 | 25239563 | 753.48% |
| 149564 | 117128 | -102.2161 | 125 | -44.0000 | -375.5297 | 25113787 | 753.48% |
| 150155 | 117500 | -250.4974 | 176 | -44.0000 | -375.5297 | 25113826 | 753.48% |
| 151053 | 117401 | -133.1193 | 72  | -44.0000 | -375.5297 | 25149498 | 753.48% |
| 152268 | 117266 | -74.6968  | 45  | -44.0000 | -375.5297 | 25133951 | 753.48% |

Elapsed time = 171.10 sec. (136215.45 ticks, tree = 5020.68 MB, solutions = 20)

Nodefile size = 2828.82 MB (2551.19 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 153265 | 117421 | -131.6317 | 86  | -44.0000 | -375.5297 | 25148312 | 753.48% |
| 153651 | 123366 | -204.8835 | 135 | -44.0000 | -375.5297 | 25710075 | 753.48% |
| 154291 | 127032 | -273.1402 | 193 | -44.0000 | -375.4562 | 26185133 | 753.31% |
| 154685 | 132699 | -230.5562 | 138 | -44.0000 | -375.4562 | 26809062 | 753.31% |
| 155410 | 135455 | -86.7902  | 48  | -44.0000 | -375.0224 | 27113648 | 752.32% |
| 156010 | 135713 | -353.6035 | 369 | -44.0000 | -374.9424 | 27159569 | 752.14% |
| 156428 | 136562 | -373.1474 | 752 | -44.0000 | -374.9424 | 27240959 | 752.14% |
| 156856 | 136991 | -207.2019 | 119 | -44.0000 | -374.9424 | 27278840 | 752.14% |
| 157325 | 137622 | -282.8151 | 202 | -44.0000 | -374.6467 | 27376398 | 751.47% |
| 157554 | 137746 | -361.1068 | 365 | -44.0000 | -374.6467 | 27400626 | 751.47% |

Elapsed time = 229.01 sec. (174835.59 ticks, tree = 6750.00 MB, solutions = 20)

Nodefile size = 4694.67 MB (4271.79 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 158142 | 137958 | -121.8675 | 82  | -44.0000 | -374.6467 | 27423219 | 751.47% |
| 158452 | 138468 | -76.5513  | 58  | -44.0000 | -374.3973 | 27479789 | 750.90% |
| 158893 | 138456 | -347.6235 | 270 | -44.0000 | -374.3973 | 27513832 | 750.90% |
| 159308 | 139453 | -83.8846  | 50  | -44.0000 | -374.3973 | 27639581 | 750.90% |
| 159480 | 139089 | -351.9897 | 348 | -44.0000 | -374.2840 | 27601366 | 750.65% |
| 159932 | 140136 | -288.8156 | 190 | -44.0000 | -374.2840 | 27773711 | 750.65% |
| 160342 | 139970 | -351.9906 | 293 | -44.0000 | -374.2840 | 27751169 | 750.65% |
| 161057 | 140601 | -366.0149 | 640 | -44.0000 | -374.2840 | 27867684 | 750.65% |
| 162160 | 140791 | -223.6580 | 127 | -44.0000 | -374.2101 | 27879510 | 750.48% |
| 163097 | 142224 | -222.4034 | 148 | -44.0000 | -374.1965 | 28026597 | 750.45% |

Elapsed time = 278.81 sec. (213139.08 ticks, tree = 6770.20 MB, solutions = 20)

Nodefile size = 4714.67 MB (4281.11 MB after compression)

|        |        |            |     |          |           |          |         |
|--------|--------|------------|-----|----------|-----------|----------|---------|
| 163912 | 142512 | infeasible |     | -44.0000 | -374.1965 | 28049351 | 750.45% |
| 164581 | 143728 | -93.8205   | 59  | -44.0000 | -374.0908 | 28152876 | 750.21% |
| 165350 | 144119 | -79.5072   | 47  | -44.0000 | -374.0698 | 28225664 | 750.16% |
| 165945 | 144892 | -229.1467  | 130 | -44.0000 | -374.0698 | 28296508 | 750.16% |
| 166536 | 145100 | -279.1562  | 190 | -44.0000 | -374.0698 | 28313847 | 750.16% |
| 167263 | 145224 | -248.0966  | 153 | -44.0000 | -374.0500 | 28324091 | 750.11% |
| 167930 | 146403 | -350.6970  | 275 | -44.0000 | -373.9883 | 28442310 | 749.97% |

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 168968 | 146615 | -100.5712 | 70  | -44.0000 | -373.9312 | 28450581 | 749.84% |
| 169395 | 147938 | -355.1343 | 366 | -44.0000 | -373.9312 | 28581082 | 749.84% |
| 170326 | 148098 | -257.4100 | 169 | -44.0000 | -373.9312 | 28588582 | 749.84% |

Elapsed time = 328.74 sec. (251329.20 ticks, tree = 6859.09 MB, solutions = 20)

Nodefile size = 4790.43 MB (4339.89 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 170842 | 148288 | -349.1396 | 362 | -44.0000 | -373.9124 | 28607750 | 749.80% |
| 171150 | 149503 | -320.2788 | 218 | -44.0000 | -373.9124 | 28727565 | 749.80% |
| 171832 | 149966 | -350.6827 | 359 | -44.0000 | -373.8929 | 28794113 | 749.76% |
| 172192 | 150174 | -170.2027 | 122 | -44.0000 | -373.8929 | 28843720 | 749.76% |
| 172580 | 149983 | -359.4415 | 786 | -44.0000 | -373.8929 | 28820435 | 749.76% |
| 172880 | 151136 | -335.9286 | 284 | -44.0000 | -373.8929 | 28944854 | 749.76% |
| 173494 | 151420 | -241.2605 | 162 | -44.0000 | -373.8929 | 28978189 | 749.76% |
| 173961 | 151599 | -79.5849  | 38  | -44.0000 | -373.8929 | 29002456 | 749.76% |
| 174586 | 152338 | -361.9703 | 801 | -44.0000 | -373.8929 | 29088367 | 749.76% |
| 175313 | 152491 | -326.2307 | 218 | -44.0000 | -373.8929 | 29085315 | 749.76% |

Elapsed time = 380.88 sec. (289676.74 ticks, tree = 7073.81 MB, solutions = 20)

Nodefile size = 4990.52 MB (4516.97 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 176015 | 152689 | -289.1985 | 182 | -44.0000 | -373.8929 | 29144336 | 749.76% |
| 176855 | 154160 | -77.4398  | 37  | -44.0000 | -373.8929 | 29266758 | 749.76% |
| 177448 | 154194 | -290.7869 | 193 | -44.0000 | -373.8929 | 29274335 | 749.76% |
| 177800 | 155086 | -352.6978 | 552 | -44.0000 | -373.8929 | 29417626 | 749.76% |
| 178144 | 155126 | -277.9166 | 175 | -44.0000 | -373.8929 | 29427343 | 749.76% |
| 178488 | 155853 | -325.1799 | 217 | -44.0000 | -373.6771 | 29539764 | 749.27% |
| 178978 | 155690 | -227.7448 | 269 | -44.0000 | -373.6771 | 29534376 | 749.27% |
| 179678 | 156294 | -172.5863 | 99  | -44.0000 | -373.6130 | 29606670 | 749.12% |
| 180144 | 157102 | -355.1944 | 657 | -44.0000 | -373.6099 | 29747844 | 749.11% |
| 180869 | 157097 | -338.7220 | 212 | -44.0000 | -373.5628 | 29743077 | 749.01% |

Elapsed time = 433.30 sec. (328264.55 ticks, tree = 7285.22 MB, solutions = 20)

Nodefile size = 5230.30 MB (4731.06 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 181719 | 157876 | -303.7777 | 268 | -44.0000 | -373.5628 | 29865351 | 749.01% |
| 182794 | 159272 | -237.1395 | 147 | -44.0000 | -373.5628 | 29984307 | 749.01% |
| 183348 | 159346 | -351.1395 | 663 | -44.0000 | -373.5628 | 30006348 | 749.01% |
| 184056 | 160314 | -367.6314 | 687 | -44.0000 | -373.4833 | 30086392 | 748.83% |
| 184762 | 160989 | -99.2792  | 65  | -44.0000 | -373.4409 | 30149317 | 748.73% |
| 185495 | 161553 | -357.1583 | 641 | -44.0000 | -373.4409 | 30227053 | 748.73% |
| 186459 | 162127 | -156.6030 | 90  | -44.0000 | -373.4409 | 30284992 | 748.73% |
| 187261 | 161936 | -61.7549  | 32  | -44.0000 | -373.3481 | 30259262 | 748.52% |
| 188114 | 162740 | -73.0164  | 36  | -44.0000 | -373.3443 | 30325642 | 748.51% |
| 189070 | 163956 | -152.9141 | 96  | -44.0000 | -373.3443 | 30438865 | 748.51% |

Elapsed time = 486.25 sec. (367163.04 ticks, tree = 7512.82 MB, solutions = 20)

Nodefile size = 5447.40 MB (4922.11 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 189644 | 164386 | -367.8376 | 887 | -44.0000 | -373.3443 | 30477271 | 748.51% |
| 190685 | 164981 | -87.2124  | 61  | -44.0000 | -373.3443 | 30514247 | 748.51% |
| 191184 | 166418 | -333.6920 | 221 | -44.0000 | -373.3443 | 30646990 | 748.51% |
| 192458 | 166950 | -208.3170 | 120 | -44.0000 | -373.3443 | 30699405 | 748.51% |
| 193547 | 167529 | -198.3154 | 118 | -44.0000 | -373.3443 | 30739547 | 748.51% |
| 194774 | 168011 | -168.6088 | 199 | -44.0000 | -373.2787 | 30794964 | 748.36% |
| 195925 | 168908 | -142.5090 | 148 | -44.0000 | -373.2427 | 30835364 | 748.28% |
| 196620 | 171308 | -224.7571 | 158 | -44.0000 | -373.2408 | 30997697 | 748.27% |
| 197264 | 171376 | -371.6623 | 716 | -44.0000 | -373.2408 | 31005841 | 748.27% |
| 198034 | 171635 | -208.1538 | 134 | -44.0000 | -373.2055 | 31055553 | 748.19% |

Elapsed time = 539.69 sec. (405452.81 ticks, tree = 7961.62 MB, solutions = 20)

Nodefile size = 5907.38 MB (5338.30 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 198412 | 172029 | -289.5103 | 235 | -44.0000 | -373.2055 | 31095374 | 748.19% |
| 198962 | 172723 | -143.3916 | 95  | -44.0000 | -373.2055 | 31160733 | 748.19% |
| 199414 | 172871 | -308.1767 | 199 | -44.0000 | -373.2055 | 31188479 | 748.19% |
| 200445 | 174277 | -67.7922  | 28  | -44.0000 | -373.1191 | 31301581 | 748.00% |
| 201225 | 174685 | -365.1012 | 671 | -44.0000 | -373.1191 | 31351164 | 748.00% |
| 201850 | 175086 | -310.6747 | 205 | -44.0000 | -373.1191 | 31384774 | 748.00% |
| 202420 | 176028 | -299.8808 | 228 | -44.0000 | -373.1191 | 31500120 | 748.00% |
| 202989 | 176150 | -356.5293 | 345 | -44.0000 | -373.1191 | 31508469 | 748.00% |
| 203966 | 177277 | -349.3249 | 252 | -44.0000 | -373.1191 | 31616486 | 748.00% |
| 204804 | 177320 | -351.0572 | 257 | -44.0000 | -373.0455 | 31638301 | 747.83% |

Elapsed time = 590.71 sec. (444013.14 ticks, tree = 8114.88 MB, solutions = 20)

Nodefile size = 6058.27 MB (5468.92 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 205628 | 178179 | -111.3682 | 81  | -44.0000 | -373.0143 | 31717251 | 747.76% |
| 206144 | 178259 | -197.6408 | 123 | -44.0000 | -373.0143 | 31727454 | 747.76% |
| 206619 | 178812 | -178.9469 | 189 | -44.0000 | -372.9949 | 31789311 | 747.72% |
| 207249 | 179762 | -363.1710 | 818 | -44.0000 | -372.9899 | 31871857 | 747.70% |
| 207745 | 180890 | -212.8827 | 131 | -44.0000 | -372.9899 | 32040405 | 747.70% |
| 208953 | 181296 | -86.9530  | 56  | -44.0000 | -372.9899 | 32078113 | 747.70% |
| 209931 | 181837 | -93.0117  | 192 | -44.0000 | -372.9480 | 32163706 | 747.61% |
| 210844 | 182022 | -195.7135 | 130 | -44.0000 | -372.9480 | 32157809 | 747.61% |
| 211479 | 182394 | -336.0640 | 243 | -44.0000 | -372.8824 | 32214463 | 747.46% |
| 211879 | 183270 | -333.1627 | 209 | -44.0000 | -372.8748 | 32262683 | 747.44% |

Elapsed time = 646.29 sec. (482797.42 ticks, tree = 8350.07 MB, solutions = 20)

Nodefile size = 6294.05 MB (5672.22 MB after compression)

|        |        |           |      |          |           |          |         |
|--------|--------|-----------|------|----------|-----------|----------|---------|
| 212147 | 184598 | -363.4645 | 1062 | -44.0000 | -372.8748 | 32370505 | 747.44% |
|--------|--------|-----------|------|----------|-----------|----------|---------|

|        |        |           |      |          |           |          |         |
|--------|--------|-----------|------|----------|-----------|----------|---------|
| 212919 | 185068 | -288.2498 | 184  | -44.0000 | -372.8748 | 32431657 | 747.44% |
| 214028 | 185646 | -210.1929 | 142  | -44.0000 | -372.8748 | 32487431 | 747.44% |
| 214899 | 185756 | -200.4004 | 137  | -44.0000 | -372.8600 | 32475142 | 747.41% |
| 215323 | 186568 | -146.7879 | 101  | -44.0000 | -372.8563 | 32572067 | 747.40% |
| 215585 | 186646 | -265.0594 | 174  | -44.0000 | -372.8430 | 32582774 | 747.37% |
| 215930 | 186866 | -296.3604 | 233  | -44.0000 | -372.8430 | 32646715 | 747.37% |
| 216342 | 188005 | -368.3260 | 1030 | -44.0000 | -372.8430 | 32726916 | 747.37% |
| 216864 | 188736 | -183.1399 | 110  | -44.0000 | -372.8430 | 32848795 | 747.37% |
| 217090 | 189090 | -331.5462 | 245  | -44.0000 | -372.8430 | 32903193 | 747.37% |

Elapsed time = 697.47 sec. (521071.74 ticks, tree = 8599.97 MB, solutions = 20)

Nodefile size = 6544.44 MB (5890.61 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 217790 | 188686 | -323.9812 | 247 | -44.0000 | -372.8014 | 32870258 | 747.28% |
| 218356 | 189541 | -133.4137 | 76  | -44.0000 | -372.7773 | 32936831 | 747.22% |
| 219174 | 190551 | -351.0221 | 300 | -44.0000 | -372.7773 | 33038249 | 747.22% |
| 219578 | 190300 | -368.7349 | 934 | -44.0000 | -372.7684 | 33027649 | 747.20% |
| 219598 | 190825 | -355.7343 | 627 | -44.0000 | -372.7631 | 33100093 | 747.19% |
| 219718 | 191769 | -139.0102 | 86  | -44.0000 | -372.7377 | 33251637 | 747.13% |
| 220184 | 191764 | -131.8059 | 121 | -44.0000 | -372.7377 | 33230928 | 747.13% |
| 221011 | 192191 | -217.5934 | 136 | -44.0000 | -372.7272 | 33365455 | 747.11% |
| 221677 | 192658 | -312.0576 | 207 | -44.0000 | -372.7272 | 33417939 | 747.11% |
| 222408 | 192605 | -131.1298 | 82  | -44.0000 | -372.6994 | 33406887 | 747.04% |

Elapsed time = 751.00 sec. (560245.75 ticks, tree = 8875.72 MB, solutions = 20)

Nodefile size = 6819.28 MB (6143.16 MB after compression)

|        |        |           |      |          |           |          |         |
|--------|--------|-----------|------|----------|-----------|----------|---------|
| 222807 | 193252 | -351.8520 | 359  | -44.0000 | -372.6994 | 33474914 | 747.04% |
| 223697 | 193819 | -368.2402 | 1014 | -44.0000 | -372.6705 | 33555864 | 746.98% |
| 224291 | 194508 | -168.4572 | 113  | -44.0000 | -372.6705 | 33597439 | 746.98% |
| 224688 | 194980 | -328.9159 | 330  | -44.0000 | -372.6705 | 33680048 | 746.98% |
| 225604 | 195221 | -350.0778 | 362  | -44.0000 | -372.6431 | 33710002 | 746.92% |
| 226659 | 196294 | -277.8216 | 183  | -44.0000 | -372.6029 | 33779087 | 746.82% |
| 227209 | 195824 | -306.6847 | 195  | -44.0000 | -372.6029 | 33766707 | 746.82% |
| 228433 | 197223 | -367.8317 | 689  | -44.0000 | -372.5677 | 33854373 | 746.74% |
| 229269 | 199080 | -361.1116 | 655  | -44.0000 | -372.5534 | 34022057 | 746.71% |
| 230336 | 199294 | -175.2973 | 112  | -44.0000 | -372.5531 | 34046870 | 746.71% |

Elapsed time = 804.93 sec. (599059.75 ticks, tree = 9113.38 MB, solutions = 20)

Nodefile size = 7058.01 MB (6351.40 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 231216 | 200588 | -358.3446 | 489 | -44.0000 | -372.5531 | 34129659 | 746.71% |
| 231583 | 200216 | -268.3678 | 255 | -44.0000 | -372.5531 | 34115070 | 746.71% |
| 232305 | 201798 | -46.5832  | 26  | -44.0000 | -372.5531 | 34219507 | 746.71% |
| 233137 | 202370 | -185.0193 | 120 | -44.0000 | -372.5031 | 34307455 | 746.60% |

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 234418 | 201984 | -225.0413 | 192 | -44.0000 | -372.4962 | 34280003 | 746.58% |
| 235315 | 203798 | -343.5671 | 300 | -44.0000 | -372.4823 | 34427805 | 746.55% |
| 235540 | 203201 | -194.1673 | 132 | -44.0000 | -372.4823 | 34396450 | 746.55% |
| 236303 | 204300 | -90.3678  | 54  | -44.0000 | -372.4732 | 34472118 | 746.53% |
| 236745 | 204491 | -353.6942 | 922 | -44.0000 | -372.4732 | 34519696 | 746.53% |
| 237725 | 205433 | -362.9104 | 718 | -44.0000 | -372.4587 | 34591948 | 746.50% |

Elapsed time = 858.28 sec. (637821.53 ticks, tree = 9338.06 MB, solutions = 20)

Nodefile size = 7269.93 MB (6536.27 MB after compression)

|        |        |           |      |          |           |          |         |
|--------|--------|-----------|------|----------|-----------|----------|---------|
| 238274 | 205925 | -85.8155  | 50   | -44.0000 | -372.4587 | 34647302 | 746.50% |
| 238981 | 207487 | -231.9881 | 149  | -44.0000 | -372.3994 | 34779028 | 746.36% |
| 239878 | 207765 | -93.4593  | 61   | -44.0000 | -372.3994 | 34786500 | 746.36% |
| 240120 | 207756 | -365.9616 | 411  | -44.0000 | -372.3994 | 34822268 | 746.36% |
| 240478 | 209365 | -199.8041 | 130  | -44.0000 | -372.3584 | 34940305 | 746.27% |
| 240821 | 209539 | -360.1367 | 638  | -44.0000 | -372.3584 | 34972410 | 746.27% |
| 241271 | 209541 | -363.1588 | 1122 | -44.0000 | -372.3584 | 34983161 | 746.27% |
| 241424 | 210053 | -361.2374 | 950  | -44.0000 | -372.3584 | 35084084 | 746.27% |
| 241576 | 210292 | -347.5688 | 297  | -44.0000 | -372.3584 | 35112261 | 746.27% |
| 241997 | 210422 | -368.2257 | 1017 | -44.0000 | -372.3584 | 35145629 | 746.27% |

Elapsed time = 912.88 sec. (676882.31 ticks, tree = 9709.04 MB, solutions = 20)

Nodefile size = 7655.42 MB (6887.57 MB after compression)

|        |        |           |      |          |           |          |         |
|--------|--------|-----------|------|----------|-----------|----------|---------|
| 242245 | 210584 | -240.9517 | 157  | -44.0000 | -372.3584 | 35171767 | 746.27% |
| 242570 | 210687 | -338.0566 | 350  | -44.0000 | -372.3584 | 35275535 | 746.27% |
| 243231 | 210809 | -332.0380 | 238  | -44.0000 | -372.2883 | 35284325 | 746.11% |
| 243525 | 211377 | -366.4540 | 682  | -44.0000 | -372.2883 | 35363030 | 746.11% |
| 243864 | 211549 | -332.6650 | 319  | -44.0000 | -372.2883 | 35413331 | 746.11% |
| 244343 | 212034 | -284.4207 | 206  | -44.0000 | -372.2542 | 35461002 | 746.03% |
| 244916 | 211665 | -371.1470 | 1019 | -44.0000 | -372.2542 | 35425781 | 746.03% |
| 245241 | 213063 | -339.6566 | 564  | -44.0000 | -372.2542 | 35635322 | 746.03% |
| 245969 | 213431 | -346.9792 | 377  | -44.0000 | -372.2542 | 35676293 | 746.03% |
| 246514 | 214170 | -356.2338 | 419  | -44.0000 | -372.2542 | 35731859 | 746.03% |

Elapsed time = 966.08 sec. (716168.10 ticks, tree = 9727.48 MB, solutions = 20)

Nodefile size = 7670.55 MB (6894.27 MB after compression)

|        |        |           |      |          |           |          |         |
|--------|--------|-----------|------|----------|-----------|----------|---------|
| 247304 | 214362 | -248.7154 | 181  | -44.0000 | -372.1984 | 35793183 | 745.91% |
| 247544 | 214195 | -368.2592 | 1074 | -44.0000 | -372.1984 | 35773514 | 745.91% |
| 248320 | 215215 | -339.6080 | 224  | -44.0000 | -372.1984 | 35912774 | 745.91% |
| 248943 | 215127 | -219.3915 | 150  | -44.0000 | -372.1939 | 35887771 | 745.90% |
| 249564 | 215696 | -329.7974 | 226  | -44.0000 | -372.1939 | 35961847 | 745.90% |
| 250132 | 216976 | -264.5542 | 167  | -44.0000 | -372.1916 | 36040514 | 745.89% |
| 250395 | 216722 | -370.6489 | 959  | -44.0000 | -372.1916 | 36031786 | 745.89% |



Performing restart 2

Repeating presolve.

Tried aggregator 1 time.

Reduced MIP has 3556 rows, 5459 columns, and 23781 nonzeros.

Reduced MIP has 4603 binaries, 51 generals, 0 SOSs, and 0 indicators.

Presolve time = 0.01 sec. (12.05 ticks)

Tried aggregator 1 time.

Reduced MIP has 3556 rows, 5459 columns, and 23781 nonzeros.

Reduced MIP has 4603 binaries, 51 generals, 0 SOSs, and 0 indicators.

Presolve time = 0.02 sec. (16.72 ticks)

Represolve time = 1.99 sec. (423.12 ticks)

|        |   |           |      |          |                    |         |
|--------|---|-----------|------|----------|--------------------|---------|
| 250594 | 0 | -385.6923 | 1361 | -44.0000 | Cuts: 281 36368218 | 745.89% |
| 250594 | 0 | -385.5894 | 1250 | -44.0000 | Cuts: 88 36373095  | 745.89% |
| 250594 | 0 | -385.5320 | 1275 | -44.0000 | Cuts: 631 36377740 | 745.89% |
| 250594 | 0 | -385.4713 | 1249 | -44.0000 | Cuts: 545 36381282 | 745.89% |
| 250594 | 0 | -385.4204 | 1259 | -44.0000 | Cuts: 957 36387163 | 745.89% |
| 250594 | 0 | -385.3847 | 1222 | -44.0000 | Cuts: 654 36390902 | 745.89% |
| 250594 | 0 | -385.3577 | 1237 | -44.0000 | Cuts: 790 36394642 | 745.89% |
| 250594 | 0 | -385.3485 | 1245 | -44.0000 | Cuts: 703 36396546 | 745.89% |
| 250594 | 0 | -385.3400 | 1274 | -44.0000 | Cuts: 658 36398676 | 745.89% |
| 250594 | 2 | -385.3400 | 1250 | -44.0000 | -372.1916 36398676 | 745.89% |
| 250597 | 5 | -382.4444 | 787  | -44.0000 | -372.1916 36411834 | 745.89% |
| 250602 | 9 | -380.3559 | 797  | -44.0000 | -372.1916 36423958 | 745.89% |

Elapsed time = 1108.28 sec. (855683.12 ticks, tree = 0.02 MB, solutions = 20)

|        |     |           |     |          |                    |         |
|--------|-----|-----------|-----|----------|--------------------|---------|
| 250611 | 6   | -378.8050 | 657 | -44.0000 | -372.1916 36417553 | 745.89% |
| 250635 | 35  | -376.0446 | 672 | -44.0000 | -372.1916 36531095 | 745.89% |
| 250672 | 68  | -370.5626 | 763 | -44.0000 | -372.1916 36616128 | 745.89% |
| 250694 | 92  | -371.9434 | 943 | -44.0000 | -372.1916 36701820 | 745.89% |
| 250721 | 118 | -362.8932 | 629 | -44.0000 | -372.1916 36801968 | 745.89% |
| 250761 | 125 | -361.9080 | 779 | -44.0000 | -372.1916 36885878 | 745.89% |
| 250789 | 184 | -368.8459 | 821 | -44.0000 | -372.1916 37004980 | 745.89% |
| 250841 | 217 | -339.4235 | 586 | -44.0000 | -372.1916 37066500 | 745.89% |
| 251153 | 486 | -210.0063 | 143 | -44.0000 | -372.1916 37133536 | 745.89% |
| 251322 | 495 | -364.4991 | 902 | -44.0000 | -372.1916 37206131 | 745.89% |

Elapsed time = 1152.80 sec. (895288.35 ticks, tree = 14.88 MB, solutions = 20)

|        |     |           |     |          |                    |         |
|--------|-----|-----------|-----|----------|--------------------|---------|
| 251351 | 672 | -367.3628 | 827 | -44.0000 | -372.1916 37251757 | 745.89% |
| 251394 | 715 | -364.1056 | 761 | -44.0000 | -372.1916 37328615 | 745.89% |

|        |      |           |     |          |           |          |         |
|--------|------|-----------|-----|----------|-----------|----------|---------|
| 251440 | 744  | -268.2901 | 507 | -44.0000 | -372.1916 | 37368491 | 745.89% |
| 251521 | 826  | -318.6446 | 749 | -44.0000 | -372.1916 | 37511071 | 745.89% |
| 251833 | 831  | -324.7711 | 304 | -44.0000 | -372.1916 | 37519578 | 745.89% |
| 252407 | 1017 | -289.7608 | 602 | -44.0000 | -372.1916 | 37636368 | 745.89% |
| 252474 | 1569 | -230.7063 | 364 | -44.0000 | -372.1916 | 37760627 | 745.89% |
| 252551 | 1641 | -175.7780 | 280 | -44.0000 | -372.1916 | 37815845 | 745.89% |
| 252648 | 1761 | -350.1193 | 690 | -44.0000 | -372.1916 | 37915832 | 745.89% |
| 252770 | 1798 | -297.9704 | 428 | -44.0000 | -372.1916 | 37931390 | 745.89% |

Elapsed time = 1202.91 sec. (933976.92 ticks, tree = 72.71 MB, solutions = 20)

|        |      |           |     |          |           |          |         |
|--------|------|-----------|-----|----------|-----------|----------|---------|
| 252957 | 1879 | -365.0530 | 907 | -44.0000 | -372.1916 | 38019591 | 745.89% |
| 253190 | 1961 | -374.1327 | 746 | -44.0000 | -372.1916 | 38105061 | 745.89% |
| 253209 | 2081 | -366.6955 | 727 | -44.0000 | -372.1916 | 38154827 | 745.89% |
| 253245 | 2107 | -349.4859 | 750 | -44.0000 | -372.1916 | 38232352 | 745.89% |
| 253296 | 2321 | -323.2255 | 719 | -44.0000 | -372.1916 | 38306497 | 745.89% |
| 253335 | 2350 | -338.7238 | 810 | -44.0000 | -372.1916 | 38399274 | 745.89% |
| 253431 | 2430 | -223.8642 | 266 | -44.0000 | -372.1916 | 38441630 | 745.89% |
| 253627 | 2511 | -375.7077 | 894 | -44.0000 | -372.1916 | 38536324 | 745.89% |
| 253710 | 2600 | -267.8143 | 648 | -44.0000 | -372.1916 | 38634838 | 745.89% |
| 253859 | 2807 | -130.4952 | 121 | -44.0000 | -372.1916 | 38706683 | 745.89% |

Elapsed time = 1250.04 sec. (972969.48 ticks, tree = 103.61 MB, solutions = 20)

|        |      |           |     |          |           |          |         |
|--------|------|-----------|-----|----------|-----------|----------|---------|
| 253990 | 2793 | -354.1329 | 866 | -44.0000 | -372.1916 | 38772365 | 745.89% |
| 254125 | 2847 | -378.1667 | 932 | -44.0000 | -372.1916 | 38821293 | 745.89% |
| 254160 | 3057 | -345.8537 | 710 | -44.0000 | -372.1916 | 38991676 | 745.89% |
| 254272 | 3174 | -338.3096 | 397 | -44.0000 | -372.1916 | 39057856 | 745.89% |
| 254829 | 3402 | -355.6737 | 381 | -44.0000 | -372.1916 | 39162730 | 745.89% |
| 255039 | 3352 | -378.1796 | 878 | -44.0000 | -372.1916 | 39140890 | 745.89% |
| 255759 | 3966 | -377.3962 | 848 | -44.0000 | -372.1916 | 39289058 | 745.89% |
| 256132 | 4683 | -376.0871 | 913 | -44.0000 | -372.1916 | 39411724 | 745.89% |
| 256571 | 4897 | -110.1847 | 135 | -44.0000 | -372.1916 | 39448784 | 745.89% |
| 256899 | 5006 | -264.7572 | 206 | -44.0000 | -372.1916 | 39493263 | 745.89% |

Elapsed time = 1299.80 sec. (1011923.48 ticks, tree = 185.99 MB, solutions = 20)

|        |      |           |     |          |           |          |         |
|--------|------|-----------|-----|----------|-----------|----------|---------|
| 257633 | 5503 | -108.6815 | 304 | -44.0000 | -372.1916 | 39551337 | 745.89% |
| 257704 | 5875 | -357.2719 | 386 | -44.0000 | -372.1916 | 39627575 | 745.89% |
| 258222 | 6596 | -269.8295 | 197 | -44.0000 | -372.1916 | 39752633 | 745.89% |
| 258860 | 6676 | -377.5047 | 795 | -44.0000 | -372.1916 | 39771980 | 745.89% |
| 259177 | 6867 | -342.8244 | 368 | -44.0000 | -372.1916 | 39847164 | 745.89% |
| 259604 | 7816 | -126.7714 | 273 | -44.0000 | -372.1916 | 39962898 | 745.89% |
| 259992 | 8066 | -346.3133 | 285 | -44.0000 | -372.1916 | 40043650 | 745.89% |
| 260634 | 8324 | -250.4738 | 183 | -44.0000 | -372.1916 | 40101264 | 745.89% |

|  |       |           |      |          |           |          |         |
|--|-------|-----------|------|----------|-----------|----------|---------|
| 261423   | 8587  | -117.3785 | 72   | -44.0000 | -372.1916 | 40156633 | 745.89% |
| 261811   | 8623  | cutoff    |      | -44.0000 | -372.1916 | 40168545 | 745.89% |
| Elapsed time = 1345.55 sec. (1050174.00 ticks, tree = 360.71 MB, solutions = 20) |       |           |      |          |           |          |         |
| 262463   | 9727  | -346.0636 | 360  | -44.0000 | -372.1916 | 40305990 | 745.89% |
| 262827   | 10015 | -53.0047  | 53   | -44.0000 | -372.1916 | 40336812 | 745.89% |
| 263497   | 10204 | -291.6292 | 329  | -44.0000 | -372.1916 | 40409727 | 745.89% |
| 263810   | 10834 | -368.7024 | 900  | -44.0000 | -372.1916 | 40508382 | 745.89% |
| 264034   | 11380 | -299.6250 | 270  | -44.0000 | -372.1916 | 40589629 | 745.89% |
| 264353   | 11408 | -333.6570 | 364  | -44.0000 | -372.1916 | 40631990 | 745.89% |
| 265209   | 11627 | -127.5949 | 81   | -44.0000 | -372.1916 | 40690974 | 745.89% |
| 265375   | 12058 | -373.9214 | 775  | -44.0000 | -372.1916 | 40825316 | 745.89% |
| 265683   | 12067 | -374.6869 | 871  | -44.0000 | -372.1916 | 40813199 | 745.89% |
| 266145   | 12871 | -108.7038 | 66   | -44.0000 | -372.1916 | 40958008 | 745.89% |
| Elapsed time = 1392.76 sec. (1089307.50 ticks, tree = 376.25 MB, solutions = 20) |       |           |      |          |           |          |         |
| 267009   | 13160 | -339.9349 | 292  | -44.0000 | -372.1916 | 41042304 | 745.89% |
| 267684   | 13451 | -235.2024 | 155  | -44.0000 | -372.1916 | 41068056 | 745.89% |
| 268135   | 14202 | -301.8026 | 239  | -44.0000 | -372.1916 | 41179259 | 745.89% |
| 269063   | 14802 | -332.9360 | 201  | -44.0000 | -372.1916 | 41233945 | 745.89% |
| 269908   | 15031 | -151.4007 | 185  | -44.0000 | -372.1916 | 41298728 | 745.89% |
| 270417   | 15902 | -355.9540 | 424  | -44.0000 | -372.1916 | 41379785 | 745.89% |
| 271179   | 15998 | -182.1055 | 124  | -44.0000 | -372.1916 | 41374578 | 745.89% |
| 271618   | 16779 | -343.4644 | 297  | -44.0000 | -372.1916 | 41483634 | 745.89% |
| 272154   | 17272 | -266.0548 | 154  | -44.0000 | -372.1916 | 41561427 | 745.89% |
| 272757   | 17853 | -107.8635 | 54   | -44.0000 | -372.1916 | 41620379 | 745.89% |
| Elapsed time = 1441.86 sec. (1127546.03 ticks, tree = 531.02 MB, solutions = 20) |       |           |      |          |           |          |         |
| 273371   | 18302 | -282.6906 | 198  | -44.0000 | -372.1916 | 41702255 | 745.89% |
| 274130   | 18595 | -244.6982 | 252  | -44.0000 | -372.1916 | 41749235 | 745.89% |
| 274538   | 18916 | -352.0270 | 368  | -44.0000 | -372.1916 | 41810597 | 745.89% |
| 275533   | 19350 | -242.7152 | 146  | -44.0000 | -372.1916 | 41846033 | 745.89% |
| 276032   | 19990 | -54.5599  | 49   | -44.0000 | -372.1916 | 41908637 | 745.89% |
| 276526   | 20374 | -115.2920 | 72   | -44.0000 | -372.1916 | 41972219 | 745.89% |
| 277076   | 21354 | -362.0541 | 532  | -44.0000 | -372.1916 | 42106109 | 745.89% |
| 277609   | 20404 | -368.4605 | 1077 | -44.0000 | -372.1916 | 41979761 | 745.89% |
| 278059   | 22108 | -337.7553 | 273  | -44.0000 | -372.1916 | 42232415 | 745.89% |
| 278647   | 22119 | -320.3121 | 220  | -44.0000 | -372.1916 | 42214941 | 745.89% |
| Elapsed time = 1491.47 sec. (1166019.37 ticks, tree = 615.31 MB, solutions = 20) |       |           |      |          |           |          |         |
| 279632   | 23591 | -334.9430 | 280  | -44.0000 | -372.1916 | 42392818 | 745.89% |
| 280126   | 23804 | -128.5027 | 69   | -44.0000 | -372.1916 | 42401404 | 745.89% |
| 280920   | 23955 | -138.4359 | 120  | -44.0000 | -372.1916 | 42477580 | 745.89% |

|   |       |           |     |          |           |          |         |
|---|-------|-----------|-----|----------|-----------|----------|---------|
| 281437  | 24950 | -129.1561 | 99  | -44.0000 | -372.1916 | 42575431 | 745.89% |
| 281989  | 25082 | -134.7455 | 71  | -44.0000 | -372.1916 | 42585611 | 745.89% |
| 282711  | 25369 | -371.6460 | 532 | -44.0000 | -372.1916 | 42618193 | 745.89% |
| 283322  | 26147 | -343.3787 | 304 | -44.0000 | -372.1916 | 42729297 | 745.89% |
| 284664  | 26732 | -334.3227 | 329 | -44.0000 | -372.1916 | 42818857 | 745.89% |
| 285866  | 26665 | -363.2964 | 860 | -44.0000 | -372.1916 | 42775391 | 745.89% |
| 286482  | 28580 | -247.8636 | 167 | -44.0000 | -372.1916 | 42941939 | 745.89% |
| Elapsed time = 1539.98 sec. (1204311.03 ticks, tree = 860.28 MB, solutions = 20)  |       |           |     |          |           |          |         |
| 287505  | 28813 | -299.1811 | 243 | -44.0000 | -372.0951 | 42963649 | 745.67% |
| 288523  | 29633 | -250.3703 | 162 | -44.0000 | -372.0110 | 43033224 | 745.48% |
| 289106  | 30046 | -295.2430 | 201 | -44.0000 | -372.0110 | 43069346 | 745.48% |
| 289455  | 30190 | -192.9309 | 112 | -44.0000 | -372.0040 | 43074509 | 745.46% |
| 289993  | 31045 | -141.5293 | 173 | -44.0000 | -372.0040 | 43163423 | 745.46% |
| 290206  | 31157 | -348.8130 | 419 | -44.0000 | -371.9483 | 43202763 | 745.34% |
| 290699  | 31651 | -341.1091 | 335 | -44.0000 | -371.9469 | 43228780 | 745.33% |
| 291317  | 32466 | -341.1582 | 315 | -44.0000 | -371.9469 | 43373635 | 745.33% |
| 291837  | 32743 | -352.7835 | 540 | -44.0000 | -371.6923 | 43438115 | 744.76% |
| 292068  | 32468 | -351.9463 | 516 | -44.0000 | -371.6923 | 43398040 | 744.76% |
| Elapsed time = 1589.93 sec. (1242794.09 ticks, tree = 1076.94 MB, solutions = 20) |       |           |     |          |           |          |         |
| 292671  | 33486 | -239.0993 | 208 | -44.0000 | -371.6923 | 43533295 | 744.76% |
| 292992  | 33266 | -363.6098 | 582 | -44.0000 | -371.6923 | 43504347 | 744.76% |
| 293493  | 33938 | -118.9946 | 101 | -44.0000 | -371.5623 | 43606836 | 744.46% |
| 293974  | 34166 | -353.3337 | 727 | -44.0000 | -371.5062 | 43668357 | 744.33% |
| 294519  | 34909 | -280.2416 | 186 | -44.0000 | -371.5062 | 43776237 | 744.33% |
| 295353  | 35538 | -189.7857 | 111 | -44.0000 | -371.2609 | 43849416 | 743.77% |
| 295790  | 35885 | -52.6185  | 40  | -44.0000 | -371.2083 | 43882368 | 743.66% |
| 296289  | 35883 | -314.7165 | 258 | -44.0000 | -371.2083 | 43920204 | 743.66% |
| 296578  | 35201 | -354.8640 | 645 | -44.0000 | -371.2083 | 43857528 | 743.66% |
| 296765  | 36460 | -354.9554 | 528 | -44.0000 | -371.2083 | 44019420 | 743.66% |
| Elapsed time = 1642.27 sec. (1284198.61 ticks, tree = 1170.56 MB, solutions = 20) |       |           |     |          |           |          |         |
| 296907  | 36344 | -353.1478 | 725 | -44.0000 | -371.2083 | 44017102 | 743.66% |
| 297436  | 37190 | -175.1358 | 102 | -44.0000 | -371.2083 | 44086601 | 743.66% |
| 297836  | 37240 | -360.3308 | 492 | -44.0000 | -371.0292 | 44096222 | 743.25% |
| 298225  | 37776 | -368.8773 | 710 | -44.0000 | -371.0292 | 44237544 | 743.25% |
| 298876  | 37904 | -76.2539  | 71  | -44.0000 | -371.0292 | 44259745 | 743.25% |
| 299088  | 38497 | -366.8987 | 596 | -44.0000 | -371.0292 | 44375456 | 743.25% |
| 299492  | 38089 | -358.5517 | 265 | -44.0000 | -370.9771 | 44293705 | 743.13% |
| 300346  | 38897 | -311.8971 | 282 | -44.0000 | -370.9771 | 44428265 | 743.13% |
| 300919  | 39134 | -357.5479 | 819 | -44.0000 | -370.9771 | 44454488 | 743.13% |

|   |       |            |      |          |           |          |         |
|---|-------|------------|------|----------|-----------|----------|---------|
| 301172  | 39614 | -319.6664  | 202  | -44.0000 | -370.8041 | 44571989 | 742.74% |
| Elapsed time = 1691.83 sec. (1323114.08 ticks, tree = 1204.52 MB, solutions = 20) |       |            |      |          |           |          |         |
| 301646  | 39448 | -344.0955  | 491  | -44.0000 | -370.8041 | 44557156 | 742.74% |
| 301836  | 40335 | -103.6051  | 83   | -44.0000 | -370.8041 | 44707703 | 742.74% |
| 302225  | 40202 | -358.3735  | 487  | -44.0000 | -370.8041 | 44704677 | 742.74% |
| 302610  | 40600 | -355.9007  | 952  | -44.0000 | -370.8041 | 44777613 | 742.74% |
| 302988  | 41309 | -298.4826  | 193  | -44.0000 | -370.6520 | 44872708 | 742.39% |
| 303374  | 40766 | -283.5381  | 167  | -44.0000 | -370.6520 | 44825751 | 742.39% |
| 303891  | 41485 | -304.3835  | 215  | -44.0000 | -370.6520 | 44908146 | 742.39% |
| 304356  | 41571 | -74.9176   | 60   | -44.0000 | -370.6109 | 44934370 | 742.30% |
| 304928  | 42264 | -364.8487  | 443  | -44.0000 | -370.4962 | 45035283 | 742.04% |
| 305462  | 42397 | -359.8320  | 501  | -44.0000 | -370.4951 | 45041146 | 742.03% |
| Elapsed time = 1741.50 sec. (1361578.50 ticks, tree = 1299.40 MB, solutions = 20) |       |            |      |          |           |          |         |
| 305990  | 43081 | -87.9339   | 46   | -44.0000 | -370.4951 | 45139238 | 742.03% |
| 306368  | 43162 | -215.9043  | 149  | -44.0000 | -370.4950 | 45145034 | 742.03% |
| 307093  | 43334 | -343.6828  | 419  | -44.0000 | -370.3971 | 45170187 | 741.81% |
| 307363  | 44228 | -335.0437  | 293  | -44.0000 | -370.3971 | 45262113 | 741.81% |
| 307994  | 44774 | -209.7137  | 119  | -44.0000 | -370.3477 | 45337005 | 741.70% |
| 308082  | 44372 | -360.5717  | 1018 | -44.0000 | -370.3477 | 45292973 | 741.70% |
| 308313  | 44758 | -359.0325  | 970  | -44.0000 | -370.3477 | 45372677 | 741.70% |
| 308796  | 45146 | -329.1411  | 285  | -44.0000 | -370.2988 | 45421832 | 741.59% |
| 309247  | 45738 | -85.4863   | 51   | -44.0000 | -370.2988 | 45556907 | 741.59% |
| 309734  | 46020 | -367.5729  | 426  | -44.0000 | -370.2988 | 45588630 | 741.59% |
| Elapsed time = 1792.12 sec. (1401098.88 ticks, tree = 1498.55 MB, solutions = 20) |       |            |      |          |           |          |         |
| 310298  | 46140 | -357.3188  | 1014 | -44.0000 | -370.1730 | 45686049 | 741.30% |
| 310880  | 46723 | -313.9365  | 262  | -44.0000 | -370.0978 | 45733688 | 741.13% |
| 311618  | 47314 | -351.6886  | 376  | -44.0000 | -370.0978 | 45815752 | 741.13% |
| 312071  | 47781 | -268.8162  | 238  | -44.0000 | -370.0978 | 45873219 | 741.13% |
| 312444  | 47505 | -244.1141  | 152  | -44.0000 | -370.0978 | 45846117 | 741.13% |
| 313037  | 48077 | -223.3538  | 252  | -44.0000 | -370.0978 | 45934014 | 741.13% |
| 313489  | 48766 | -231.3842  | 174  | -44.0000 | -370.0978 | 45982195 | 741.13% |
| 314106  | 49110 | -286.7892  | 161  | -44.0000 | -369.8680 | 46027720 | 740.61% |
| 314277  | 49227 | -352.6875  | 410  | -44.0000 | -369.7946 | 46049462 | 740.44% |
| 315052  | 49499 | -356.5130  | 502  | -44.0000 | -369.7890 | 46093606 | 740.43% |
| Elapsed time = 1844.27 sec. (1439867.53 ticks, tree = 1727.94 MB, solutions = 20) |       |            |      |          |           |          |         |
| 315430  | 50490 | infeasible |      | -44.0000 | -369.7665 | 46227867 | 740.38% |
| 315633  | 50873 | -116.4103  | 66   | -44.0000 | -369.7325 | 46279007 | 740.30% |
| 316395  | 50950 | -319.2967  | 221  | -44.0000 | -369.7325 | 46305582 | 740.30% |
| 317079  | 51065 | -360.8404  | 415  | -44.0000 | -369.6889 | 46312413 | 740.20% |

|   |       |           |      |          |           |          |         |
|---|-------|-----------|------|----------|-----------|----------|---------|
| 317677  | 51183 | -365.7037 | 1061 | -44.0000 | -369.6668 | 46348889 | 740.15% |
| 318344  | 51962 | -125.6950 | 92   | -44.0000 | -369.6668 | 46450552 | 740.15% |
| 318572  | 51990 | -368.0280 | 694  | -44.0000 | -369.6179 | 46457249 | 740.04% |
| 318765  | 52695 | -357.1016 | 1077 | -44.0000 | -369.5690 | 46541748 | 739.93% |
| 319126  | 52963 | -352.8065 | 686  | -44.0000 | -369.5690 | 46586748 | 739.93% |
| 319440  | 53430 | -260.1408 | 161  | -44.0000 | -369.5690 | 46663375 | 739.93% |
| Elapsed time = 1896.37 sec. (1479194.25 ticks, tree = 1951.39 MB, solutions = 20) |       |           |      |          |           |          |         |
| 320144  | 53982 | -234.4145 | 165  | -44.0000 | -369.5411 | 46755129 | 739.87% |
| 320530  | 53857 | -207.5893 | 175  | -44.0000 | -369.5411 | 46726581 | 739.87% |
| 320617  | 53926 | -344.9031 | 756  | -44.0000 | -369.5411 | 46789304 | 739.87% |
| 321019  | 54333 | -331.2943 | 278  | -44.0000 | -369.5411 | 46876025 | 739.87% |
| 321384  | 54728 | -330.9338 | 393  | -44.0000 | -369.4818 | 46956127 | 739.73% |
| Began writing nodes to disk (directory ./cpx6hXQcQ created)                       |       |           |      |          |           |          |         |
| 321929  | 55231 | -205.4632 | 119  | -44.0000 | -369.4596 | 47068125 | 739.68% |
| 322419  | 55580 | -324.8614 | 213  | -44.0000 | -369.4596 | 47114860 | 739.68% |
| 322789  | 55897 | -364.3820 | 405  | -44.0000 | -369.3454 | 47171636 | 739.42% |
| 323522  | 56158 | -364.5998 | 889  | -44.0000 | -369.3454 | 47201561 | 739.42% |
| 323533  | 56166 | -341.7744 | 430  | -44.0000 | -369.3454 | 47208791 | 739.42% |
| Elapsed time = 1948.33 sec. (1518462.54 ticks, tree = 2111.35 MB, solutions = 20) |       |           |      |          |           |          |         |
| Nodefile size = 58.62 MB (51.63 MB after compression)                             |       |           |      |          |           |          |         |
| 323942  | 57003 | -96.3349  | 92   | -44.0000 | -369.3155 | 47332465 | 739.35% |
| 324164  | 57093 | -340.3201 | 295  | -44.0000 | -369.3155 | 47380106 | 739.35% |
| 324358  | 57091 | -342.8492 | 664  | -44.0000 | -369.3155 | 47399665 | 739.35% |
| 324721  | 57452 | -332.6673 | 256  | -44.0000 | -369.3155 | 47485341 | 739.35% |
| 325593  | 57417 | -80.5629  | 105  | -44.0000 | -369.2700 | 47458323 | 739.25% |
| 325870  | 57756 | -344.9406 | 339  | -44.0000 | -369.2662 | 47566012 | 739.24% |
| 326635  | 58368 | -235.1431 | 177  | -44.0000 | -369.2522 | 47647462 | 739.21% |
| 326735  | 58498 | -310.1259 | 223  | -44.0000 | -369.2522 | 47686593 | 739.21% |
| 327241  | 58889 | -332.4587 | 307  | -44.0000 | -369.2522 | 47744689 | 739.21% |
| 328157  | 58732 | -348.2701 | 337  | -44.0000 | -369.2483 | 47714755 | 739.20% |
| Elapsed time = 2000.08 sec. (1556813.49 ticks, tree = 2191.10 MB, solutions = 20) |       |           |      |          |           |          |         |
| Nodefile size = 138.10 MB (121.57 MB after compression)                           |       |           |      |          |           |          |         |
| 328696  | 59366 | -349.9339 | 591  | -44.0000 | -369.2483 | 47866301 | 739.20% |
| 329258  | 59928 | -200.9429 | 112  | -44.0000 | -369.2483 | 47903916 | 739.20% |
| 330085  | 59816 | -360.8325 | 274  | -44.0000 | -369.2169 | 47888319 | 739.13% |
| 330696  | 60569 | -251.8809 | 167  | -44.0000 | -369.1513 | 47944891 | 738.98% |
| 331215  | 61510 | -350.2743 | 253  | -44.0000 | -369.1513 | 48067414 | 738.98% |
| 331643  | 61684 | -252.4282 | 148  | -44.0000 | -369.1169 | 48074972 | 738.90% |
| 332328  | 62542 | -300.0368 | 269  | -44.0000 | -369.1169 | 48153942 | 738.90% |

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 333052 | 62613 | -172.4415 | 137 | -44.0000 | -369.1169 | 48170227 | 738.90% |
| 333503 | 63456 | -273.7816 | 225 | -44.0000 | -369.0920 | 48254726 | 738.85% |
| 334319 | 64313 | -129.4382 | 75  | -44.0000 | -369.0066 | 48319508 | 738.65% |

Elapsed time = 2053.05 sec. (1595009.26 ticks, tree = 2609.90 MB, solutions = 20)

Nodefile size = 546.80 MB (482.47 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 334526 | 64366 | -353.2900 | 430 | -44.0000 | -369.0066 | 48353456 | 738.65% |
| 335096 | 64236 | -348.8633 | 383 | -44.0000 | -369.0066 | 48342110 | 738.65% |
| 335482 | 64995 | -357.2174 | 248 | -44.0000 | -369.0066 | 48410627 | 738.65% |
| 335751 | 65112 | -108.3985 | 85  | -44.0000 | -369.0066 | 48422213 | 738.65% |
| 336342 | 65566 | -342.3519 | 298 | -44.0000 | -369.0066 | 48508876 | 738.65% |
| 336872 | 65367 | -278.6137 | 218 | -44.0000 | -369.0030 | 48496547 | 738.64% |
| 337666 | 66284 | -241.4814 | 163 | -44.0000 | -369.0030 | 48624088 | 738.64% |
| 338557 | 67101 | -71.7748  | 33  | -44.0000 | -368.7571 | 48737948 | 738.08% |
| 339421 | 67550 | -280.2961 | 200 | -44.0000 | -368.7571 | 48788027 | 738.08% |
| 340094 | 67778 | -72.4334  | 62  | -44.0000 | -368.7571 | 48792340 | 738.08% |

Elapsed time = 2105.71 sec. (1633306.25 ticks, tree = 2773.62 MB, solutions = 20)

Nodefile size = 694.67 MB (612.65 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 340708 | 68252 | -89.3731  | 41  | -44.0000 | -368.7571 | 48849031 | 738.08% |
| 341145 | 68828 | -235.1402 | 140 | -44.0000 | -368.7364 | 48907267 | 738.04% |
| 342133 | 69534 | -227.6095 | 155 | -44.0000 | -368.6620 | 49008465 | 737.87% |
| 343080 | 69560 | cutoff    |     | -44.0000 | -368.6620 | 48981554 | 737.87% |
| 343436 | 70905 | -359.4257 | 669 | -44.0000 | -368.6480 | 49119605 | 737.84% |
| 344064 | 69862 | -316.9504 | 228 | -44.0000 | -368.6321 | 49055558 | 737.80% |
| 344917 | 71337 | -358.6754 | 317 | -44.0000 | -368.6321 | 49158258 | 737.80% |
| 345459 | 71450 | -241.4689 | 183 | -44.0000 | -368.5854 | 49178803 | 737.69% |
| 345806 | 72770 | -350.6402 | 414 | -44.0000 | -368.5854 | 49313002 | 737.69% |
| 346180 | 72776 | -344.2606 | 682 | -44.0000 | -368.5854 | 49334729 | 737.69% |

Elapsed time = 2158.28 sec. (1671605.97 ticks, tree = 3247.77 MB, solutions = 20)

Nodefile size = 1193.67 MB (1058.69 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 346629 | 73045 | -306.0790 | 188 | -44.0000 | -368.5714 | 49381248 | 737.66% |
| 346989 | 73311 | -326.8352 | 274 | -44.0000 | -368.5714 | 49410860 | 737.66% |
| 347251 | 73656 | -159.0263 | 107 | -44.0000 | -368.5025 | 49428784 | 737.51% |
| 347944 | 74202 | -186.4601 | 103 | -44.0000 | -368.4952 | 49535435 | 737.49% |
| 348859 | 74293 | -334.4883 | 288 | -44.0000 | -368.4952 | 49557222 | 737.49% |
| 349336 | 74834 | -85.2232  | 153 | -44.0000 | -368.4952 | 49628825 | 737.49% |
| 349792 | 75367 | -246.7459 | 197 | -44.0000 | -368.4952 | 49673306 | 737.49% |
| 350409 | 75634 | -214.3057 | 148 | -44.0000 | -368.4689 | 49693562 | 737.43% |
| 351125 | 76103 | -65.2717  | 23  | -44.0000 | -368.4689 | 49729789 | 737.43% |
| 351528 | 76502 | -121.4386 | 73  | -44.0000 | -368.4689 | 49803180 | 737.43% |

Elapsed time = 2212.26 sec. (1709831.49 ticks, tree = 3429.06 MB, solutions = 20)

Nodefile size = 1374.50 MB (1216.81 MB after compression)

|               |           |     |          |           |          |         |
|---------------|-----------|-----|----------|-----------|----------|---------|
| 351877 76695  | -210.5933 | 124 | -44.0000 | -368.3886 | 49818966 | 737.25% |
| *352083+76771 |           |     | -46.0000 | -368.3886 |          | 700.84% |
| 352358 77214  | -203.4235 | 147 | -46.0000 | -368.3886 | 49867602 | 700.84% |
| 352954 77661  | -354.4451 | 635 | -46.0000 | -368.3848 | 49922905 | 700.84% |

GUB cover cuts applied: 1479

Clique cuts applied: 53

Cover cuts applied: 4469

Implied bound cuts applied: 115

Flow cuts applied: 171

Mixed integer rounding cuts applied: 2859

Zero-half cuts applied: 135

Lift and project cuts applied: 20

Gomory fractional cuts applied: 182

Root node processing (before b&c):

Real time = 0.00 sec. (2.63 ticks)

Parallel b&c, 8 threads:

Real time = 2233.60 sec. (1733502.38 ticks)

Sync time (average) = 300.51 sec.

Wait time (average) = 0.08 sec.

-----  
Total (root+branch&cut) = 2233.60 sec. (1733505.01 ticks)

-----  
Iteration 10

Bounds on # of cuts = 8 with [3 3 2]

Error = 54 (out of 100 instances)

Accuracy = 46

Solving time = 37.2267415 min (minutes)

Accumulated time = 68.199989864 min (minutes)

Solution status code = 104

LB on error = -268.366653275

Relative objective gap = 7.007970723

Selected variables:



A\_AGE (Continuous)

PEMLR (Categorical)

Number of selected variables = 2 (1 continuous + 1 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |                    |
|--------------------------------|--------------------|
| CPXPARAM_MIP_Strategy_File     | 3                  |
| CPXPARAM_MIP_Limits_Solutions  | 1                  |
| CPXPARAM_TimeLimit             | 82308.000608154296 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800             |

| Nodes |      | Cuts/     |      |              |            |       |     |
|-------|------|-----------|------|--------------|------------|-------|-----|
| Node  | Left | Objective | IInf | Best Integer | Best Bound | ItCnt | Gap |

352957 78439      infeasible                      -46.0000           -368.3667 50058943   700.80%

Elapsed time = 0.58 sec. (13.44 ticks, tree = 3578.62 MB, solutions = 21)

Nodefile size = 1531.15 MB (1354.94 MB after compression)

|              |           |     |          |           |          |         |
|--------------|-----------|-----|----------|-----------|----------|---------|
| 352959 78441 | -355.0696 | 622 | -46.0000 | -368.3667 | 50059517 | 700.80% |
| 352960 78442 | -354.9621 | 614 | -46.0000 | -368.3667 | 50059978 | 700.80% |
| 352961 78441 | -368.1422 | 467 | -46.0000 | -368.3667 | 50059688 | 700.80% |
| 352963 78442 | -366.8929 | 459 | -46.0000 | -368.3667 | 50061062 | 700.80% |
| 352970 78443 | -364.4998 | 478 | -46.0000 | -368.3667 | 50063349 | 700.80% |
| 352991 78459 | -359.1808 | 287 | -46.0000 | -368.3667 | 50061782 | 700.80% |
| 353012 78471 | -341.2399 | 250 | -46.0000 | -368.3667 | 50062182 | 700.80% |
| 353032 78481 | -314.3891 | 241 | -46.0000 | -368.3667 | 50062713 | 700.80% |
| 353075 78464 | -352.9182 | 243 | -46.0000 | -368.3667 | 50065349 | 700.80% |
| 353290 78522 | -216.3510 | 139 | -46.0000 | -368.3667 | 50066815 | 700.80% |

Elapsed time = 5.58 sec. (3453.73 ticks, tree = 3574.72 MB, solutions = 21)

Nodefile size = 1531.15 MB (1354.94 MB after compression)

|              |           |     |          |           |          |         |
|--------------|-----------|-----|----------|-----------|----------|---------|
| 353412 78478 | -313.4469 | 240 | -46.0000 | -368.3065 | 50067622 | 700.67% |
| 353582 78573 | -120.4601 | 54  | -46.0000 | -368.3065 | 50068969 | 700.67% |
| 353756 78583 | -366.5572 | 569 | -46.0000 | -368.3065 | 50069592 | 700.67% |
| 353915 78593 | -350.4133 | 356 | -46.0000 | -368.3065 | 50071762 | 700.67% |
| 354013 78638 | -255.5095 | 182 | -46.0000 | -368.3065 | 50073098 | 700.67% |
| 354172 78670 | -225.7101 | 139 | -46.0000 | -368.3065 | 50075904 | 700.67% |
| 354385 78504 | -226.4890 | 127 | -46.0000 | -368.2929 | 50093543 | 700.64% |
| 354717 78838 | -68.3427  | 35  | -46.0000 | -368.2929 | 50076924 | 700.64% |
| 354895 78735 | -366.5307 | 385 | -46.0000 | -368.2929 | 50081410 | 700.64% |
| 355013 78725 | -358.3571 | 260 | -46.0000 | -368.2929 | 50081358 | 700.64% |

Elapsed time = 18.04 sec. (13079.83 ticks, tree = 3596.11 MB, solutions = 21)

Nodefile size = 1531.15 MB (1354.94 MB after compression)

|               |       |           |     |          |           |          |         |
|---------------|-------|-----------|-----|----------|-----------|----------|---------|
| 355350        | 78840 | -106.1301 | 61  | -46.0000 | -368.2929 | 50082313 | 700.64% |
| 355421        | 78637 | -265.3412 | 275 | -46.0000 | -368.2929 | 50101647 | 700.64% |
| 355525        | 78674 | -185.2515 | 141 | -46.0000 | -368.2802 | 50103370 | 700.61% |
| *355558+78900 |       |           |     | -47.0000 | -368.2802 |          | 683.57% |
| 355620        | 78594 | -339.7121 | 378 | -47.0000 | -368.2802 | 50098468 | 683.57% |
| 355766        | 78770 | -294.4367 | 166 | -47.0000 | -368.2802 | 50106522 | 683.57% |
| 356139        | 78635 | -175.6360 | 123 | -47.0000 | -368.2802 | 50098267 | 683.57% |
| 356248        | 78595 | -327.9391 | 290 | -47.0000 | -368.2802 | 50116071 | 683.57% |
| 356341        | 78649 | -216.7224 | 142 | -47.0000 | -368.2802 | 50118193 | 683.57% |
| 356578        | 78816 | -170.0356 | 106 | -47.0000 | -368.2802 | 50108680 | 683.57% |
| 356638        | 78453 | -344.8623 | 449 | -47.0000 | -368.2802 | 50116537 | 683.57% |

Elapsed time = 29.93 sec. (23092.66 ticks, tree = 3533.95 MB, solutions = 24)

Nodefile size = 1531.15 MB (1354.94 MB after compression)

|               |       |           |      |          |           |          |         |
|---------------|-------|-----------|------|----------|-----------|----------|---------|
| 356671        | 78466 | -341.4183 | 357  | -47.0000 | -368.2802 | 50117958 | 683.57% |
| 356751        | 78750 | -256.5897 | 150  | -47.0000 | -368.2802 | 50111786 | 683.57% |
| 356870        | 78469 | -366.3548 | 433  | -47.0000 | -368.2802 | 50121648 | 683.57% |
| 356949        | 78525 | -255.7729 | 163  | -47.0000 | -368.2802 | 50124119 | 683.57% |
| 357102        | 78851 | -349.7279 | 232  | -47.0000 | -368.2802 | 50117120 | 683.57% |
| *357191+78873 |       |           |      | -48.0000 | -368.2802 |          | 667.25% |
| 357191        | 78711 | -367.6334 | 1100 | -48.0000 | -368.2802 | 50124118 | 667.25% |
| 357194        | 78714 | -367.6270 | 1104 | -48.0000 | -368.2802 | 50124781 | 667.25% |
| 357195        | 78609 | -342.4514 | 413  | -48.0000 | -368.2802 | 50139710 | 667.25% |
| 357262        | 78665 | -248.5754 | 138  | -48.0000 | -368.2802 | 50141684 | 667.25% |
| 357380        | 78718 | -354.8980 | 803  | -48.0000 | -368.2802 | 50142887 | 667.25% |

Elapsed time = 44.43 sec. (43023.32 ticks, tree = 3542.02 MB, solutions = 27)

Nodefile size = 1531.15 MB (1354.94 MB after compression)

|        |       |           |      |          |           |          |         |
|--------|-------|-----------|------|----------|-----------|----------|---------|
| 357385 | 78720 | -354.1313 | 745  | -48.0000 | -368.2802 | 50144502 | 667.25% |
| 357389 | 78723 | -352.5103 | 493  | -48.0000 | -368.2802 | 50146723 | 667.25% |
| 357394 | 78727 | -339.5890 | 283  | -48.0000 | -368.2802 | 50148761 | 667.25% |
| 357420 | 78744 | -332.3197 | 331  | -48.0000 | -368.2802 | 50149654 | 667.25% |
| 357451 | 78769 | -280.8813 | 168  | -48.0000 | -368.2802 | 50150722 | 667.25% |
| 357488 | 78795 | -215.9856 | 158  | -48.0000 | -368.2802 | 50151746 | 667.25% |
| 357527 | 78746 | -354.7789 | 1031 | -48.0000 | -368.2802 | 50162814 | 667.25% |
| 357530 | 78749 | -354.6699 | 1031 | -48.0000 | -368.2802 | 50163649 | 667.25% |
| 357531 | 78750 | -346.2256 | 653  | -48.0000 | -368.2802 | 50170449 | 667.25% |
| 357533 | 78752 | -344.5490 | 744  | -48.0000 | -368.2802 | 50171923 | 667.25% |

Elapsed time = 55.57 sec. (57967.17 ticks, tree = 3535.25 MB, solutions = 27)

Nodefile size = 1531.15 MB (1354.94 MB after compression)

|        |       |           |      |          |           |          |         |
|--------|-------|-----------|------|----------|-----------|----------|---------|
| 357536 | 78821 | -366.0749 | 1161 | -48.0000 | -368.2802 | 50157991 | 667.25% |
| 357540 | 78823 | -366.0599 | 1158 | -48.0000 | -368.2802 | 50158619 | 667.25% |
| 357556 | 78769 | -325.5245 | 302  | -48.0000 | -368.2802 | 50177346 | 667.25% |
| 357590 | 78792 | -291.4648 | 232  | -48.0000 | -368.2802 | 50178499 | 667.25% |
| 357621 | 78817 | -233.7738 | 198  | -48.0000 | -368.2802 | 50179962 | 667.25% |
| 357636 | 78824 | -365.1710 | 595  | -48.0000 | -368.2802 | 50183101 | 667.25% |
| 357669 | 78849 | -340.1584 | 284  | -48.0000 | -368.2802 | 50185185 | 667.25% |
| 357722 | 78826 | -361.9055 | 1039 | -48.0000 | -368.2802 | 50168111 | 667.25% |
| 357723 | 78827 | -354.3601 | 752  | -48.0000 | -368.2802 | 50176673 | 667.25% |
| 357725 | 78829 | -352.8350 | 745  | -48.0000 | -368.2802 | 50178651 | 667.25% |

Elapsed time = 63.73 sec. (73838.94 ticks, tree = 3542.48 MB, solutions = 28)

Nodefile size = 1531.15 MB (1354.94 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 357727 | 78831 | -351.3868 | 663 | -48.0000 | -368.2802 | 50180601 | 667.25% |
| 357729 | 78833 | -349.5185 | 509 | -48.0000 | -368.2802 | 50182598 | 667.25% |
| 357733 | 78835 | -339.0805 | 430 | -48.0000 | -368.2802 | 50184554 | 667.25% |
| 357757 | 78857 | -321.4356 | 295 | -48.0000 | -368.2802 | 50185975 | 667.25% |
| 357781 | 78864 | -367.4109 | 559 | -48.0000 | -368.2802 | 50189238 | 667.25% |
| 357788 | 78868 | -362.7362 | 469 | -48.0000 | -368.2802 | 50191101 | 667.25% |
| 357803 | 78879 | -356.6581 | 374 | -48.0000 | -368.2802 | 50192864 | 667.25% |

GUB cover cuts applied: 1515

Clique cuts applied: 53

Cover cuts applied: 4487

Implied bound cuts applied: 116

Flow cuts applied: 171

Mixed integer rounding cuts applied: 3009

Zero-half cuts applied: 135

Lift and project cuts applied: 20

Gomory fractional cuts applied: 183

Root node processing (before b&c):

Real time = 0.00 sec. (1.95 ticks)

Parallel b&c, 8 threads:

Real time = 70.85 sec. (82977.94 ticks)

Sync time (average) = 1.52 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 70.85 sec. (82979.89 ticks)

-----

Iteration 11

Bounds on # of cuts = 8 with [3 3 2]

Error = 52 (out of 100 instances)

Accuracy = 48

Solving time = 1.180936951 min (minutes)

Accumulated time = 69.380926815 min (minutes)

Solution status code = 104

LB on error = -268.191364056

Relative objective gap = 6.670653418

Selected variables:

A\_AGE (Continuous)

PEMLR (Categorical)

Number of selected variables = 2 (1 continuous + 1 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |                    |
|--------------------------------|--------------------|
| CPXPARAM_MIP_Strategy_File     | 3                  |
| CPXPARAM_MIP_Limits_Solutions  | 1                  |
| CPXPARAM_TimeLimit             | 82237.144391113281 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800             |

| Nodes  |       |            |      | Cuts/        |            |          |         |
|--|-------|------------|------|--------------|------------|----------|---------|
| Node   | Left  | Objective  | IInf | Best Integer | Best Bound | ItCnt    | Gap     |
| 357813   | 81848 | infeasible |      | -48.0000     | -368.1914  | 50513898 | 667.07% |
| Elapsed time = 0.66 sec. (292.33 ticks, tree = 3726.48 MB, solutions = 29) |       |            |      |              |            |          |         |
| Nodefile size = 1679.11 MB (1484.78 MB after compression)                  |       |            |      |              |            |          |         |
| 357826   | 81861 | -292.1446  | 183  | -48.0000     | -368.1914  | 50513559 | 667.07% |
| 357851   | 81885 | -234.4599  | 151  | -48.0000     | -368.1914  | 50514204 | 667.07% |
| 357887   | 81913 | -152.0224  | 89   | -48.0000     | -368.1909  | 50514540 | 667.06% |
| 357920   | 81854 | -357.2824  | 437  | -48.0000     | -368.1909  | 50516152 | 667.06% |
| 357957   | 81858 | -352.0901  | 310  | -48.0000     | -368.1909  | 50519329 | 667.06% |
| 358005   | 81876 | -328.8730  | 208  | -48.0000     | -368.1909  | 50519839 | 667.06% |
| 358061   | 81952 | -365.6237  | 549  | -48.0000     | -368.1909  | 50516426 | 667.06% |
| 358123   | 81944 | -173.5007  | 110  | -48.0000     | -368.1909  | 50520624 | 667.06% |

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 358187 | 81986 | -63.5680  | 31  | -48.0000 | -368.1909 | 50520867 | 667.06% |
| 358404 | 81869 | -356.0177 | 335 | -48.0000 | -368.1843 | 50525639 | 667.05% |

Elapsed time = 4.90 sec. (3429.12 ticks, tree = 3706.40 MB, solutions = 29)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 358736 | 81977 | -104.3151 | 66  | -48.0000 | -368.1843 | 50527782 | 667.05% |
| 359077 | 81930 | -213.6064 | 155 | -48.0000 | -368.1843 | 50539357 | 667.05% |
| 359402 | 81958 | -126.7440 | 131 | -48.0000 | -368.1843 | 50534882 | 667.05% |
| 359558 | 82114 | -323.8779 | 203 | -48.0000 | -368.1843 | 50527920 | 667.05% |
| 360011 | 82123 | -110.9767 | 62  | -48.0000 | -368.1843 | 50534255 | 667.05% |
| 360279 | 82251 | -303.4537 | 198 | -48.0000 | -368.1843 | 50531448 | 667.05% |
| 360674 | 82270 | -333.9872 | 256 | -48.0000 | -368.1843 | 50533165 | 667.05% |
| 360773 | 82324 | -216.5179 | 149 | -48.0000 | -368.1433 | 50535459 | 666.97% |
| 360935 | 81876 | -334.8739 | 394 | -48.0000 | -368.1433 | 50554007 | 666.97% |
| 361126 | 82233 | -126.4382 | 85  | -48.0000 | -368.1433 | 50538997 | 666.97% |

Elapsed time = 16.84 sec. (13063.54 ticks, tree = 3721.75 MB, solutions = 29)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 361224 | 82365 | -356.3953 | 443 | -48.0000 | -368.1433 | 50542559 | 666.97% |
| 361281 | 82131 | -357.4859 | 303 | -48.0000 | -368.1433 | 50550840 | 666.97% |
| 361426 | 82156 | -326.2501 | 224 | -48.0000 | -368.1433 | 50553536 | 666.97% |
| 361646 | 82220 | -176.9277 | 120 | -48.0000 | -368.1433 | 50556001 | 666.97% |
| 361770 | 82452 | -180.0865 | 199 | -48.0000 | -368.1433 | 50554805 | 666.97% |
| 361955 | 82503 | -57.9050  | 56  | -48.0000 | -368.1433 | 50556571 | 666.97% |
| 362344 | 82097 | -142.5888 | 80  | -48.0000 | -368.1433 | 50569144 | 666.97% |
| 362616 | 82168 | -298.4494 | 201 | -48.0000 | -368.1433 | 50555327 | 666.97% |
| 362791 | 82238 | -120.0840 | 76  | -48.0000 | -368.1433 | 50557846 | 666.97% |
| 363008 | 82410 | -348.3597 | 333 | -48.0000 | -368.1433 | 50568317 | 666.97% |

Elapsed time = 29.19 sec. (22675.86 ticks, tree = 3702.14 MB, solutions = 29)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 363419 | 82370 | -120.3047 | 72  | -48.0000 | -368.1433 | 50561564 | 666.97% |
| 363578 | 82189 | -249.4025 | 251 | -48.0000 | -368.1433 | 50581892 | 666.97% |
| 363716 | 82216 | -192.8838 | 220 | -48.0000 | -368.1433 | 50583993 | 666.97% |
| 364045 | 82643 | -113.9610 | 77  | -48.0000 | -368.1433 | 50563974 | 666.97% |
| 364090 | 82681 | -358.5332 | 390 | -48.0000 | -368.1433 | 50576810 | 666.97% |
| 364122 | 82699 | -341.6880 | 311 | -48.0000 | -368.1433 | 50578930 | 666.97% |
| 364284 | 82291 | -317.6356 | 231 | -48.0000 | -368.1433 | 50591814 | 666.97% |
| 364631 | 82674 | -357.5447 | 338 | -48.0000 | -368.1433 | 50572614 | 666.97% |
| 364749 | 82708 | -296.0979 | 196 | -48.0000 | -368.1433 | 50574904 | 666.97% |
| 364984 | 82786 | -87.9932  | 99  | -48.0000 | -368.1433 | 50575721 | 666.97% |

Elapsed time = 41.83 sec. (32254.33 ticks, tree = 3717.44 MB, solutions = 29)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 365223 | 82504 | -191.5209 | 217 | -48.0000 | -368.1433 | 50591049 | 666.97% |
| 365504 | 82549 | -331.3050 | 208 | -48.0000 | -368.1433 | 50601365 | 666.97% |
| 365992 | 82893 | -127.0245 | 73  | -48.0000 | -368.1433 | 50588165 | 666.97% |
| 366170 | 82544 | -366.6969 | 623 | -48.0000 | -368.1433 | 50597281 | 666.97% |
| 366176 | 82548 | -355.5594 | 469 | -48.0000 | -368.1433 | 50601349 | 666.97% |
| 366189 | 82559 | -351.7782 | 427 | -48.0000 | -368.1433 | 50603729 | 666.97% |
| 366204 | 82569 | -339.4731 | 368 | -48.0000 | -368.1433 | 50607134 | 666.97% |
| 366249 | 82599 | -272.1125 | 282 | -48.0000 | -368.1433 | 50608232 | 666.97% |
| 366396 | 82671 | -114.3516 | 71  | -48.0000 | -368.1433 | 50609897 | 666.97% |
| 366634 | 82736 | -309.9270 | 209 | -48.0000 | -368.1433 | 50611201 | 666.97% |

Elapsed time = 54.67 sec. (42460.70 ticks, tree = 3710.17 MB, solutions = 29)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 366756 | 82821 | -111.5596 | 54  | -48.0000 | -368.1433 | 50612395 | 666.97% |
| 366807 | 82858 | -343.9349 | 258 | -48.0000 | -368.1433 | 50613675 | 666.97% |
| 366896 | 82914 | -211.1564 | 174 | -48.0000 | -368.1433 | 50615760 | 666.97% |
| 366985 | 82971 | -366.4920 | 430 | -48.0000 | -368.1433 | 50617063 | 666.97% |
| 367034 | 82400 | -351.3165 | 559 | -48.0000 | -368.1433 | 50587667 | 666.97% |
| 367120 | 83037 | -244.8728 | 179 | -48.0000 | -368.1433 | 50620481 | 666.97% |
| 367337 | 82703 | -334.1119 | 233 | -48.0000 | -368.1433 | 50628475 | 666.97% |
| 367706 | 82986 | -316.4094 | 188 | -48.0000 | -368.1433 | 50617616 | 666.97% |
| 367821 | 83126 | -356.0752 | 340 | -48.0000 | -368.1433 | 50627458 | 666.97% |
| 368044 | 82503 | -135.1360 | 111 | -48.0000 | -368.1433 | 50593666 | 666.97% |

Elapsed time = 67.00 sec. (52139.75 ticks, tree = 3695.91 MB, solutions = 29)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 368238 | 82922 | -164.7335 | 92  | -48.0000 | -368.1433 | 50634114 | 666.97% |
| 368430 | 83224 | -123.8483 | 141 | -48.0000 | -368.1433 | 50637485 | 666.97% |
| 368773 | 83201 | -128.9948 | 87  | -48.0000 | -368.1433 | 50629760 | 666.97% |
| 368913 | 83264 | -357.5110 | 311 | -48.0000 | -368.1433 | 50641918 | 666.97% |
| 369098 | 83112 | -324.3748 | 198 | -48.0000 | -368.1433 | 50639612 | 666.97% |
| 369400 | 83329 | -191.7452 | 204 | -48.0000 | -368.1433 | 50645762 | 666.97% |
| 369572 | 83433 | -223.7018 | 132 | -48.0000 | -368.1433 | 50636921 | 666.97% |
| 369806 | 82380 | -287.5304 | 169 | -48.0000 | -368.1433 | 50648326 | 666.97% |
| 370042 | 83155 | -230.0538 | 152 | -48.0000 | -368.1433 | 50627192 | 666.97% |
| 370296 | 83206 | -105.6802 | 84  | -48.0000 | -368.1433 | 50627997 | 666.97% |

Elapsed time = 79.67 sec. (61734.30 ticks, tree = 3719.22 MB, solutions = 29)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 370473 | 83648 | -363.5100 | 330 | -48.0000 | -368.1433 | 50644687 | 666.97% |
| 370572 | 83690 | -301.8013 | 207 | -48.0000 | -368.1433 | 50648101 | 666.97% |

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 370729 | 83483 | -197.3347 | 130 | -48.0000 | -368.1387 | 50658662 | 666.96% |
| 370929 | 83541 | -365.7080 | 488 | -48.0000 | -368.1387 | 50660523 | 666.96% |
| 371088 | 83221 | -351.9229 | 387 | -48.0000 | -368.1387 | 50653084 | 666.96% |
| 371487 | 83670 | -73.6233  | 44  | -48.0000 | -368.1387 | 50663896 | 666.96% |
| 371836 | 83297 | -205.4547 | 120 | -48.0000 | -368.1387 | 50656731 | 666.96% |
| 371955 | 84037 | -363.3737 | 398 | -48.0000 | -368.1387 | 50658794 | 666.96% |
| 372245 | 84150 | -104.1935 | 62  | -48.0000 | -368.1387 | 50660639 | 666.96% |
| 372599 | 84174 | -356.4815 | 416 | -48.0000 | -368.1387 | 50662713 | 666.96% |

Elapsed time = 91.72 sec. (71418.27 ticks, tree = 3710.01 MB, solutions = 29)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 372758 | 83830 | -350.2123 | 218 | -48.0000 | -368.1387 | 50673011 | 666.96% |
| 372917 | 83910 | -185.9764 | 100 | -48.0000 | -368.1337 | 50675434 | 666.95% |
| 373114 | 82774 | -318.4387 | 220 | -48.0000 | -368.1337 | 50678770 | 666.95% |
| 373417 | 84320 | -338.0692 | 224 | -48.0000 | -368.1337 | 50669801 | 666.95% |
| 373666 | 83414 | -320.7274 | 235 | -48.0000 | -368.1337 | 50655149 | 666.95% |
| 374022 | 83475 | -168.1748 | 126 | -48.0000 | -368.1337 | 50656810 | 666.95% |
| 374273 | 84491 | -280.5796 | 200 | -48.0000 | -368.1337 | 50676353 | 666.95% |
| 374608 | 84074 | -110.7467 | 74  | -48.0000 | -368.1337 | 50687542 | 666.95% |
| 374870 | 83955 | -200.9511 | 127 | -48.0000 | -368.1337 | 50773859 | 666.95% |
| 375060 | 84635 | -264.2193 | 176 | -48.0000 | -368.1337 | 50681732 | 666.95% |

Elapsed time = 104.63 sec. (80997.62 ticks, tree = 3712.07 MB, solutions = 29)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 375289 | 83674 | -313.4418 | 201 | -48.0000 | -368.1337 | 50666202 | 666.95% |
| 375652 | 83029 | -311.7428 | 205 | -48.0000 | -368.1337 | 50695634 | 666.95% |
| 375861 | 83121 | -243.7553 | 181 | -48.0000 | -368.1337 | 50707677 | 666.95% |
| 376042 | 83812 | -322.3605 | 225 | -48.0000 | -368.1337 | 50672426 | 666.95% |
| 376328 | 83907 | -76.8829  | 55  | -48.0000 | -368.1337 | 50673938 | 666.95% |
| 376562 | 84043 | -315.9558 | 248 | -48.0000 | -368.1337 | 50786727 | 666.95% |
| 376701 | 84097 | -203.0215 | 121 | -48.0000 | -368.1337 | 50788420 | 666.95% |
| 376892 | 83281 | -94.0053  | 88  | -48.0000 | -368.1337 | 50707850 | 666.95% |
| 376963 | 84416 | -300.0476 | 169 | -48.0000 | -368.1337 | 50708399 | 666.95% |
| 377680 | 83473 | -295.0804 | 190 | -48.0000 | -368.1337 | 50717425 | 666.95% |

Elapsed time = 120.42 sec. (93442.31 ticks, tree = 3693.86 MB, solutions = 29)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 378589 | 84784 | -62.4796  | 50  | -48.0000 | -368.1337 | 50723926 | 666.95% |
| 379167 | 84588 | -357.1111 | 256 | -48.0000 | -368.1295 | 50809279 | 666.94% |
| 379898 | 84778 | -210.9325 | 156 | -48.0000 | -368.1295 | 50814162 | 666.94% |
| 381019 | 83619 | -115.1233 | 68  | -48.0000 | -368.1295 | 50707029 | 666.94% |
| 382720 | 83365 | -140.2585 | 105 | -48.0000 | -368.1295 | 50688807 | 666.94% |

|   |        |           |     |          |           |          |         |
|---|--------|-----------|-----|----------|-----------|----------|---------|
| 384080  | 83309  | -101.5742 | 51  | -48.0000 | -368.1295 | 50766747 | 666.94% |
| 384963  | 83446  | -105.2105 | 49  | -48.0000 | -368.1295 | 50774019 | 666.94% |
| 386015  | 84519  | -346.9758 | 297 | -48.0000 | -368.1265 | 50783476 | 666.93% |
| 386910  | 85693  | -155.1845 | 151 | -48.0000 | -368.1265 | 50775095 | 666.93% |
| 387595  | 84934  | -333.2850 | 217 | -48.0000 | -368.1265 | 50794129 | 666.93% |
| Elapsed time = 167.93 sec. (131619.11 ticks, tree = 3741.29 MB, solutions = 29) |        |           |     |          |           |          |         |
| Nodefile size = 1679.11 MB (1484.78 MB after compression)                       |        |           |     |          |           |          |         |
| 388775  | 86007  | -55.9050  | 38  | -48.0000 | -368.1265 | 50790936 | 666.93% |
| 389667  | 89849  | -58.8835  | 63  | -48.0000 | -368.1265 | 51217466 | 666.93% |
| 390428  | 84259  | -235.6584 | 138 | -48.0000 | -368.1265 | 50820389 | 666.93% |
| 391907  | 85686  | -200.5898 | 122 | -48.0000 | -368.1265 | 50817259 | 666.93% |
| 393428  | 86618  | -190.2522 | 146 | -48.0000 | -368.1265 | 51023481 | 666.93% |
| 394894  | 85686  | -338.0291 | 262 | -48.0000 | -368.1265 | 50892802 | 666.93% |
| 396235  | 86317  | -283.0987 | 189 | -48.0000 | -368.1265 | 50835383 | 666.93% |
| 397505  | 86197  | -70.7395  | 64  | -48.0000 | -368.1265 | 50901768 | 666.93% |
| 398333  | 86550  | -347.5027 | 457 | -48.0000 | -368.1265 | 50846264 | 666.93% |
| 399245  | 86427  | -177.6206 | 95  | -48.0000 | -368.1265 | 50911461 | 666.93% |
| Elapsed time = 217.63 sec. (169797.21 ticks, tree = 3979.15 MB, solutions = 29) |        |           |     |          |           |          |         |
| Nodefile size = 1679.11 MB (1484.78 MB after compression)                       |        |           |     |          |           |          |         |
| 400219  | 86967  | -365.8791 | 488 | -48.0000 | -368.1265 | 50855776 | 666.93% |
| 401660  | 91267  | -243.3707 | 155 | -48.0000 | -368.1265 | 51274192 | 666.93% |
| 403296  | 87512  | -341.1402 | 231 | -48.0000 | -368.1265 | 50866250 | 666.93% |
| 404989  | 84983  | -140.2182 | 86  | -48.0000 | -368.0929 | 50859564 | 666.86% |
| 406525  | 88101  | -184.9819 | 105 | -48.0000 | -368.0929 | 50876062 | 666.86% |
| 407805  | 92086  | -259.9844 | 159 | -48.0000 | -368.0929 | 51296163 | 666.86% |
| 409441  | 86511  | -258.7671 | 146 | -48.0000 | -368.0929 | 50913194 | 666.86% |
| 411560  | 92832  | -360.5152 | 318 | -48.0000 | -368.0929 | 51306048 | 666.86% |
| 413551  | 93075  | -71.0918  | 41  | -48.0000 | -368.0929 | 51311387 | 666.86% |
| 415320  | 93351  | -366.3324 | 416 | -48.0000 | -368.0856 | 51316812 | 666.84% |
| Elapsed time = 280.95 sec. (207992.61 ticks, tree = 4136.27 MB, solutions = 29) |        |           |     |          |           |          |         |
| Nodefile size = 1679.11 MB (1484.78 MB after compression)                       |        |           |     |          |           |          |         |
| 416761  | 93635  | -356.6959 | 307 | -48.0000 | -368.0856 | 51321961 | 666.84% |
| 417641  | 103611 | -333.2727 | 267 | -48.0000 | -368.0856 | 52115151 | 666.84% |
| 418995  | 86717  | -91.4659  | 93  | -48.0000 | -368.0856 | 50923115 | 666.84% |
| 420375  | 95010  | -345.7725 | 227 | -48.0000 | -368.0856 | 51592947 | 666.84% |
| 422388  | 97745  | -208.8593 | 113 | -48.0000 | -368.0856 | 51806281 | 666.84% |
| *424820+95327   |        |           |     | -49.0000 | -368.0856 |          | 651.20% |
| 424875  | 86974  | -117.5452 | 83  | -49.0000 | -368.0856 | 50941301 | 651.20% |
| 426829  | 88296  | -141.1596 | 108 | -49.0000 | -368.0856 | 51174273 | 651.20% |



|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 428842 | 87107 | -81.6216  | 48  | -49.0000 | -368.0856 | 50956823 | 651.20% |
| 430040 | 88694 | -143.4552 | 113 | -49.0000 | -368.0856 | 51183846 | 651.20% |
| 431654 | 88993 | -56.4649  | 57  | -49.0000 | -368.0856 | 51187570 | 651.20% |

Elapsed time = 330.56 sec. (246162.32 ticks, tree = 3912.30 MB, solutions = 30)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |       |           |     |          |           |          |         |
|--------|-------|-----------|-----|----------|-----------|----------|---------|
| 432487 | 89155 | -309.7494 | 252 | -49.0000 | -368.0856 | 51192129 | 651.20% |
| 433820 | 98871 | -248.0751 | 169 | -49.0000 | -368.0856 | 51844744 | 651.20% |
| 434923 | 89508 | -95.4429  | 54  | -49.0000 | -368.0856 | 50996457 | 651.20% |
| 436455 | 90671 | -329.4717 | 245 | -49.0000 | -368.0856 | 51072363 | 651.20% |
| 438281 | 90148 | -118.6082 | 102 | -49.0000 | -368.0856 | 51006030 | 651.20% |
| 439742 | 90497 | -207.3705 | 167 | -49.0000 | -368.0856 | 51216254 | 651.20% |
| 441567 | 90674 | -173.8533 | 102 | -49.0000 | -368.0856 | 51016082 | 651.20% |
| 443828 | 91216 | -303.3454 | 206 | -49.0000 | -368.0856 | 51223635 | 651.20% |
| 445236 | 87736 | -175.7545 | 94  | -49.0000 | -368.0856 | 51043195 | 651.20% |
| 447049 | 91633 | -313.8024 | 195 | -49.0000 | -368.0856 | 51113941 | 651.20% |

Elapsed time = 373.44 sec. (284339.53 ticks, tree = 4204.39 MB, solutions = 30)

Nodefile size = 1679.11 MB (1484.78 MB after compression)

|        |        |           |      |          |           |          |         |
|--------|--------|-----------|------|----------|-----------|----------|---------|
| 447980 | 100629 | -348.9983 | 289  | -49.0000 | -368.0856 | 51894673 | 651.20% |
| 449086 | 92335  | -127.1360 | 75   | -49.0000 | -368.0856 | 51244067 | 651.20% |
| 449528 | 92362  | -357.3279 | 1052 | -49.0000 | -368.0856 | 51255961 | 651.20% |

GUB cover cuts applied: 1587

Clique cuts applied: 53

Cover cuts applied: 4561

Implied bound cuts applied: 116

Flow cuts applied: 178

Mixed integer rounding cuts applied: 3530

Zero-half cuts applied: 136

Lift and project cuts applied: 20

Gomory fractional cuts applied: 183

Root node processing (before b&c):

Real time = 0.00 sec. (2.15 ticks)

Parallel b&c, 8 threads:

Real time = 430.29 sec. (305295.57 ticks)

Sync time (average) = 41.19 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 430.29 sec. (305297.72 ticks)

-----

Iteration 12

Bounds on # of cuts = 8 with [3 3 2]

Error = 51 (out of 100 instances)

Accuracy = 49

Solving time = 7.171601351 min (minutes)

Accumulated time = 76.552528166 min (minutes)

Solution status code = 104

LB on error = -267.975324274

Relative objective gap = 6.509700495

Selected variables:

A\_AGE (Continuous)

PEMLR (Categorical)

Number of selected variables = 2 (1 continuous + 1 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |                    |
|--------------------------------|--------------------|
| CPXPARAM_MIP_Strategy_File     | 3                  |
| CPXPARAM_MIP_Limits_Solutions  | 1                  |
| CPXPARAM_TimeLimit             | 81806.848310058587 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800             |

| Nodes   |        |            |      | Cuts/        |            |          |         |
|---|--------|------------|------|--------------|------------|----------|---------|
| Node  | Left   | Objective  | IInf | Best Integer | Best Bound | ItCnt    | Gap     |
| 449529  | 148551 | infeasible |      | -49.0000     | -367.9753  | 54370598 | 650.97% |
| Elapsed time = 0.47 sec. (14.98 ticks, tree = 8107.53 MB, solutions = 30) |        |            |      |              |            |          |         |
| Nodefile size = 6060.88 MB (5290.89 MB after compression)                 |        |            |      |              |            |          |         |
| 449531  | 148553 | -359.5659  | 442  | -49.0000     | -367.9753  | 54371140 | 650.97% |
| 449538  | 148551 | infeasible |      | -49.0000     | -367.9753  | 54371316 | 650.97% |
| 449555  | 148565 | -356.7244  | 318  | -49.0000     | -367.9753  | 54371964 | 650.97% |
| 449593  | 148577 | -332.7352  | 218  | -49.0000     | -367.9753  | 54373247 | 650.97% |
| 449639  | 148602 | -280.7380  | 198  | -49.0000     | -367.9753  | 54373435 | 650.97% |
| 449702  | 148606 | -260.2627  | 157  | -49.0000     | -367.9753  | 54373161 | 650.97% |
| 449786  | 148649 | -166.4203  | 107  | -49.0000     | -367.9753  | 54373940 | 650.97% |
| 449880  | 148675 | -94.9784   | 61   | -49.0000     | -367.9753  | 54374029 | 650.97% |

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 449971 | 148638 | -203.4032 | 129 | -49.0000 | -367.9753 | 54375734 | 650.97% |
| 450059 | 148698 | -366.2099 | 443 | -49.0000 | -367.9753 | 54375106 | 650.97% |

Elapsed time = 5.04 sec. (3168.00 ticks, tree = 8124.01 MB, solutions = 30)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 450236 | 148594 | -295.4153 | 184 | -49.0000 | -367.9753 | 54382327 | 650.97% |
| 450577 | 148682 | -63.8978  | 27  | -49.0000 | -367.9753 | 54385978 | 650.97% |
| 450591 | 148559 | -360.5034 | 415 | -49.0000 | -367.8207 | 54398193 | 650.65% |
| 450738 | 148908 | -173.4438 | 111 | -49.0000 | -367.8207 | 54383205 | 650.65% |
| 450900 | 148662 | -146.4658 | 101 | -49.0000 | -367.8207 | 54401032 | 650.65% |
| 451012 | 148976 | -333.3717 | 213 | -49.0000 | -367.8207 | 54385969 | 650.65% |
| 451296 | 148560 | -363.7896 | 978 | -49.0000 | -367.6854 | 54392980 | 650.38% |
| 451342 | 149129 | -304.8566 | 181 | -49.0000 | -367.6854 | 54388385 | 650.38% |
| 451481 | 148830 | -361.6500 | 361 | -49.0000 | -367.6854 | 54396382 | 650.38% |
| 451603 | 148878 | -283.0614 | 180 | -49.0000 | -367.6854 | 54397899 | 650.38% |

Elapsed time = 17.82 sec. (12954.41 ticks, tree = 8108.39 MB, solutions = 30)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 451826 | 148953 | -82.9050  | 50  | -49.0000 | -367.6854 | 54398543 | 650.38% |
| 451879 | 148704 | -340.0657 | 313 | -49.0000 | -367.6854 | 54393842 | 650.38% |
| 451961 | 149414 | -296.1621 | 239 | -49.0000 | -367.6854 | 54395518 | 650.38% |
| 452167 | 148607 | -276.8603 | 214 | -49.0000 | -367.6854 | 54403955 | 650.38% |
| 452428 | 149031 | -219.7767 | 147 | -49.0000 | -367.6854 | 54406146 | 650.38% |
| 452701 | 148652 | -365.3107 | 433 | -49.0000 | -367.6854 | 54406178 | 650.38% |
| 453008 | 148875 | -265.3827 | 181 | -49.0000 | -367.6854 | 54403380 | 650.38% |
| 453289 | 149184 | -154.6563 | 92  | -49.0000 | -367.6854 | 54411487 | 650.38% |
| 453348 | 148960 | -360.0414 | 372 | -49.0000 | -367.6854 | 54406637 | 650.38% |
| 453502 | 149046 | -148.5781 | 74  | -49.0000 | -367.6854 | 54407919 | 650.38% |

Elapsed time = 30.74 sec. (22572.71 ticks, tree = 8146.19 MB, solutions = 30)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

|                |        |           |     |          |           |          |         |
|----------------|--------|-----------|-----|----------|-----------|----------|---------|
| 453759         | 148853 | -256.7948 | 204 | -49.0000 | -367.6854 | 54415433 | 650.38% |
| 453922         | 148937 | -60.9847  | 87  | -49.0000 | -367.6854 | 54416165 | 650.38% |
| 454060         | 149366 | -363.9560 | 517 | -49.0000 | -367.6854 | 54420697 | 650.38% |
| *454067+148947 |        |           |     | -50.0000 | -367.6854 |          | 635.37% |
| 454103         | 149399 | -314.6991 | 203 | -50.0000 | -367.6854 | 54422606 | 635.37% |
| 454237         | 149500 | -56.4004  | 29  | -50.0000 | -367.6854 | 54423429 | 635.37% |
| 454247         | 148825 | -356.6694 | 887 | -50.0000 | -367.6854 | 54420679 | 635.37% |
| 454277         | 148835 | -290.6358 | 185 | -50.0000 | -367.6854 | 54422588 | 635.37% |
| 454414         | 148923 | -67.9049  | 38  | -50.0000 | -367.6854 | 54423303 | 635.37% |
| 454472         | 148930 | -363.1861 | 506 | -50.0000 | -367.6854 | 54424890 | 635.37% |
| 454545         | 149615 | -91.8766  | 82  | -50.0000 | -367.6854 | 54431081 | 635.37% |

Elapsed time = 43.16 sec. (32219.69 ticks, tree = 8192.55 MB, solutions = 31)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 454566 | 149628 | -364.7786 | 412 | -50.0000 | -367.6854 | 54432926 | 635.37% |
| 454641 | 149685 | -257.6134 | 147 | -50.0000 | -367.6854 | 54434532 | 635.37% |
| 454765 | 149232 | -338.9140 | 319 | -50.0000 | -367.6854 | 54425621 | 635.37% |
| 454818 | 149263 | -264.9478 | 165 | -50.0000 | -367.6854 | 54427210 | 635.37% |
| 455006 | 148623 | -232.9872 | 171 | -50.0000 | -367.6854 | 54453546 | 635.37% |
| 455113 | 148698 | -365.3190 | 406 | -50.0000 | -367.6854 | 54454977 | 635.37% |
| 455205 | 148741 | -298.9809 | 232 | -50.0000 | -367.6854 | 54456259 | 635.37% |
| 455387 | 149424 | -232.1075 | 128 | -50.0000 | -367.6854 | 54435736 | 635.37% |
| 455507 | 148735 | -264.2029 | 170 | -50.0000 | -367.6854 | 54427522 | 635.37% |
| 455726 | 149833 | -203.7847 | 140 | -50.0000 | -367.6854 | 54447876 | 635.37% |

Elapsed time = 54.10 sec. (41946.00 ticks, tree = 8217.64 MB, solutions = 32)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

|        |        |            |     |          |           |          |         |
|--------|--------|------------|-----|----------|-----------|----------|---------|
| 455921 | 149884 | infeasible |     | -50.0000 | -367.6854 | 54452377 | 635.37% |
| 455956 | 149909 | -340.9434  | 221 | -50.0000 | -367.6854 | 54453965 | 635.37% |
| 456118 | 148703 | -322.7887  | 332 | -50.0000 | -367.6854 | 54448276 | 635.37% |
| 456211 | 150028 | -361.5807  | 311 | -50.0000 | -367.6854 | 54457854 | 635.37% |
| 456551 | 150147 | -90.9050   | 48  | -50.0000 | -367.6854 | 54458849 | 635.37% |
| 456710 | 150218 | -244.2240  | 146 | -50.0000 | -367.6854 | 54460397 | 635.37% |
| 456937 | 150290 | -365.6604  | 620 | -50.0000 | -367.6854 | 54461963 | 635.37% |
| 457104 | 150332 | -301.2754  | 178 | -50.0000 | -367.6854 | 54463828 | 635.37% |
| 457325 | 149253 | -317.2975  | 220 | -50.0000 | -367.6854 | 54475276 | 635.37% |
| 457456 | 149351 | -66.9050   | 55  | -50.0000 | -367.6854 | 54475951 | 635.37% |

Elapsed time = 68.03 sec. (53360.20 ticks, tree = 8134.99 MB, solutions = 33)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

|        |        |            |      |          |           |          |         |
|--------|--------|------------|------|----------|-----------|----------|---------|
| 457550 | 149392 | -299.9797  | 180  | -50.0000 | -367.6854 | 54477445 | 635.37% |
| 457686 | 148828 | -349.3764  | 432  | -50.0000 | -367.6854 | 54460618 | 635.37% |
| 457810 | 148869 | -286.1150  | 166  | -50.0000 | -367.6854 | 54462183 | 635.37% |
| 458021 | 148956 | -366.7730  | 1041 | -50.0000 | -367.6854 | 54465966 | 635.37% |
| 458023 | 148958 | -365.0671  | 968  | -50.0000 | -367.6854 | 54471615 | 635.37% |
| 458024 | 148959 | -363.9372  | 1032 | -50.0000 | -367.6854 | 54476003 | 635.37% |
| 458026 | 148959 | infeasible |      | -50.0000 | -367.6854 | 54482253 | 635.37% |
| 458028 | 149619 | -355.0212  | 967  | -50.0000 | -367.6854 | 54505490 | 635.37% |
| 458029 | 149620 | -354.8428  | 952  | -50.0000 | -367.6854 | 54509299 | 635.37% |
| 458031 | 148960 | -361.1371  | 1077 | -50.0000 | -367.6854 | 54490873 | 635.37% |

Elapsed time = 75.01 sec. (76144.16 ticks, tree = 8099.72 MB, solutions = 33)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 458035 | 149623 | -338.0811 | 587 | -50.0000 | -367.6854 | 54515789 | 635.37% |
|--------|--------|-----------|-----|----------|-----------|----------|---------|

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 458072 | 149654 | -292.3925 | 206 | -50.0000 | -367.6854 | 54517524 | 635.37% |
| 458195 | 149745 | -366.2947 | 371 | -50.0000 | -367.6854 | 54518192 | 635.37% |
| 458268 | 149801 | -265.0918 | 206 | -50.0000 | -367.6854 | 54519721 | 635.37% |
| 458362 | 148969 | -339.0310 | 358 | -50.0000 | -367.6854 | 54499208 | 635.37% |
| 458394 | 148993 | -294.8755 | 208 | -50.0000 | -367.6854 | 54501358 | 635.37% |
| 458507 | 149871 | -352.6250 | 646 | -50.0000 | -367.6854 | 54535166 | 635.37% |
| 458509 | 149873 | -348.5649 | 612 | -50.0000 | -367.6854 | 54536702 | 635.37% |
| 458514 | 149878 | -344.9235 | 428 | -50.0000 | -367.6854 | 54539075 | 635.37% |
| 458536 | 149895 | -297.6408 | 238 | -50.0000 | -367.6854 | 54541041 | 635.37% |

Elapsed time = 88.09 sec. (94500.64 ticks, tree = 8197.13 MB, solutions = 33)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 458680 | 149994 | -364.9267 | 362 | -50.0000 | -367.6854 | 54542471 | 635.37% |
| 458801 | 149115 | -328.4475 | 206 | -50.0000 | -367.6854 | 54526877 | 635.37% |
| 459008 | 150143 | -344.6698 | 288 | -50.0000 | -367.6854 | 54544620 | 635.37% |
| 459201 | 150256 | -366.0108 | 502 | -50.0000 | -367.6854 | 54545677 | 635.37% |
| 459262 | 150301 | -288.3912 | 191 | -50.0000 | -367.6854 | 54547706 | 635.37% |
| 459384 | 149217 | cutoff    |     | -50.0000 | -367.6854 | 54536299 | 635.37% |
| 459407 | 150400 | -355.7017 | 347 | -50.0000 | -367.6854 | 54550553 | 635.37% |
| 459462 | 150443 | -285.5415 | 194 | -50.0000 | -367.6854 | 54552575 | 635.37% |
| 459552 | 150512 | -80.8691  | 63  | -50.0000 | -367.6854 | 54553583 | 635.37% |
| 459612 | 150559 | -306.0035 | 185 | -50.0000 | -367.6854 | 54555246 | 635.37% |

Elapsed time = 95.25 sec. (104655.04 ticks, tree = 8273.17 MB, solutions = 33)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 459757 | 150659 | -364.0543 | 363 | -50.0000 | -367.6854 | 54556163 | 635.37% |
| 460012 | 150786 | -365.0957 | 367 | -50.0000 | -367.6854 | 54557236 | 635.37% |
| 460166 | 150852 | -257.4208 | 157 | -50.0000 | -367.6854 | 54558763 | 635.37% |
| 460271 | 150928 | -364.7451 | 440 | -50.0000 | -367.6854 | 54559507 | 635.37% |
| 460315 | 150961 | -322.3830 | 231 | -50.0000 | -367.6854 | 54560849 | 635.37% |
| 460444 | 151056 | -365.3064 | 533 | -50.0000 | -367.6854 | 54562520 | 635.37% |
| 460460 | 151063 | -349.8631 | 236 | -50.0000 | -367.6854 | 54564641 | 635.37% |
| 460548 | 151134 | -168.2526 | 125 | -50.0000 | -367.6854 | 54565692 | 635.37% |
| 460596 | 149345 | -353.9889 | 773 | -50.0000 | -367.6854 | 54557078 | 635.37% |
| 460634 | 149374 | -285.4250 | 215 | -50.0000 | -367.6854 | 54563745 | 635.37% |

Elapsed time = 104.38 sec. (117804.09 ticks, tree = 8133.27 MB, solutions = 33)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 460972 | 151200 | -309.7938 | 276 | -50.0000 | -367.6854 | 54579043 | 635.37% |
| 460986 | 149605 | -354.4270 | 858 | -50.0000 | -367.6854 | 54576765 | 635.37% |
| 461156 | 149721 | -353.2440 | 644 | -50.0000 | -367.6854 | 54594267 | 635.37% |
| 461200 | 149747 | -319.7503 | 298 | -50.0000 | -367.6854 | 54601578 | 635.37% |

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 461459 | 149970 | -140.8536 | 83  | -50.0000 | -367.6854 | 54607404 | 635.37% |
| 461869 | 150271 | -362.2076 | 370 | -50.0000 | -367.6854 | 54611721 | 635.37% |
| 462205 | 150520 | -348.8006 | 380 | -50.0000 | -367.6854 | 54618159 | 635.37% |
| 462684 | 150874 | -141.8029 | 82  | -50.0000 | -367.6854 | 54623422 | 635.37% |
| 462904 | 151045 | -365.6643 | 568 | -50.0000 | -367.6854 | 54630449 | 635.37% |
| 463109 | 151192 | -349.4642 | 263 | -50.0000 | -367.6854 | 54638262 | 635.37% |

Elapsed time = 136.21 sec. (163970.28 ticks, tree = 8327.89 MB, solutions = 34)

Nodefile size = 6060.88 MB (5290.89 MB after compression)

GUB cover cuts applied: 1636

Clique cuts applied: 53

Cover cuts applied: 4620

Implied bound cuts applied: 117

Flow cuts applied: 182

Mixed integer rounding cuts applied: 3798

Zero-half cuts applied: 137

Lift and project cuts applied: 21

Gomory fractional cuts applied: 183

Root node processing (before b&c):

Real time = 0.00 sec. (2.40 ticks)

Parallel b&c, 8 threads:

Real time = 139.89 sec. (165844.88 ticks)

Sync time (average) = 3.07 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 139.89 sec. (165847.28 ticks)

-----

Iteration 13

Bounds on # of cuts = 8 with [3 3 2]

Error = 50 (out of 100 instances)

Accuracy = 50

Solving time = 2.331538167 min (minutes)

Accumulated time = 78.884066333 min (minutes)

Solution status code = 104

LB on error = -267.498135184

Relative objective gap = 6.349962704

Selected variables:

A\_AGE (Continuous)

PEMLR (Categorical)

Number of selected variables = 2 (1 continuous + 1 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |                    |
|--------------------------------|--------------------|
| CPXPARAM_MIP_Strategy_File     | 3                  |
| CPXPARAM_MIP_Limits_Solutions  | 1                  |
| CPXPARAM_TimeLimit             | 81666.956020019526 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800             |

| Nodes |      | Cuts/     |      |              |            |       |     |
|-------|------|-----------|------|--------------|------------|-------|-----|
| Node  | Left | Objective | IInf | Best Integer | Best Bound | ItCnt | Gap |

463135 158775    infeasible                    -50.0000        -367.4981 55198048    635.00%

Elapsed time = 0.72 sec. (15.17 ticks, tree = 9214.61 MB, solutions = 35)

Nodefile size = 7167.73 MB (6279.59 MB after compression)

|               |           |     |          |           |          |         |
|---------------|-----------|-----|----------|-----------|----------|---------|
| 463136 158777 | -366.5895 | 490 | -50.0000 | -367.4981 | 55198583 | 635.00% |
| 463140 158777 | -366.5176 | 642 | -50.0000 | -367.4981 | 55198925 | 635.00% |
| 463162 158789 | -348.1658 | 230 | -50.0000 | -367.4981 | 55199716 | 635.00% |
| 463191 158808 | -305.6908 | 217 | -50.0000 | -367.4981 | 55200151 | 635.00% |
| 463231 158839 | -228.0707 | 125 | -50.0000 | -367.4981 | 55200362 | 635.00% |
| 463277 158868 | -155.1797 | 87  | -50.0000 | -367.4981 | 55200885 | 635.00% |
| 463346 158903 | -73.9050  | 40  | -50.0000 | -367.4981 | 55201169 | 635.00% |
| 463386 158807 | -332.2260 | 227 | -50.0000 | -367.4981 | 55203386 | 635.00% |
| 463443 158821 | -309.8742 | 204 | -50.0000 | -367.4981 | 55202374 | 635.00% |
| 463885 158912 | -57.9050  | 30  | -50.0000 | -367.4981 | 55206450 | 635.00% |

Elapsed time = 4.78 sec. (3333.40 ticks, tree = 9185.11 MB, solutions = 35)

Nodefile size = 7167.73 MB (6279.59 MB after compression)

|               |           |     |          |           |          |         |
|---------------|-----------|-----|----------|-----------|----------|---------|
| 463977 158951 | -311.4922 | 247 | -50.0000 | -367.4981 | 55207360 | 635.00% |
| 464319 159014 | -129.0656 | 74  | -50.0000 | -367.4981 | 55211007 | 635.00% |
| 464400 159039 | -365.9692 | 556 | -50.0000 | -367.4981 | 55214011 | 635.00% |
| 464435 158914 | -363.0478 | 611 | -50.0000 | -367.4981 | 55217781 | 635.00% |
| 464654 158929 | -332.7367 | 352 | -50.0000 | -367.4981 | 55213624 | 635.00% |
| 464900 158970 | -238.0384 | 158 | -50.0000 | -367.3236 | 55215938 | 634.65% |
| 465154 159315 | -57.9050  | 43  | -50.0000 | -367.3236 | 55221298 | 634.65% |
| 465181 159068 | -320.7091 | 311 | -50.0000 | -367.3236 | 55222588 | 634.65% |

|   |        |           |     |          |           |          |         |
|---|--------|-----------|-----|----------|-----------|----------|---------|
| 465201  | 158920 | -354.1757 | 744 | -50.0000 | -367.3236 | 55218060 | 634.65% |
| 465256  | 159111 | -246.3611 | 193 | -50.0000 | -367.3236 | 55228446 | 634.65% |
| Elapsed time = 18.42 sec. (13757.59 ticks, tree = 9195.97 MB, solutions = 35) |        |           |     |          |           |          |         |
| Nodefile size = 7167.73 MB (6279.59 MB after compression)                     |        |           |     |          |           |          |         |
| 465358  | 159084 | -314.4182 | 271 | -50.0000 | -367.3236 | 55226164 | 634.65% |
| 465456  | 159131 | -187.6688 | 114 | -50.0000 | -367.3236 | 55228695 | 634.65% |
| 465661  | 158957 | -277.9212 | 163 | -50.0000 | -367.3236 | 55224025 | 634.65% |
| 466060  | 159341 | -322.8122 | 208 | -50.0000 | -367.3236 | 55231554 | 634.65% |
| 466373  | 159214 | -320.7883 | 207 | -50.0000 | -367.3236 | 55238808 | 634.65% |
| 466710  | 159450 | -363.6421 | 406 | -50.0000 | -367.3236 | 55235082 | 634.65% |
| 467092  | 159174 | -82.9050  | 46  | -50.0000 | -367.2274 | 55234189 | 634.45% |
| 467517  | 159450 | -80.0285  | 38  | -50.0000 | -367.2274 | 55243721 | 634.45% |
| 467643  | 159181 | -361.5120 | 332 | -50.0000 | -367.2274 | 55237667 | 634.45% |
| 467857  | 159282 | -137.5505 | 86  | -50.0000 | -367.2274 | 55239206 | 634.45% |
| Elapsed time = 30.58 sec. (23322.97 ticks, tree = 9206.18 MB, solutions = 35) |        |           |     |          |           |          |         |
| Nodefile size = 7167.73 MB (6279.59 MB after compression)                     |        |           |     |          |           |          |         |
| 468131  | 159579 | -98.6959  | 54  | -50.0000 | -367.2274 | 55248828 | 634.45% |
| 468495  | 159424 | -138.5116 | 92  | -50.0000 | -367.2274 | 55251419 | 634.45% |
| 468860  | 159757 | -299.5947 | 187 | -50.0000 | -367.2274 | 55249968 | 634.45% |
| 469263  | 159717 | -102.4586 | 55  | -50.0000 | -367.2274 | 55254216 | 634.45% |
| 469473  | 159677 | -150.4201 | 83  | -50.0000 | -367.2274 | 55251829 | 634.45% |
| 469748  | 159820 | -174.4052 | 108 | -50.0000 | -367.2274 | 55257568 | 634.45% |
| 470173  | 159481 | -323.6713 | 253 | -50.0000 | -367.2274 | 55252810 | 634.45% |
| 470415  | 158856 | -199.7805 | 124 | -50.0000 | -367.2274 | 55276184 | 634.45% |
| 470751  | 159959 | -175.7107 | 99  | -50.0000 | -367.2274 | 55263101 | 634.45% |
| 471015  | 159827 | -151.8560 | 89  | -50.0000 | -367.2274 | 55267815 | 634.45% |
| Elapsed time = 42.21 sec. (32903.35 ticks, tree = 9179.86 MB, solutions = 35) |        |           |     |          |           |          |         |
| Nodefile size = 7167.73 MB (6279.59 MB after compression)                     |        |           |     |          |           |          |         |
| 471249  | 160104 | -129.7341 | 76  | -50.0000 | -367.2274 | 55266272 | 634.45% |
| 471728  | 159717 | cutoff    |     | -50.0000 | -367.2274 | 55262790 | 634.45% |
| 472043  | 158873 | -146.7093 | 92  | -50.0000 | -367.2274 | 55269576 | 634.45% |
| 472112  | 159045 | -359.1444 | 299 | -50.0000 | -367.2274 | 55288895 | 634.45% |
| 472255  | 159107 | -255.2068 | 161 | -50.0000 | -367.2274 | 55290947 | 634.45% |
| 472607  | 160018 | -340.2480 | 214 | -50.0000 | -367.2274 | 55279581 | 634.45% |
| 473049  | 160115 | -107.4381 | 59  | -50.0000 | -367.2274 | 55281245 | 634.45% |
| 473256  | 160127 | -327.8756 | 214 | -50.0000 | -367.2274 | 55275796 | 634.45% |
| 473588  | 159992 | -67.9050  | 32  | -50.0000 | -367.2274 | 55278335 | 634.45% |
| 473847  | 159971 | -349.1251 | 284 | -50.0000 | -367.2274 | 55276168 | 634.45% |
| Elapsed time = 53.92 sec. (42468.69 ticks, tree = 9219.60 MB, solutions = 35) |        |           |     |          |           |          |         |



Nodefile size = 7167.73 MB (6279.59 MB after compression)

|                |           |     |  |          |                    |         |
|----------------|-----------|-----|--|----------|--------------------|---------|
| *473936+160266 |           |     |  | -51.0000 | -367.2274          | 620.05% |
| 474206 160073  | -106.9895 | 61  |  | -51.0000 | -367.2274 55277413 | 620.05% |
| 474463 160635  | -153.2612 | 94  |  | -51.0000 | -367.2274 55286212 | 620.05% |
| 474720 160190  | -231.7403 | 139 |  | -51.0000 | -367.2274 55285078 | 620.05% |
| 474998 160214  | -188.9340 | 119 |  | -51.0000 | -367.2274 55293399 | 620.05% |
| 475115 158909  | -351.2163 | 434 |  | -51.0000 | -367.2274 55286348 | 620.05% |
| 475182 160297  | -322.9094 | 208 |  | -51.0000 | -367.2274 55297449 | 620.05% |
| 475430 159398  | -178.7548 | 109 |  | -51.0000 | -367.2274 55314927 | 620.05% |
| 475645 160241  | -343.1800 | 338 |  | -51.0000 | -367.2274 55290066 | 620.05% |
| 475689 159453  | -352.9342 | 244 |  | -51.0000 | -367.2274 55318299 | 620.05% |
| 475854 159546  | -132.8329 | 74  |  | -51.0000 | -367.2274 55319648 | 620.05% |

Elapsed time = 65.35 sec. (52182.49 ticks, tree = 9149.24 MB, solutions = 37)

Nodefile size = 7167.73 MB (6279.59 MB after compression)

|               |           |     |  |          |                    |         |
|---------------|-----------|-----|--|----------|--------------------|---------|
| 476031 160718 | -240.2005 | 152 |  | -51.0000 | -367.2274 55306433 | 620.05% |
| 476142 159580 | -362.2827 | 332 |  | -51.0000 | -367.2274 55324358 | 620.05% |
| 476249 160829 | -310.6718 | 209 |  | -51.0000 | -367.2274 55309938 | 620.05% |
| 476542 159639 | -255.0189 | 186 |  | -51.0000 | -367.2274 55330168 | 620.05% |
| 476682 159724 | -364.8578 | 329 |  | -51.0000 | -367.2274 55332953 | 620.05% |
| 476863 159830 | -123.2319 | 72  |  | -51.0000 | -367.2274 55334306 | 620.05% |
| 477115 159915 | -264.5046 | 167 |  | -51.0000 | -367.2274 55335820 | 620.05% |
| 477332 159993 | -363.7070 | 330 |  | -51.0000 | -367.2274 55337385 | 620.05% |
| 477539 160005 | -346.0468 | 269 |  | -51.0000 | -367.2274 55340473 | 620.05% |
| 477743 160033 | -289.9295 | 263 |  | -51.0000 | -367.2274 55343355 | 620.05% |

Elapsed time = 76.10 sec. (61944.06 ticks, tree = 9151.21 MB, solutions = 37)

Nodefile size = 7167.73 MB (6279.59 MB after compression)

|               |           |     |  |          |                    |         |
|---------------|-----------|-----|--|----------|--------------------|---------|
| 478067 160528 | -58.4099  | 23  |  | -51.0000 | -367.2274 55320438 | 620.05% |
| 478272 161231 | -353.4015 | 234 |  | -51.0000 | -367.2274 55327993 | 620.05% |
| 478528 161319 | -127.3948 | 80  |  | -51.0000 | -367.2274 55330121 | 620.05% |
| 478842 160780 | -107.5241 | 73  |  | -51.0000 | -367.2274 55324854 | 620.05% |
| 479065 160251 | -364.3253 | 339 |  | -51.0000 | -367.2274 55353325 | 620.05% |
| 479151 160321 | -214.6277 | 139 |  | -51.0000 | -367.2274 55354988 | 620.05% |
| 479262 160382 | -363.8436 | 407 |  | -51.0000 | -367.2274 55356639 | 620.05% |
| 479450 159282 | -67.9050  | 30  |  | -51.0000 | -367.2274 55326580 | 620.05% |
| 479573 160516 | -80.8811  | 56  |  | -51.0000 | -367.2274 55359174 | 620.05% |
| 479698 159343 | -257.4662 | 179 |  | -51.0000 | -367.2274 55329998 | 620.05% |

Elapsed time = 87.26 sec. (71569.74 ticks, tree = 9167.39 MB, solutions = 37)

Nodefile size = 7167.73 MB (6279.59 MB after compression)

|               |          |    |  |          |                    |         |
|---------------|----------|----|--|----------|--------------------|---------|
| 479968 159410 | -78.9050 | 42 |  | -51.0000 | -367.2274 55331365 | 620.05% |
|---------------|----------|----|--|----------|--------------------|---------|

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 480111 | 160658 | -364.4200 | 444 | -51.0000 | -367.2274 | 55364600 | 620.05% |
| 480282 | 159204 | -331.5965 | 250 | -51.0000 | -367.2274 | 55319373 | 620.05% |
| 480731 | 161741 | -101.9345 | 64  | -51.0000 | -367.2274 | 55352367 | 620.05% |
| 480977 | 160912 | -99.4795  | 61  | -51.0000 | -367.2274 | 55369544 | 620.05% |
| 481190 | 161873 | -98.8474  | 60  | -51.0000 | -367.2274 | 55355666 | 620.05% |
| 481381 | 159573 | -347.1083 | 234 | -51.0000 | -367.2274 | 55341855 | 620.05% |
| 481707 | 160908 | -133.3562 | 68  | -51.0000 | -367.2274 | 55346119 | 620.05% |
| 481897 | 160938 | -363.3551 | 308 | -51.0000 | -367.2274 | 55348000 | 620.05% |
| 481964 | 162036 | -343.0073 | 212 | -51.0000 | -367.2274 | 55364517 | 620.05% |

Elapsed time = 98.33 sec. (81154.62 ticks, tree = 9209.33 MB, solutions = 37)

Nodefile size = 7167.73 MB (6279.59 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 482104 | 162103 | -209.0701 | 120 | -51.0000 | -367.2274 | 55366952 | 620.05% |
| 482251 | 161057 | -106.7135 | 99  | -51.0000 | -367.2274 | 55353243 | 620.05% |
| 482354 | 162205 | -281.0030 | 193 | -51.0000 | -367.2274 | 55370235 | 620.05% |
| 482515 | 161109 | -330.1069 | 237 | -51.0000 | -367.2274 | 55357746 | 620.05% |
| 482708 | 162411 | -81.9050  | 43  | -51.0000 | -367.2274 | 55372148 | 620.05% |
| 482820 | 162458 | -269.5278 | 203 | -51.0000 | -367.2274 | 55374343 | 620.05% |
| 482988 | 161088 | -309.6921 | 433 | -51.0000 | -367.2274 | 55399414 | 620.05% |
| 483039 | 162556 | -348.2095 | 215 | -51.0000 | -367.2274 | 55378317 | 620.05% |
| 483226 | 162656 | -89.9044  | 79  | -51.0000 | -367.2274 | 55379615 | 620.05% |
| 483938 | 161562 | -209.0311 | 125 | -51.0000 | -367.2274 | 55374982 | 620.05% |

Elapsed time = 113.95 sec. (93675.38 ticks, tree = 9187.73 MB, solutions = 37)

Nodefile size = 7167.73 MB (6279.59 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 484586 | 159413 | -172.3045 | 113 | -51.0000 | -367.2274 | 55359518 | 620.05% |
| 485529 | 161722 | -101.4604 | 54  | -51.0000 | -367.2274 | 55433697 | 620.05% |
| 486131 | 161941 | -232.0853 | 139 | -51.0000 | -367.2274 | 55443663 | 620.05% |
| 486946 | 162526 | -81.6550  | 59  | -51.0000 | -367.2274 | 55404513 | 620.05% |
| 487527 | 162760 | -156.1149 | 92  | -51.0000 | -367.2274 | 55412036 | 620.05% |
| 488098 | 162756 | -160.2393 | 94  | -51.0000 | -367.2274 | 55463473 | 620.05% |
| 488873 | 163196 | -364.3675 | 591 | -51.0000 | -367.2274 | 55428823 | 620.05% |
| 489167 | 163437 | -131.5328 | 86  | -51.0000 | -367.2274 | 55437245 | 620.05% |
| 489499 | 163605 | -353.8026 | 297 | -51.0000 | -367.2274 | 55443068 | 620.05% |
| 490304 | 163909 | -255.8353 | 167 | -51.0000 | -367.2274 | 55449013 | 620.05% |

Elapsed time = 143.38 sec. (132189.37 ticks, tree = 9198.49 MB, solutions = 37)

Nodefile size = 7167.73 MB (6279.59 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 490905 | 160344 | -153.9110 | 84  | -51.0000 | -367.2274 | 55422663 | 620.05% |
| 491333 | 160512 | -362.6557 | 903 | -51.0000 | -367.2274 | 55435036 | 620.05% |
| 491496 | 164109 | -56.2383  | 27  | -51.0000 | -367.2274 | 55478391 | 620.05% |
| 492194 | 160785 | -95.2200  | 49  | -51.0000 | -367.2274 | 55448138 | 620.05% |

|        |        |           |      |          |           |          |         |
|--------|--------|-----------|------|----------|-----------|----------|---------|
| 492741 | 160943 | -352.7760 | 226  | -51.0000 | -367.2274 | 55453097 | 620.05% |
| 493057 | 164745 | -364.0406 | 1032 | -51.0000 | -367.2274 | 55509590 | 620.05% |
| 493058 | 164746 | -359.9377 | 895  | -51.0000 | -367.2274 | 55516078 | 620.05% |
| 493120 | 164797 | -239.5931 | 151  | -51.0000 | -367.2274 | 55522135 | 620.05% |
| 493562 | 165115 | -101.7102 | 52   | -51.0000 | -367.2274 | 55526531 | 620.05% |
| 493915 | 165390 | -364.7521 | 472  | -51.0000 | -367.2274 | 55531114 | 620.05% |

Elapsed time = 181.06 sec. (181989.34 ticks, tree = 9277.64 MB, solutions = 37)

Nodefile size = 7167.73 MB (6279.59 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 494186 | 165607 | -206.6682 | 119 | -51.0000 | -367.2274 | 55535763 | 620.05% |
|--------|--------|-----------|-----|----------|-----------|----------|---------|

GUB cover cuts applied: 1670

Clique cuts applied: 55

Cover cuts applied: 4658

Implied bound cuts applied: 117

Flow cuts applied: 184

Mixed integer rounding cuts applied: 4034

Zero-half cuts applied: 137

Lift and project cuts applied: 21

Gomory fractional cuts applied: 185

Root node processing (before b&c):

Real time = 0.00 sec. (2.58 ticks)

Parallel b&c, 8 threads:

Real time = 188.35 sec. (189207.47 ticks)

Sync time (average) = 8.78 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 188.35 sec. (189210.06 ticks)

-----

Iteration 14

Bounds on # of cuts = 8 with [3 3 2]

Error = 49 (out of 100 instances)

Accuracy = 51

Solving time = 3.139274398 min (minutes)

Accumulated time = 82.023340731 min (minutes)

Solution status code = 104

LB on error = -267.006174534

Relative objective gap = 6.196199501

Selected variables:

A\_AGE (Continuous)

PEMLR (Categorical)

Number of selected variables = 2 (1 continuous + 1 categorical)

-----

Version identifier: 22.1.1.0 | 2022-11-28 | 9160aff4d

|                                |                    |
|--------------------------------|--------------------|
| CPXPARAM_MIP_Strategy_File     | 3                  |
| CPXPARAM_MIP_Limits_Solutions  | 1                  |
| CPXPARAM_TimeLimit             | 81478.599556152345 |
| CPXPARAM_MIP_Limits_TreeMemory | 204800             |

| Nodes   |        |            |      | Cuts/        |            |          |         |
|---|--------|------------|------|--------------|------------|----------|---------|
| Node  | Left   | Objective  | IInf | Best Integer | Best Bound | ItCnt    | Gap     |
| 494456  | 182201 | infeasible |      | -51.0000     | -367.0062  | 56675674 | 619.62% |
| Elapsed time = 0.24 sec. (15.33 ticks, tree = 9524.00 MB, solutions = 37)   |        |            |      |              |            |          |         |
| Nodefile size = 7477.22 MB (6520.03 MB after compression)                   |        |            |      |              |            |          |         |
| 494475  | 182210 | -351.9932  | 224  | -51.0000     | -367.0062  | 56676084 | 619.62% |
| 494530  | 182230 | -312.2393  | 195  | -51.0000     | -367.0062  | 56676456 | 619.62% |
| 494589  | 182255 | -259.6874  | 171  | -51.0000     | -367.0062  | 56676687 | 619.62% |
| 494665  | 182282 | -180.5270  | 126  | -51.0000     | -367.0062  | 56676863 | 619.62% |
| 494755  | 182309 | -122.6764  | 100  | -51.0000     | -367.0062  | 56677062 | 619.62% |
| 494863  | 182335 | cutoff     |      | -51.0000     | -367.0062  | 56677152 | 619.62% |
| 494937  | 182324 | -78.8158   | 40   | -51.0000     | -367.0062  | 56678670 | 619.62% |
| 494991  | 182280 | -211.8674  | 166  | -51.0000     | -367.0062  | 56678002 | 619.62% |
| 495064  | 182323 | -88.9050   | 60   | -51.0000     | -367.0062  | 56678696 | 619.62% |
| 495298  | 182342 | -361.4826  | 400  | -51.0000     | -367.0062  | 56679876 | 619.62% |
| Elapsed time = 4.70 sec. (3143.89 ticks, tree = 9530.75 MB, solutions = 37) |        |            |      |              |            |          |         |
| Nodefile size = 7477.22 MB (6520.03 MB after compression)                   |        |            |      |              |            |          |         |
| 495594  | 182388 | -251.8648  | 214  | -51.0000     | -367.0062  | 56683074 | 619.62% |
| 495860  | 182577 | -108.7543  | 80   | -51.0000     | -366.9523  | 56694950 | 619.51% |
| 496088  | 182540 | -189.7373  | 134  | -51.0000     | -366.9144  | 56684616 | 619.44% |
| 496320  | 182525 | -286.3870  | 178  | -51.0000     | -366.8762  | 56685783 | 619.37% |
| 496537  | 182580 | -340.4613  | 383  | -51.0000     | -366.8762  | 56706383 | 619.37% |
| 496821  | 182691 | -147.6478  | 81   | -51.0000     | -366.8762  | 56689431 | 619.37% |
| 497372  | 182733 | -88.9050   | 52   | -51.0000     | -366.8762  | 56690879 | 619.37% |

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 497664 | 182720 | -358.8124 | 331 | -51.0000 | -366.8762 | 56710686 | 619.37% |
| 498118 | 182764 | -237.3959 | 195 | -51.0000 | -366.8762 | 56719970 | 619.37% |
| 498480 | 182825 | -73.9050  | 56  | -51.0000 | -366.8762 | 56720555 | 619.37% |

Elapsed time = 17.54 sec. (12704.97 ticks, tree = 9531.09 MB, solutions = 37)

Nodefile size = 7477.22 MB (6520.03 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 498995 | 182744 | -91.4849  | 132 | -51.0000 | -366.8762 | 56695063 | 619.37% |
| 499164 | 182989 | -359.6095 | 298 | -51.0000 | -366.8762 | 56716539 | 619.37% |
| 499601 | 182253 | -244.0278 | 167 | -51.0000 | -366.8762 | 56701358 | 619.37% |
| 500209 | 183036 | -344.9522 | 226 | -51.0000 | -366.8762 | 56700971 | 619.37% |
| 500569 | 183145 | cutoff    |     | -51.0000 | -366.8762 | 56701706 | 619.37% |
| 500875 | 183215 | -223.8724 | 139 | -51.0000 | -366.8681 | 56703419 | 619.35% |
| 501515 | 183296 | -345.3847 | 265 | -51.0000 | -366.8681 | 56704825 | 619.35% |
| 502158 | 182831 | -92.9050  | 50  | -51.0000 | -366.8681 | 56713383 | 619.35% |
| 502527 | 183166 | -226.7766 | 170 | -51.0000 | -366.8681 | 56734624 | 619.35% |
| 502909 | 182911 | -262.1243 | 189 | -51.0000 | -366.8681 | 56716455 | 619.35% |

Elapsed time = 31.50 sec. (22253.24 ticks, tree = 9560.30 MB, solutions = 37)

Nodefile size = 7477.22 MB (6520.03 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 503332 | 183801 | -327.4005 | 260 | -51.0000 | -366.8681 | 56775885 | 619.35% |
| 503678 | 183393 | -63.9050  | 28  | -51.0000 | -366.8681 | 56750272 | 619.35% |
| 503992 | 183427 | -231.5535 | 138 | -51.0000 | -366.8681 | 56739737 | 619.35% |
| 504587 | 183223 | -69.9050  | 35  | -51.0000 | -366.8681 | 56721762 | 619.35% |
| 504948 | 183535 | -301.0740 | 190 | -51.0000 | -366.8681 | 56742532 | 619.35% |
| 505495 | 184109 | -189.3199 | 149 | -51.0000 | -366.8681 | 56735249 | 619.35% |
| 505823 | 184172 | -347.1391 | 255 | -51.0000 | -366.8681 | 56736378 | 619.35% |
| 506089 | 184248 | -152.5782 | 92  | -51.0000 | -366.8681 | 56737407 | 619.35% |
| 506643 | 185098 | -102.4718 | 45  | -51.0000 | -366.8681 | 56816717 | 619.35% |
| 507163 | 183514 | -94.8596  | 38  | -51.0000 | -366.8681 | 56762693 | 619.35% |

Elapsed time = 46.09 sec. (31831.63 ticks, tree = 9612.19 MB, solutions = 37)

Nodefile size = 7507.91 MB (6546.68 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 507847 | 183617 | -150.3053 | 85  | -51.0000 | -366.8681 | 56764277 | 619.35% |
| 508280 | 183802 | -328.5517 | 206 | -51.0000 | -366.8681 | 56736660 | 619.35% |
| 508940 | 182769 | -294.7658 | 190 | -51.0000 | -366.8681 | 56727257 | 619.35% |
| 509517 | 183778 | -95.4761  | 51  | -51.0000 | -366.8681 | 56769219 | 619.35% |
| 509986 | 183838 | -290.1692 | 199 | -51.0000 | -366.8681 | 56771014 | 619.35% |
| 510665 | 185497 | -128.6918 | 82  | -51.0000 | -366.8681 | 56826754 | 619.35% |
| 511065 | 184321 | -310.4287 | 177 | -51.0000 | -366.8681 | 56758291 | 619.35% |
| 511453 | 184748 | -323.7543 | 217 | -51.0000 | -366.8681 | 56799934 | 619.35% |
| 511733 | 185661 | -352.0178 | 342 | -51.0000 | -366.8681 | 56831520 | 619.35% |
| 512296 | 184878 | -331.4491 | 218 | -51.0000 | -366.8681 | 56802445 | 619.35% |

Elapsed time = 57.78 sec. (41390.10 ticks, tree = 9769.69 MB, solutions = 37)

Nodefile size = 7582.35 MB (6611.74 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 512740 | 183738 | -354.3047 | 315 | -51.0000 | -366.8681 | 56746494 | 619.35% |
| 513064 | 183797 | -218.5924 | 179 | -51.0000 | -366.8681 | 56747822 | 619.35% |
| 513481 | 184788 | -81.0717  | 42  | -51.0000 | -366.8681 | 56759505 | 619.35% |
| 513901 | 185908 | -76.0885  | 72  | -51.0000 | -366.8681 | 56837494 | 619.35% |
| 514340 | 185153 | -329.4190 | 291 | -51.0000 | -366.8681 | 56808466 | 619.35% |
| 514728 | 186009 | -167.6558 | 111 | -51.0000 | -366.8681 | 56840056 | 619.35% |
| 515145 | 186083 | -313.4338 | 183 | -51.0000 | -366.8681 | 56841160 | 619.35% |
| 515566 | 186176 | -351.2108 | 233 | -51.0000 | -366.8681 | 56842573 | 619.35% |
| 516099 | 183458 | -234.0999 | 156 | -51.0000 | -366.8681 | 56749879 | 619.35% |
| 516357 | 184213 | -145.4731 | 71  | -51.0000 | -366.8681 | 56758558 | 619.35% |

Elapsed time = 70.16 sec. (50950.48 ticks, tree = 9712.96 MB, solutions = 37)

Nodefile size = 7477.22 MB (6520.03 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 516670 | 183638 | -94.4050  | 69  | -51.0000 | -366.8681 | 56751485 | 619.35% |
| 516864 | 185539 | -353.3629 | 464 | -51.0000 | -366.8681 | 56816763 | 619.35% |
| 517026 | 184475 | -139.9466 | 79  | -51.0000 | -366.8681 | 56762655 | 619.35% |
| 517314 | 183765 | -107.6787 | 60  | -51.0000 | -366.8681 | 56756087 | 619.35% |
| 517555 | 183845 | -229.9116 | 137 | -51.0000 | -366.8681 | 56757069 | 619.35% |
| 517758 | 185685 | -338.3882 | 320 | -51.0000 | -366.8681 | 56822383 | 619.35% |
| 517891 | 186354 | -219.8397 | 132 | -51.0000 | -366.8681 | 56852885 | 619.35% |
| 518073 | 184508 | -358.8005 | 571 | -51.0000 | -366.8681 | 56769302 | 619.35% |
| 518144 | 186464 | -294.3353 | 217 | -51.0000 | -366.8681 | 56855343 | 619.35% |
| 518452 | 184522 | -338.0686 | 327 | -51.0000 | -366.8681 | 56773560 | 619.35% |

Elapsed time = 82.11 sec. (60586.41 ticks, tree = 9748.86 MB, solutions = 37)

Nodefile size = 7477.22 MB (6520.03 MB after compression)

|        |        |            |     |          |           |          |         |
|--------|--------|------------|-----|----------|-----------|----------|---------|
| 518550 | 186598 | -301.8589  | 186 | -51.0000 | -366.8681 | 56857731 | 619.35% |
| 518811 | 184586 | -223.8810  | 142 | -51.0000 | -366.8681 | 56777456 | 619.35% |
| 519155 | 186711 | -339.9077  | 213 | -51.0000 | -366.8681 | 56860244 | 619.35% |
| 519520 | 184342 | -334.0798  | 215 | -51.0000 | -366.8681 | 56774326 | 619.35% |
| 520022 | 184788 | -364.9442  | 404 | -51.0000 | -366.8681 | 56781028 | 619.35% |
| 520231 | 184896 | -112.3531  | 60  | -51.0000 | -366.8681 | 56782057 | 619.35% |
| 520511 | 186342 | -61.9044   | 48  | -51.0000 | -366.8681 | 56836938 | 619.35% |
| 520730 | 185006 | -324.4910  | 234 | -51.0000 | -366.8681 | 56821850 | 619.35% |
| 521264 | 186394 | -278.5470  | 174 | -51.0000 | -366.8681 | 56840495 | 619.35% |
| 521704 | 187004 | infeasible |     | -51.0000 | -366.8681 | 56869988 | 619.35% |

Elapsed time = 94.06 sec. (70165.35 ticks, tree = 10016.79 MB, solutions = 37)

Nodefile size = 7722.86 MB (6734.35 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 522368 | 185197 | -202.6451 | 126 | -51.0000 | -366.8681 | 56827042 | 619.35% |
|--------|--------|-----------|-----|----------|-----------|----------|---------|

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 523238 | 186645 | -324.7403 | 228 | -51.0000 | -366.8681 | 56843991 | 619.35% |
| 523980 | 184871 | -232.7469 | 163 | -51.0000 | -366.8681 | 56807304 | 619.35% |
| 524708 | 185358 | -157.1693 | 125 | -51.0000 | -366.8681 | 56831143 | 619.35% |
| 525280 | 185365 | -269.3653 | 153 | -51.0000 | -366.8681 | 56795954 | 619.35% |
| 526076 | 187442 | -206.7137 | 130 | -51.0000 | -366.8681 | 56875020 | 619.35% |
| 526790 | 187097 | -172.2746 | 99  | -51.0000 | -366.8681 | 56849651 | 619.35% |
| 527291 | 187608 | -120.3658 | 68  | -51.0000 | -366.8681 | 56877135 | 619.35% |
| 527767 | 187253 | -100.7237 | 59  | -51.0000 | -366.8681 | 56851707 | 619.35% |
| 528154 | 185854 | -221.2637 | 143 | -51.0000 | -366.8681 | 56837647 | 619.35% |

Elapsed time = 105.04 sec. (79721.78 ticks, tree = 9885.67 MB, solutions = 37)

Nodefile size = 7507.91 MB (6546.68 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 528448 | 185109 | -360.5449 | 304 | -51.0000 | -366.8681 | 56798386 | 619.35% |
| 528973 | 187895 | -53.9050  | 24  | -51.0000 | -366.8681 | 56882736 | 619.35% |
| 529424 | 187460 | -214.0870 | 144 | -51.0000 | -366.8681 | 56857690 | 619.35% |
| 529852 | 185284 | -258.7113 | 179 | -51.0000 | -366.8681 | 56801753 | 619.35% |
| 530303 | 185125 | -310.7185 | 195 | -51.0000 | -366.8681 | 56801060 | 619.35% |
| 530717 | 186242 | -282.9556 | 190 | -51.0000 | -366.8681 | 56845048 | 619.35% |
| 531229 | 188181 | -355.5929 | 249 | -51.0000 | -366.8681 | 56888841 | 619.35% |
| 531749 | 185561 | -244.8323 | 151 | -51.0000 | -366.8681 | 56806389 | 619.35% |
| 532217 | 187856 | -154.1270 | 103 | -51.0000 | -366.8681 | 56865472 | 619.35% |
| 534491 | 186745 | -336.7932 | 237 | -51.0000 | -366.8681 | 56853455 | 619.35% |

Elapsed time = 119.93 sec. (92134.22 ticks, tree = 9989.67 MB, solutions = 37)

Nodefile size = 7507.91 MB (6546.68 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 537173 | 186121 | -92.9050  | 64  | -51.0000 | -366.8681 | 56817216 | 619.35% |
| 539433 | 186104 | -360.0615 | 320 | -51.0000 | -366.8681 | 56829949 | 619.35% |
| 541783 | 189363 | -350.7550 | 227 | -51.0000 | -366.8681 | 56911498 | 619.35% |
| 544525 | 189732 | -354.4750 | 399 | -51.0000 | -366.8681 | 56916526 | 619.35% |
| 547325 | 187207 | -180.8447 | 112 | -51.0000 | -366.8681 | 56852153 | 619.35% |
| 549534 | 187269 | -359.7960 | 299 | -51.0000 | -366.8681 | 56841886 | 619.35% |
| 552483 | 188561 | -76.0000  | 37  | -51.0000 | -366.8681 | 56890908 | 619.35% |
| 555018 | 187941 | -292.0210 | 169 | -51.0000 | -366.8681 | 56850235 | 619.35% |
| 557686 | 188231 | -248.4755 | 165 | -51.0000 | -366.8681 | 56855537 | 619.35% |
| 560583 | 190787 | -328.4668 | 210 | -51.0000 | -366.8681 | 56924690 | 619.35% |

Elapsed time = 165.90 sec. (130289.67 ticks, tree = 10459.45 MB, solutions = 37)

Nodefile size = 7582.35 MB (6611.74 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 563125 | 189628 | -59.9050  | 34  | -51.0000 | -366.8681 | 56911187 | 619.35% |
| 565396 | 189136 | -263.8448 | 164 | -51.0000 | -366.8681 | 56885160 | 619.35% |
| 568071 | 190242 | -138.8590 | 81  | -51.0000 | -366.8209 | 56920270 | 619.26% |
| 570320 | 189734 | -104.5327 | 70  | -51.0000 | -366.8209 | 56893599 | 619.26% |

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 573161 | 191852 | -256.3504 | 179 | -51.0000 | -366.8209 | 57017459 | 619.26% |
| 575843 | 191145 | -210.8755 | 128 | -51.0000 | -366.8209 | 56934904 | 619.26% |
| 578475 | 190142 | -345.4650 | 248 | -51.0000 | -366.8209 | 56896990 | 619.26% |
| 581192 | 192533 | -166.7373 | 98  | -51.0000 | -366.8209 | 57036295 | 619.26% |
| 583459 | 192174 | -248.0752 | 140 | -51.0000 | -366.8209 | 56949279 | 619.26% |
| 585497 | 192912 | -207.3005 | 124 | -51.0000 | -366.8209 | 57048453 | 619.26% |

Elapsed time = 227.81 sec. (168444.95 ticks, tree = 10705.98 MB, solutions = 37)

Nodefile size = 8470.98 MB (7389.34 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 587923 | 194446 | -219.1194 | 128 | -51.0000 | -366.8209 | 57002407 | 619.26% |
| 590344 | 193814 | -191.1955 | 108 | -51.0000 | -366.8209 | 56985418 | 619.26% |
| 592510 | 191113 | -132.6357 | 88  | -51.0000 | -366.8209 | 56935710 | 619.26% |
| 594613 | 193928 | -278.0600 | 157 | -51.0000 | -366.8209 | 57069018 | 619.26% |
| 596034 | 194250 | -121.5324 | 72  | -51.0000 | -366.8209 | 57074094 | 619.26% |
| 597396 | 191764 | -298.5444 | 188 | -51.0000 | -366.8209 | 56955753 | 619.26% |
| 598784 | 192141 | -156.6665 | 97  | -51.0000 | -366.8209 | 56955666 | 619.26% |
| 599769 | 192343 | -327.9550 | 264 | -51.0000 | -366.8209 | 56962010 | 619.26% |
| 600940 | 192582 | -61.4004  | 30  | -51.0000 | -366.8209 | 56968128 | 619.26% |
| 602947 | 191282 | -360.3925 | 339 | -51.0000 | -366.8209 | 56966375 | 619.26% |

Elapsed time = 273.41 sec. (206606.47 ticks, tree = 10538.83 MB, solutions = 37)

Nodefile size = 7477.22 MB (6520.03 MB after compression)

|        |        |           |      |          |           |          |         |
|--------|--------|-----------|------|----------|-----------|----------|---------|
| 604824 | 195159 | -209.5223 | 165  | -51.0000 | -366.8209 | 57110082 | 619.26% |
| 606991 | 194686 | -228.1652 | 141  | -51.0000 | -366.8209 | 57033764 | 619.26% |
| 609377 | 196058 | -89.4794  | 40   | -51.0000 | -366.8209 | 57072395 | 619.26% |
| 611483 | 196054 | -210.2735 | 128  | -51.0000 | -366.8209 | 57126646 | 619.26% |
| 612145 | 196417 | -241.6389 | 147  | -51.0000 | -366.8209 | 57130810 | 619.26% |
| 612256 | 195015 | -359.0492 | 1034 | -51.0000 | -366.8125 | 57046859 | 619.24% |
| 612368 | 217470 | -320.2838 | 211  | -51.0000 | -366.7797 | 57738968 | 619.18% |
| 612887 | 228501 | -284.2145 | 276  | -51.0000 | -366.7797 | 58010282 | 619.18% |
| 613500 | 239780 | -358.5293 | 274  | -51.0000 | -366.7797 | 58330379 | 619.18% |
| 613861 | 251538 | -360.7471 | 397  | -51.0000 | -366.7514 | 58625105 | 619.12% |

Elapsed time = 387.78 sec. (245504.90 ticks, tree = 17529.07 MB, solutions = 37)

Nodefile size = 15466.73 MB (13518.12 MB after compression)

|        |        |           |      |          |           |          |         |
|--------|--------|-----------|------|----------|-----------|----------|---------|
| 615353 | 239610 | -359.5604 | 1040 | -51.0000 | -366.7514 | 58326157 | 619.12% |
| 616586 | 263789 | -273.0794 | 174  | -51.0000 | -366.7514 | 58939204 | 619.12% |
| 617658 | 274839 | -355.0167 | 266  | -51.0000 | -366.3450 | 59284748 | 618.32% |
| 618974 | 275150 | -281.4216 | 230  | -51.0000 | -366.3450 | 59302104 | 618.32% |
| 620336 | 276782 | -209.2482 | 130  | -51.0000 | -366.3450 | 59362700 | 618.32% |
| 621684 | 277961 | -214.6874 | 119  | -51.0000 | -366.3450 | 59441273 | 618.32% |
| 622900 | 278715 | -298.6923 | 213  | -51.0000 | -366.3450 | 59465451 | 618.32% |



|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 624291 | 279922 | -315.4854 | 231 | -51.0000 | -366.3450 | 59533597 | 618.32% |
| 625218 | 281037 | -120.8353 | 63  | -51.0000 | -366.3450 | 59570495 | 618.32% |
| 625993 | 281792 | -361.4253 | 347 | -51.0000 | -366.3450 | 59617364 | 618.32% |

Elapsed time = 469.11 sec. (283897.44 ticks, tree = 21071.25 MB, solutions = 37)

Nodefile size = 18993.43 MB (16609.64 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 626629 | 282086 | -355.1436 | 393 | -51.0000 | -366.3450 | 59634771 | 618.32% |
| 627551 | 282737 | -161.8955 | 100 | -51.0000 | -366.3450 | 59683802 | 618.32% |
| 628412 | 283151 | -358.0560 | 333 | -51.0000 | -366.3450 | 59702143 | 618.32% |
| 629606 | 283908 | -223.1311 | 128 | -51.0000 | -366.3358 | 59768358 | 618.31% |
| 630987 | 285351 | -186.6854 | 131 | -51.0000 | -365.9983 | 59853631 | 617.64% |
| 631970 | 286256 | -60.4004  | 37  | -51.0000 | -365.9983 | 59881553 | 617.64% |
| 632808 | 286815 | -190.7839 | 136 | -51.0000 | -365.9983 | 59919228 | 617.64% |
| 634294 | 287409 | -119.7052 | 96  | -51.0000 | -365.9983 | 59983074 | 617.64% |
| 635715 | 288834 | -355.2322 | 320 | -51.0000 | -365.8797 | 60038286 | 617.41% |
| 636500 | 289526 | -336.6266 | 237 | -51.0000 | -365.8797 | 60093169 | 617.41% |

Elapsed time = 527.49 sec. (322134.89 ticks, tree = 22006.45 MB, solutions = 37)

Nodefile size = 19922.83 MB (17427.82 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 637899 | 289868 | -261.2537 | 170 | -51.0000 | -365.8532 | 60117036 | 617.36% |
| 639303 | 291156 | -357.4336 | 362 | -51.0000 | -365.8468 | 60164756 | 617.35% |
| 640364 | 292296 | -357.0002 | 225 | -51.0000 | -365.8468 | 60205310 | 617.35% |
| 641826 | 293296 | -129.2980 | 67  | -51.0000 | -365.8468 | 60231289 | 617.35% |
| 643710 | 294344 | -324.7103 | 219 | -51.0000 | -365.8468 | 60275209 | 617.35% |
| 645087 | 295929 | -357.5296 | 251 | -51.0000 | -365.8468 | 60347341 | 617.35% |
| 647574 | 297096 | -361.3072 | 347 | -51.0000 | -365.8468 | 60403205 | 617.35% |
| 650132 | 298525 | -157.9824 | 91  | -51.0000 | -365.8468 | 60437070 | 617.35% |
| 652370 | 300285 | -215.2495 | 130 | -51.0000 | -365.8468 | 60481233 | 617.35% |
| 653642 | 302565 | -225.2487 | 127 | -51.0000 | -365.8468 | 60540176 | 617.35% |

Elapsed time = 588.75 sec. (360318.24 ticks, tree = 23214.25 MB, solutions = 37)

Nodefile size = 21147.62 MB (18482.80 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 655359 | 303578 | -241.1639 | 143 | -51.0000 | -365.8468 | 60576128 | 617.35% |
| 656778 | 304539 | -233.3815 | 133 | -51.0000 | -365.7387 | 60611664 | 617.13% |
| 658460 | 305910 | -334.7923 | 278 | -51.0000 | -365.6873 | 60683628 | 617.03% |
| 661036 | 307178 | -306.5428 | 187 | -51.0000 | -365.6873 | 60721530 | 617.03% |
| 662791 | 308542 | -360.1018 | 349 | -51.0000 | -365.6873 | 60767056 | 617.03% |
| 664931 | 310615 | -73.4004  | 33  | -51.0000 | -365.6873 | 60843282 | 617.03% |
| 666181 | 311479 | -80.9050  | 38  | -51.0000 | -365.5489 | 60873920 | 616.76% |
| 667712 | 313460 | -341.7799 | 221 | -51.0000 | -365.4342 | 60942375 | 616.54% |
| 668738 | 314033 | -250.3615 | 164 | -51.0000 | -365.4342 | 60969439 | 616.54% |
| 670378 | 314777 | -340.3181 | 254 | -51.0000 | -365.4342 | 61007417 | 616.54% |

Elapsed time = 648.51 sec. (398512.68 ticks, tree = 24220.43 MB, solutions = 37)

Nodefile size = 22149.07 MB (19347.63 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 671660 | 316624 | -190.6028 | 117 | -51.0000 | -365.4342 | 61082628 | 616.54% |
| 673339 | 316740 | -255.8649 | 201 | -51.0000 | -365.4342 | 61117104 | 616.54% |
| 675296 | 318619 | -119.2922 | 64  | -51.0000 | -365.4342 | 61162844 | 616.54% |
| 677401 | 320444 | -231.1208 | 167 | -51.0000 | -365.4342 | 61223447 | 616.54% |
| 679864 | 321923 | -307.6958 | 207 | -51.0000 | -365.4342 | 61254347 | 616.54% |
| 681222 | 323429 | -355.7521 | 293 | -51.0000 | -365.4342 | 61293481 | 616.54% |
| 682604 | 324985 | -164.2641 | 90  | -51.0000 | -365.3694 | 61405616 | 616.41% |
| 684015 | 325743 | -179.6358 | 117 | -51.0000 | -365.3555 | 61458609 | 616.38% |
| 685518 | 327413 | -250.6560 | 141 | -51.0000 | -365.3071 | 61539485 | 616.29% |
| 687434 | 328626 | -146.6897 | 95  | -51.0000 | -365.3062 | 61584384 | 616.29% |

Elapsed time = 708.04 sec. (436685.01 ticks, tree = 25451.98 MB, solutions = 37)

Nodefile size = 23372.09 MB (20413.94 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 689399 | 329467 | -99.3480  | 36  | -51.0000 | -365.2479 | 61635355 | 616.17% |
| 691000 | 331344 | -346.8231 | 238 | -51.0000 | -365.2050 | 61692904 | 616.09% |
| 692237 | 332230 | -329.2119 | 241 | -51.0000 | -365.2050 | 61733192 | 616.09% |
| 693523 | 332898 | -86.5479  | 42  | -51.0000 | -365.2050 | 61759830 | 616.09% |
| 694552 | 333849 | -187.8206 | 113 | -51.0000 | -365.1849 | 61826192 | 616.05% |
| 696545 | 334946 | -64.0000  | 28  | -51.0000 | -365.1849 | 61889587 | 616.05% |
| 698225 | 336435 | -223.7746 | 142 | -51.0000 | -365.1395 | 61969519 | 615.96% |
| 700385 | 337181 | -141.2558 | 76  | -51.0000 | -365.1393 | 61999411 | 615.96% |
| 701942 | 339213 | -228.3630 | 129 | -51.0000 | -365.1151 | 62061295 | 615.91% |
| 703039 | 340138 | -336.6943 | 518 | -51.0000 | -365.1074 | 62106040 | 615.90% |

Elapsed time = 769.48 sec. (474868.46 ticks, tree = 26523.33 MB, solutions = 37)

Nodefile size = 24455.97 MB (21345.49 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 703806 | 340972 | -154.5474 | 96  | -51.0000 | -365.1074 | 62151674 | 615.90% |
| 704648 | 342280 | -338.7462 | 252 | -51.0000 | -365.1031 | 62231946 | 615.89% |
| 705803 | 342510 | -349.4838 | 328 | -51.0000 | -365.0948 | 62264654 | 615.87% |
| 706909 | 343736 | -348.7916 | 269 | -51.0000 | -365.0948 | 62339333 | 615.87% |
| 708639 | 344121 | -208.9617 | 132 | -51.0000 | -365.0948 | 62361186 | 615.87% |
| 710029 | 345547 | -179.6985 | 112 | -51.0000 | -365.0948 | 62447113 | 615.87% |
| 711771 | 346626 | -185.8141 | 108 | -51.0000 | -365.0912 | 62486059 | 615.87% |
| 712627 | 348066 | -362.4201 | 343 | -51.0000 | -365.0912 | 62582067 | 615.87% |
| 713715 | 348780 | -80.0606  | 43  | -51.0000 | -365.0912 | 62624224 | 615.87% |
| 715391 | 349314 | -306.6991 | 235 | -51.0000 | -365.0912 | 62666144 | 615.87% |

Elapsed time = 824.55 sec. (513173.77 ticks, tree = 26881.08 MB, solutions = 37)

Nodefile size = 24808.87 MB (21640.42 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 717378 | 350702 | -353.4336 | 324 | -51.0000 | -365.0912 | 62715620 | 615.87% |
|--------|--------|-----------|-----|----------|-----------|----------|---------|

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 719540 | 351649 | -316.9172 | 222 | -51.0000 | -365.0912 | 62746033 | 615.87% |
| 721322 | 353579 | -162.3109 | 86  | -51.0000 | -365.0912 | 62799262 | 615.87% |
| 723113 | 355134 | -63.9143  | 35  | -51.0000 | -365.0289 | 62843640 | 615.74% |
| 724802 | 356270 | -143.9895 | 81  | -51.0000 | -365.0169 | 62884338 | 615.72% |
| 726441 | 357146 | -175.7427 | 100 | -51.0000 | -365.0169 | 62911220 | 615.72% |
| 728427 | 358874 | -343.8456 | 331 | -51.0000 | -365.0169 | 63006867 | 615.72% |
| 731003 | 361195 | -342.7434 | 262 | -51.0000 | -365.0169 | 63074158 | 615.72% |
| 733427 | 361941 | -268.4267 | 171 | -51.0000 | -364.9677 | 63090909 | 615.62% |
| 735290 | 363459 | cutoff    |     | -51.0000 | -364.9677 | 63130298 | 615.62% |

Elapsed time = 885.78 sec. (551330.14 ticks, tree = 28246.52 MB, solutions = 37)

Nodefile size = 26162.99 MB (22819.78 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 737115 | 365594 | -144.9050 | 89  | -51.0000 | -364.9635 | 63178021 | 615.61% |
| 738541 | 366505 | -117.0880 | 69  | -51.0000 | -364.9446 | 63192669 | 615.58% |
| 739326 | 367895 | -338.1909 | 310 | -51.0000 | -364.9446 | 63273313 | 615.58% |
| 740151 | 368444 | -354.4144 | 323 | -51.0000 | -364.9446 | 63300507 | 615.58% |
| 742291 | 369430 | -258.6669 | 164 | -51.0000 | -364.9336 | 63409029 | 615.56% |
| 745357 | 370124 | -133.1314 | 67  | -51.0000 | -364.9268 | 63420455 | 615.54% |
| 747378 | 373306 | -70.4004  | 24  | -51.0000 | -364.9221 | 63486694 | 615.53% |
| 749580 | 374547 | -60.0000  | 43  | -51.0000 | -364.9158 | 63533026 | 615.52% |
| 752396 | 376503 | -224.8379 | 132 | -51.0000 | -364.9158 | 63590702 | 615.52% |
| 753817 | 377198 | -110.4004 | 59  | -51.0000 | -364.9158 | 63601596 | 615.52% |

Elapsed time = 947.27 sec. (589510.67 ticks, tree = 29838.63 MB, solutions = 37)

Nodefile size = 27723.94 MB (24182.95 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 754664 | 378350 | -313.3719 | 241 | -51.0000 | -364.9158 | 63637522 | 615.52% |
| 755945 | 380009 | -132.6635 | 77  | -51.0000 | -364.8896 | 63692159 | 615.47% |
| 756996 | 381032 | -114.4004 | 55  | -51.0000 | -364.8721 | 63750087 | 615.44% |
| 758046 | 382017 | -353.4691 | 330 | -51.0000 | -364.8721 | 63794359 | 615.44% |
| 758657 | 382456 | -354.2886 | 246 | -51.0000 | -364.8721 | 63843088 | 615.44% |
| 759881 | 382519 | -240.3827 | 153 | -51.0000 | -364.8710 | 63859500 | 615.43% |
| 761113 | 384017 | -109.7342 | 57  | -51.0000 | -364.8710 | 63946364 | 615.43% |
| 762231 | 384489 | -201.7776 | 137 | -51.0000 | -364.8699 | 63967543 | 615.43% |
| 763687 | 385146 | -167.7341 | 97  | -51.0000 | -364.8699 | 64005961 | 615.43% |
| 764990 | 386464 | -360.0574 | 326 | -51.0000 | -364.8699 | 64058084 | 615.43% |

Elapsed time = 1005.19 sec. (627814.24 ticks, tree = 30794.27 MB, solutions = 37)

Nodefile size = 28692.51 MB (25023.74 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 765714 | 386900 | -139.3959 | 80  | -51.0000 | -364.8697 | 64109034 | 615.43% |
| 766817 | 387531 | -295.4339 | 190 | -51.0000 | -364.8697 | 64159777 | 615.43% |
| 767913 | 388740 | -70.4004  | 29  | -51.0000 | -364.8697 | 64211795 | 615.43% |
| 768975 | 390150 | -137.9050 | 71  | -51.0000 | -364.8697 | 64307062 | 615.43% |

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 771045 | 390586 | -353.6152 | 274 | -51.0000 | -364.8488 | 64348089 | 615.39% |
| 773557 | 392244 | -62.7203  | 32  | -51.0000 | -364.8292 | 64409874 | 615.35% |
| 775988 | 394237 | cutoff    |     | -51.0000 | -364.8095 | 64462634 | 615.31% |
| 777702 | 396139 | -166.8143 | 88  | -51.0000 | -364.8095 | 64503623 | 615.31% |
| 779614 | 396520 | -122.6436 | 68  | -51.0000 | -364.7910 | 64539613 | 615.28% |
| 782146 | 398855 | -312.5603 | 192 | -51.0000 | -364.7910 | 64610935 | 615.28% |

Elapsed time = 1065.82 sec. (665982.42 ticks, tree = 32000.35 MB, solutions = 37)

Nodefile size = 29928.83 MB (26098.76 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 784000 | 399838 | -224.3325 | 136 | -51.0000 | -364.7910 | 64651290 | 615.28% |
| 785883 | 401786 | -194.0282 | 115 | -51.0000 | -364.7910 | 64740881 | 615.28% |
| 787276 | 402494 | -236.2952 | 187 | -51.0000 | -364.7910 | 64773173 | 615.28% |
| 788203 | 403332 | -208.3501 | 132 | -51.0000 | -364.7626 | 64821019 | 615.22% |
| 789654 | 404080 | -274.5377 | 173 | -51.0000 | -364.7626 | 64871019 | 615.22% |
| 791185 | 405717 | -136.7522 | 74  | -51.0000 | -364.7626 | 64928476 | 615.22% |
| 792944 | 407063 | -143.8552 | 81  | -51.0000 | -364.7489 | 65009012 | 615.19% |
| 794449 | 407935 | -60.4004  | 35  | -51.0000 | -364.7489 | 65055525 | 615.19% |
| 796012 | 408937 | -244.0269 | 148 | -51.0000 | -364.7489 | 65090206 | 615.19% |
| 797658 | 410676 | -108.4004 | 65  | -51.0000 | -364.7316 | 65157440 | 615.16% |

Elapsed time = 1123.50 sec. (704203.36 ticks, tree = 32906.29 MB, solutions = 37)

Nodefile size = 30835.32 MB (26886.41 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 799447 | 411601 | -334.4220 | 270 | -51.0000 | -364.7302 | 65214712 | 615.16% |
| 800825 | 412665 | -327.5934 | 259 | -51.0000 | -364.7141 | 65259056 | 615.13% |
| 801941 | 413971 | -339.3653 | 241 | -51.0000 | -364.7058 | 65332119 | 615.11% |
| 803933 | 414717 | -68.2934  | 28  | -51.0000 | -364.7058 | 65352630 | 615.11% |
| 806553 | 416163 | -182.9371 | 105 | -51.0000 | -364.7058 | 65420516 | 615.11% |
| 808329 | 417827 | -92.0000  | 46  | -51.0000 | -364.6968 | 65446803 | 615.09% |
| 809926 | 419512 | -324.4454 | 225 | -51.0000 | -364.6968 | 65503730 | 615.09% |
| 811015 | 420726 | -346.9501 | 222 | -51.0000 | -364.6855 | 65546728 | 615.07% |
| 812351 | 421285 | -332.8297 | 220 | -51.0000 | -364.6809 | 65576229 | 615.06% |
| 813635 | 422486 | -188.0082 | 108 | -51.0000 | -364.6809 | 65605887 | 615.06% |

Elapsed time = 1183.30 sec. (742384.03 ticks, tree = 34000.77 MB, solutions = 37)

Nodefile size = 31911.50 MB (27825.65 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 815552 | 423494 | -73.9775  | 32  | -51.0000 | -364.6777 | 65663571 | 615.05% |
| 817134 | 424794 | -341.0814 | 263 | -51.0000 | -364.6777 | 65690837 | 615.05% |
| 818641 | 426281 | -180.3990 | 110 | -51.0000 | -364.6777 | 65757727 | 615.05% |
| 820682 | 426974 | -165.8716 | 91  | -51.0000 | -364.6777 | 65800359 | 615.05% |
| 822833 | 428289 | -84.4004  | 53  | -51.0000 | -364.6777 | 65824189 | 615.05% |
| 824603 | 430176 | -322.1515 | 209 | -51.0000 | -364.6777 | 65871864 | 615.05% |
| 826717 | 432281 | -222.8604 | 118 | -51.0000 | -364.6777 | 65938161 | 615.05% |

|   |        |           |     |          |           |          |         |
|---|--------|-----------|-----|----------|-----------|----------|---------|
| 828986  | 432669 | -221.0570 | 168 | -51.0000 | -364.6777 | 65943629 | 615.05% |
| 830980  | 435000 | -274.5929 | 162 | -51.0000 | -364.6777 | 66001113 | 615.05% |
| 833801  | 436907 | -324.0902 | 213 | -51.0000 | -364.6475 | 66128348 | 615.00% |
| Elapsed time = 1245.90 sec. (780552.64 ticks, tree = 35882.93 MB, solutions = 37) |        |           |     |          |           |          |         |
| Nodefile size = 33776.48 MB (29467.99 MB after compression)                       |        |           |     |          |           |          |         |
| 835709  | 439181 | -133.2156 | 72  | -51.0000 | -364.6475 | 66178885 | 615.00% |
| 837674  | 439908 | -175.4624 | 114 | -51.0000 | -364.6475 | 66189714 | 615.00% |
| 839601  | 441162 | -250.9862 | 176 | -51.0000 | -364.6475 | 66240455 | 615.00% |
| 841355  | 442464 | -300.2932 | 199 | -51.0000 | -364.5726 | 66291801 | 614.85% |
| 842695  | 444227 | -317.4591 | 246 | -51.0000 | -364.5726 | 66361667 | 614.85% |
| 844185  | 445795 | -174.4656 | 98  | -51.0000 | -364.5726 | 66440393 | 614.85% |
| 845686  | 446846 | -285.6416 | 179 | -51.0000 | -364.5718 | 66500594 | 614.85% |
| 847592  | 448069 | -114.7342 | 59  | -51.0000 | -364.5542 | 66550404 | 614.81% |
| 849312  | 448835 | -257.9658 | 167 | -51.0000 | -364.5542 | 66582371 | 614.81% |
| 851394  | 450013 | -314.9399 | 211 | -51.0000 | -364.5542 | 66633782 | 614.81% |
| Elapsed time = 1307.35 sec. (818726.26 ticks, tree = 37244.89 MB, solutions = 37) |        |           |     |          |           |          |         |
| Nodefile size = 35133.82 MB (30656.34 MB after compression)                       |        |           |     |          |           |          |         |
| 853084  | 452324 | -312.0660 | 196 | -51.0000 | -364.5542 | 66693652 | 614.81% |
| 854812  | 453846 | -356.9786 | 261 | -51.0000 | -364.5542 | 66761242 | 614.81% |
| 855968  | 454651 | -63.4004  | 24  | -51.0000 | -364.5542 | 66802143 | 614.81% |
| 857129  | 455667 | -171.9293 | 96  | -51.0000 | -364.5490 | 66843806 | 614.80% |
| 858381  | 456135 | -163.1172 | 96  | -51.0000 | -364.5490 | 66892873 | 614.80% |
| 860461  | 456922 | -61.1046  | 29  | -51.0000 | -364.5490 | 66953083 | 614.80% |
| 862972  | 458277 | -214.0353 | 124 | -51.0000 | -364.5200 | 66982830 | 614.75% |
| 865304  | 460473 | -180.0223 | 111 | -51.0000 | -364.5200 | 67059361 | 614.75% |
| 867660  | 461169 | -321.5716 | 208 | -51.0000 | -364.4985 | 67072536 | 614.70% |
| 870293  | 463316 | -340.5852 | 217 | -51.0000 | -364.4819 | 67128946 | 614.67% |
| Elapsed time = 1368.78 sec. (856888.40 ticks, tree = 38648.48 MB, solutions = 37) |        |           |     |          |           |          |         |
| Nodefile size = 36539.17 MB (31877.98 MB after compression)                       |        |           |     |          |           |          |         |
| 873538  | 467608 | -217.7467 | 139 | -51.0000 | -364.4664 | 67233746 | 614.64% |
| 876593  | 467125 | -244.4728 | 135 | -51.0000 | -364.4574 | 67228464 | 614.62% |
| 879178  | 470882 | -154.9824 | 104 | -51.0000 | -364.4499 | 67296718 | 614.61% |
| 881958  | 472445 | -284.8297 | 214 | -51.0000 | -364.4351 | 67334944 | 614.58% |
| 884732  | 474861 | -279.1491 | 156 | -51.0000 | -364.4351 | 67377191 | 614.58% |
| 887617  | 477416 | -315.0698 | 194 | -51.0000 | -364.4211 | 67435378 | 614.55% |
| 890379  | 478124 | -214.2439 | 123 | -51.0000 | -364.4195 | 67448458 | 614.55% |
| 892245  | 480785 | -325.1725 | 248 | -51.0000 | -364.4066 | 67510545 | 614.52% |
| 894557  | 482750 | -324.9394 | 205 | -51.0000 | -364.4066 | 67569546 | 614.52% |
| 896840  | 483406 | -343.9195 | 287 | -51.0000 | -364.3964 | 67595487 | 614.50% |

Elapsed time = 1434.42 sec. (895055.27 ticks, tree = 41047.78 MB, solutions = 37)

Nodefile size = 38972.02 MB (34000.81 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 898846 | 485804 | -362.7281 | 405 | -51.0000 | -364.3964 | 67685395 | 614.50% |
| 900772 | 486739 | -93.3809  | 45  | -51.0000 | -364.3964 | 67709447 | 614.50% |
| 902306 | 488326 | -249.0641 | 223 | -51.0000 | -364.3780 | 67756185 | 614.47% |
| 904443 | 489887 | -182.8472 | 107 | -51.0000 | -364.3780 | 67817292 | 614.47% |
| 906206 | 491028 | -234.4828 | 133 | -51.0000 | -364.3780 | 67848657 | 614.47% |
| 907466 | 491892 | -312.0740 | 182 | -51.0000 | -364.3676 | 67899357 | 614.45% |
| 908931 | 493915 | -326.9604 | 233 | -51.0000 | -364.3676 | 67959190 | 614.45% |
| 910191 | 494806 | -275.8860 | 191 | -51.0000 | -364.3676 | 68017211 | 614.45% |
| 911432 | 496455 | -70.3965  | 32  | -51.0000 | -364.3676 | 68085484 | 614.45% |
| 912334 | 496717 | -64.4004  | 28  | -51.0000 | -364.3676 | 68095822 | 614.45% |

Elapsed time = 1492.98 sec. (933225.40 ticks, tree = 41910.78 MB, solutions = 37)

Nodefile size = 39834.84 MB (34729.80 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 913439 | 497838 | -194.3815 | 105 | -51.0000 | -364.3676 | 68177102 | 614.45% |
| 914980 | 498261 | -152.9293 | 86  | -51.0000 | -364.3676 | 68196338 | 614.45% |
| 915804 | 499766 | -323.8244 | 224 | -51.0000 | -364.3575 | 68290289 | 614.43% |
| 916628 | 500079 | -302.3960 | 211 | -51.0000 | -364.3575 | 68305529 | 614.43% |
| 918039 | 500368 | -343.3726 | 228 | -51.0000 | -364.3403 | 68340234 | 614.39% |
| 920007 | 501929 | -275.8006 | 198 | -51.0000 | -364.3317 | 68419509 | 614.38% |
| 922741 | 503623 | -362.6283 | 406 | -51.0000 | -364.3275 | 68467641 | 614.37% |
| 925606 | 505643 | -142.1086 | 79  | -51.0000 | -364.3179 | 68521503 | 614.35% |
| 928546 | 508163 | -217.8474 | 137 | -51.0000 | -364.3103 | 68580599 | 614.33% |
| 930886 | 509848 | -158.5826 | 87  | -51.0000 | -364.2995 | 68622180 | 614.31% |

Elapsed time = 1554.53 sec. (971382.80 ticks, tree = 43251.15 MB, solutions = 37)

Nodefile size = 41149.86 MB (35884.09 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 932899 | 511986 | -119.3072 | 74  | -51.0000 | -364.2902 | 68685278 | 614.29% |
| 934637 | 512936 | -269.4526 | 187 | -51.0000 | -364.2902 | 68703163 | 614.29% |
| 936749 | 513505 | -198.9682 | 162 | -51.0000 | -364.2805 | 68733415 | 614.28% |
| 939019 | 516384 | -100.4004 | 61  | -51.0000 | -364.2805 | 68830529 | 614.28% |
| 940965 | 516910 | -213.4897 | 124 | -51.0000 | -364.2729 | 68840204 | 614.26% |
| 943366 | 518019 | -329.1310 | 247 | -51.0000 | -364.2674 | 68885751 | 614.25% |
| 946119 | 520442 | -350.7558 | 252 | -51.0000 | -364.2625 | 68944343 | 614.24% |
| 949262 | 523916 | -170.8749 | 94  | -51.0000 | -364.2478 | 69045300 | 614.21% |
| 951577 | 525662 | -284.4097 | 170 | -51.0000 | -364.2457 | 69087488 | 614.21% |
| 953822 | 526036 | -343.7839 | 272 | -51.0000 | -364.2457 | 69097886 | 614.21% |

Elapsed time = 1618.93 sec. (1009540.36 ticks, tree = 44976.81 MB, solutions = 37)

Nodefile size = 42900.58 MB (37403.42 MB after compression)

|        |        |           |    |          |           |          |         |
|--------|--------|-----------|----|----------|-----------|----------|---------|
| 956067 | 528253 | -114.9327 | 57 | -51.0000 | -364.2457 | 69141165 | 614.21% |
|--------|--------|-----------|----|----------|-----------|----------|---------|

|        |        |            |     |          |           |          |         |
|--------|--------|------------|-----|----------|-----------|----------|---------|
| 958128 | 529673 | -203.9004  | 114 | -51.0000 | -364.2349 | 69171360 | 614.19% |
| 960075 | 531911 | -80.4004   | 39  | -51.0000 | -364.2178 | 69250399 | 614.15% |
| 961383 | 532901 | -192.4865  | 122 | -51.0000 | -364.2178 | 69269827 | 614.15% |
| 963351 | 534290 | -331.6833  | 237 | -51.0000 | -364.2171 | 69334703 | 614.15% |
| 964998 | 535026 | -292.4749  | 209 | -51.0000 | -364.2171 | 69368474 | 614.15% |
| 966596 | 537588 | -233.1557  | 129 | -51.0000 | -364.2171 | 69455104 | 614.15% |
| 968783 | 537908 | infeasible |     | -51.0000 | -364.1968 | 69462106 | 614.11% |
| 970664 | 538749 | -158.7677  | 91  | -51.0000 | -364.1944 | 69525096 | 614.11% |
| 971877 | 540717 | -303.3489  | 187 | -51.0000 | -364.1830 | 69565557 | 614.08% |

Elapsed time = 1681.97 sec. (1047705.63 ticks, tree = 46825.36 MB, solutions = 37)

Nodefile size = 44749.88 MB (39030.34 MB after compression)

|        |        |           |     |          |           |          |         |
|--------|--------|-----------|-----|----------|-----------|----------|---------|
| 972591 | 541449 | -360.6409 | 389 | -51.0000 | -364.1830 | 69614316 | 614.08% |
| 973284 | 542393 | -346.1220 | 219 | -51.0000 | -364.1810 | 69668081 | 614.08% |
| 974504 | 543255 | -356.6271 | 308 | -51.0000 | -364.1748 | 69742147 | 614.07% |
| 975615 | 544122 | -82.3339  | 49  | -51.0000 | -364.1721 | 69809177 | 614.06% |
| 976405 | 544162 | -359.4143 | 328 | -51.0000 | -364.1721 | 69815975 | 614.06% |
| 978363 | 545748 | -101.4004 | 57  | -51.0000 | -364.1668 | 69906213 | 614.05% |
| 979846 | 546197 | -351.0579 | 406 | -51.0000 | -364.1654 | 69950306 | 614.05% |
| 981386 | 547870 | -81.4004  | 39  | -51.0000 | -364.1654 | 69980541 | 614.05% |
| 982550 | 549015 | -333.7721 | 202 | -51.0000 | -364.1654 | 70056096 | 614.05% |
| 983567 | 549656 | -147.8308 | 79  | -51.0000 | -364.1654 | 70073713 | 614.05% |

Elapsed time = 1742.23 sec. (1085912.50 ticks, tree = 47716.70 MB, solutions = 37)

Nodefile size = 45612.43 MB (39779.51 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 984554  | 551413 | cutoff    |     | -51.0000 | -364.1654 | 70161318 | 614.05% |
| 985491  | 551428 | -150.5823 | 93  | -51.0000 | -364.1654 | 70191726 | 614.05% |
| 986750  | 552700 | -282.6257 | 188 | -51.0000 | -364.1467 | 70255403 | 614.01% |
| 988694  | 553598 | -362.4581 | 443 | -51.0000 | -364.1387 | 70317096 | 614.00% |
| 990679  | 555384 | -217.3788 | 127 | -51.0000 | -364.1311 | 70394011 | 613.98% |
| 992846  | 556974 | -362.6461 | 391 | -51.0000 | -364.1311 | 70465635 | 613.98% |
| 994875  | 556704 | -249.0947 | 144 | -51.0000 | -364.1311 | 70449904 | 613.98% |
| 996495  | 558587 | -56.8487  | 28  | -51.0000 | -364.1193 | 70519524 | 613.96% |
| 998699  | 558897 | -98.4589  | 53  | -51.0000 | -364.1120 | 70551356 | 613.95% |
| 1000118 | 561480 | -343.5201 | 231 | -51.0000 | -364.1120 | 70621249 | 613.95% |

Elapsed time = 1798.66 sec. (1124089.14 ticks, tree = 48342.35 MB, solutions = 37)

Nodefile size = 46248.91 MB (40321.99 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1002022 | 563411 | -277.8063 | 195 | -51.0000 | -364.1120 | 70676416 | 613.95% |
| 1003930 | 564748 | -65.4004  | 19  | -51.0000 | -364.1120 | 70710284 | 613.95% |
| 1006162 | 565013 | -362.5691 | 336 | -51.0000 | -364.1120 | 70739515 | 613.95% |
| 1008681 | 566024 | -125.8004 | 73  | -51.0000 | -364.1120 | 70757009 | 613.95% |

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1010748 | 569646 | -67.4004  | 33  | -51.0000 | -364.1120 | 70829790 | 613.95% |
| 1012267 | 569841 | -291.9516 | 204 | -51.0000 | -364.1120 | 70837248 | 613.95% |
| 1013891 | 572086 | -161.2518 | 85  | -51.0000 | -364.1120 | 70909039 | 613.95% |
| 1015221 | 573589 | -211.6472 | 122 | -51.0000 | -364.1120 | 70967323 | 613.95% |
| 1016223 | 573677 | -312.2773 | 198 | -51.0000 | -364.1120 | 70974601 | 613.95% |
| 1018064 | 575321 | -64.4004  | 27  | -51.0000 | -364.0706 | 71125303 | 613.86% |

Elapsed time = 1860.88 sec. (1162268.08 ticks, tree = 49744.02 MB, solutions = 37)

Nodefile size = 47631.36 MB (41523.58 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1019166 | 576465 | -115.9403 | 63  | -51.0000 | -364.0706 | 71178541 | 613.86% |
| 1020846 | 576679 | -64.4004  | 35  | -51.0000 | -364.0568 | 71195308 | 613.84% |
| 1022213 | 578055 | -173.5622 | 90  | -51.0000 | -364.0568 | 71266779 | 613.84% |
| 1023857 | 578647 | -65.4004  | 29  | -51.0000 | -364.0531 | 71297045 | 613.83% |
| 1026303 | 581678 | -234.5717 | 164 | -51.0000 | -364.0414 | 71391239 | 613.81% |
| 1029153 | 583567 | -158.5802 | 93  | -51.0000 | -364.0414 | 71445861 | 613.81% |
| 1032346 | 585534 | -348.8949 | 248 | -51.0000 | -364.0236 | 71475979 | 613.77% |
| 1035328 | 585926 | -347.8431 | 215 | -51.0000 | -364.0196 | 71480905 | 613.76% |
| 1037744 | 587920 | -211.7419 | 131 | -51.0000 | -364.0029 | 71521216 | 613.73% |
| 1040441 | 591033 | -303.7881 | 176 | -51.0000 | -363.9979 | 71589175 | 613.72% |

Elapsed time = 1926.76 sec. (1200428.91 ticks, tree = 51781.74 MB, solutions = 37)

Nodefile size = 49671.30 MB (43311.39 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1042352 | 593264 | -71.9796  | 30  | -51.0000 | -363.9963 | 71626550 | 613.72% |
| 1043678 | 593042 | -324.0286 | 219 | -51.0000 | -363.9963 | 71627371 | 613.72% |
| 1045587 | 595732 | -200.1915 | 114 | -51.0000 | -363.9832 | 71708209 | 613.69% |
| 1047688 | 596461 | -254.6115 | 163 | -51.0000 | -363.9832 | 71730582 | 613.69% |
| 1049872 | 597740 | -287.0454 | 175 | -51.0000 | -363.9832 | 71785578 | 613.69% |
| 1051704 | 600386 | -91.4004  | 47  | -51.0000 | -363.9832 | 71849627 | 613.69% |
| 1053617 | 602054 | -261.5171 | 153 | -51.0000 | -363.9772 | 71927071 | 613.68% |
| 1055976 | 603674 | -132.4849 | 72  | -51.0000 | -363.9772 | 71965461 | 613.68% |
| 1058607 | 604897 | -255.3902 | 153 | -51.0000 | -363.9635 | 72011301 | 613.65% |
| 1060413 | 605986 | -354.7212 | 330 | -51.0000 | -363.9578 | 72031929 | 613.64% |

Elapsed time = 1988.67 sec. (1238609.25 ticks, tree = 53778.28 MB, solutions = 37)

Nodefile size = 51644.80 MB (45060.90 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1061914 | 607317 | cutoff    |     | -51.0000 | -363.9507 | 72074436 | 613.63% |
| 1063680 | 609340 | -360.3288 | 326 | -51.0000 | -363.9390 | 72148771 | 613.61% |
| 1065328 | 610155 | -124.4046 | 63  | -51.0000 | -363.9390 | 72161179 | 613.61% |
| 1066797 | 611383 | -59.0000  | 29  | -51.0000 | -363.9390 | 72237860 | 613.61% |
| 1068142 | 612237 | -224.3689 | 137 | -51.0000 | -363.9354 | 72271213 | 613.60% |
| 1070142 | 614705 | -76.4004  | 67  | -51.0000 | -363.9267 | 72406469 | 613.58% |
| 1071992 | 614979 | -246.9402 | 155 | -51.0000 | -363.9267 | 72398235 | 613.58% |



|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1073903 | 617010 | -228.2843 | 137 | -51.0000 | -363.9267 | 72494327 | 613.58% |
| 1075706 | 617392 | -204.5836 | 114 | -51.0000 | -363.9267 | 72507148 | 613.58% |
| 1077501 | 619338 | -86.0025  | 40  | -51.0000 | -363.9267 | 72547889 | 613.58% |

Elapsed time = 2046.66 sec. (1276770.39 ticks, tree = 54677.74 MB, solutions = 37)

Nodefile size = 52565.31 MB (45853.57 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1079161 | 620410 | -209.3248 | 118 | -51.0000 | -363.9135 | 72608861 | 613.56% |
| 1081649 | 622851 | -300.1106 | 181 | -51.0000 | -363.8983 | 72686256 | 613.53% |
| 1083926 | 623234 | -323.1341 | 202 | -51.0000 | -363.8983 | 72691650 | 613.53% |
| 1086076 | 625246 | -193.9602 | 117 | -51.0000 | -363.8939 | 72732098 | 613.52% |
| 1088179 | 627756 | -283.5262 | 204 | -51.0000 | -363.8939 | 72790211 | 613.52% |
| 1091190 | 628092 | -287.6054 | 202 | -51.0000 | -363.8939 | 72814198 | 613.52% |
| 1093431 | 629524 | -254.8223 | 146 | -51.0000 | -363.8939 | 72854966 | 613.52% |
| 1095986 | 632197 | -346.0530 | 225 | -51.0000 | -363.8939 | 72931006 | 613.52% |
| 1098500 | 634277 | -179.1473 | 104 | -51.0000 | -363.8939 | 72978948 | 613.52% |
| 1100539 | 636794 | -187.8855 | 109 | -51.0000 | -363.8939 | 73044618 | 613.52% |

Elapsed time = 2112.64 sec. (1314938.67 ticks, tree = 56546.65 MB, solutions = 37)

Nodefile size = 54466.62 MB (47506.30 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1103600 | 637668 | -312.4463 | 201 | -51.0000 | -363.8939 | 73072583 | 613.52% |
| 1106082 | 638900 | -267.2381 | 173 | -51.0000 | -363.8939 | 73105694 | 613.52% |
| 1108007 | 641241 | -209.4077 | 120 | -51.0000 | -363.8939 | 73190173 | 613.52% |
| 1109950 | 644769 | -99.5139  | 51  | -51.0000 | -363.8939 | 73272081 | 613.52% |
| 1111945 | 645280 | -92.0000  | 48  | -51.0000 | -363.8939 | 73287605 | 613.52% |
| 1113936 | 646411 | -228.3004 | 131 | -51.0000 | -363.8939 | 73319493 | 613.52% |
| 1116470 | 648988 | -229.0410 | 145 | -51.0000 | -363.8939 | 73413311 | 613.52% |
| 1119248 | 649821 | -191.2266 | 109 | -51.0000 | -363.8939 | 73426213 | 613.52% |
| 1121744 | 651852 | -229.0925 | 141 | -51.0000 | -363.8939 | 73474305 | 613.52% |
| 1124550 | 652993 | -117.5139 | 51  | -51.0000 | -363.8939 | 73494935 | 613.52% |

Elapsed time = 2177.62 sec. (1353097.69 ticks, tree = 58255.81 MB, solutions = 37)

Nodefile size = 56118.36 MB (48944.37 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1127139 | 655456 | -90.7754  | 40  | -51.0000 | -363.8939 | 73547001 | 613.52% |
| 1130118 | 657939 | -351.8666 | 276 | -51.0000 | -363.8281 | 73617943 | 613.39% |
| 1132460 | 659122 | -340.0214 | 322 | -51.0000 | -363.8281 | 73638023 | 613.39% |
| 1135268 | 661999 | -350.3458 | 253 | -51.0000 | -363.8281 | 73703788 | 613.39% |
| 1138155 | 663270 | -349.7733 | 221 | -51.0000 | -363.7914 | 73727031 | 613.32% |
| 1141315 | 666997 | -109.6681 | 61  | -51.0000 | -363.7801 | 73803719 | 613.29% |
| 1143035 | 667300 | -319.7683 | 197 | -51.0000 | -363.7685 | 73809554 | 613.27% |
| 1144567 | 670776 | -253.0387 | 158 | -51.0000 | -363.7537 | 73913216 | 613.24% |
| 1146521 | 670545 | -259.3532 | 152 | -51.0000 | -363.7537 | 73901076 | 613.24% |
| 1149449 | 672203 | -348.4441 | 219 | -51.0000 | -363.7500 | 73968135 | 613.24% |

Elapsed time = 2242.11 sec. (1391262.97 ticks, tree = 60633.18 MB, solutions = 37)

Nodefile size = 58549.92 MB (51084.18 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1152049 | 673941 | -272.6028 | 196 | -51.0000 | -363.7500 | 74029925 | 613.24% |
| 1154335 | 675960 | -232.3749 | 144 | -51.0000 | -363.7346 | 74096293 | 613.21% |
| 1156256 | 677959 | -342.2852 | 228 | -51.0000 | -363.7346 | 74162994 | 613.21% |
| 1158262 | 679301 | -283.8515 | 185 | -51.0000 | -363.7346 | 74213670 | 613.21% |
| 1160659 | 681152 | -329.8099 | 233 | -51.0000 | -363.7346 | 74291318 | 613.21% |
| 1163080 | 682052 | -356.6172 | 229 | -51.0000 | -363.7346 | 74302383 | 613.21% |
| 1164962 | 684898 | -239.2677 | 149 | -51.0000 | -363.7346 | 74363108 | 613.21% |
| 1166859 | 686253 | -215.5065 | 147 | -51.0000 | -363.7035 | 74429048 | 613.14% |
| 1169268 | 687434 | -137.5978 | 79  | -51.0000 | -363.7026 | 74462687 | 613.14% |
| 1171545 | 689622 | -209.2428 | 119 | -51.0000 | -363.7026 | 74521715 | 613.14% |

Elapsed time = 2302.32 sec. (1429431.71 ticks, tree = 61810.58 MB, solutions = 37)

Nodefile size = 59703.04 MB (52075.58 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1173411 | 692218 | -356.7395 | 294 | -51.0000 | -363.7002 | 74586749 | 613.14% |
| 1175378 | 692552 | -168.7210 | 87  | -51.0000 | -363.6861 | 74594723 | 613.11% |
| 1177260 | 694405 | -353.1794 | 310 | -51.0000 | -363.6861 | 74666144 | 613.11% |
| 1178498 | 695421 | -323.5001 | 196 | -51.0000 | -363.6825 | 74706969 | 613.10% |
| 1180148 | 696748 | -157.0337 | 90  | -51.0000 | -363.6825 | 74757697 | 613.10% |
| 1181894 | 698492 | -174.7770 | 102 | -51.0000 | -363.6749 | 74851125 | 613.09% |
| 1183386 | 700062 | -74.6611  | 40  | -51.0000 | -363.6749 | 74931587 | 613.09% |
| 1185302 | 699922 | -80.6800  | 35  | -51.0000 | -363.6678 | 74926413 | 613.07% |
| 1186617 | 701400 | -271.7142 | 167 | -51.0000 | -363.6671 | 74988295 | 613.07% |
| 1189228 | 702436 | -317.6486 | 188 | -51.0000 | -363.6556 | 75016408 | 613.05% |

Elapsed time = 2360.98 sec. (1467594.59 ticks, tree = 62502.87 MB, solutions = 37)

Nodefile size = 60366.86 MB (52639.96 MB after compression)

|         |        |            |     |          |           |          |         |
|---------|--------|------------|-----|----------|-----------|----------|---------|
| 1191792 | 705430 | -255.5873  | 151 | -51.0000 | -363.6524 | 75108073 | 613.04% |
| 1194437 | 706237 | -124.2892  | 69  | -51.0000 | -363.6470 | 75131286 | 613.03% |
| 1197089 | 707759 | -307.1593  | 218 | -51.0000 | -363.6470 | 75162684 | 613.03% |
| 1199984 | 710769 | -130.2921  | 67  | -51.0000 | -363.6466 | 75226744 | 613.03% |
| 1202782 | 713542 | infeasible |     | -51.0000 | -363.6466 | 75289008 | 613.03% |
| 1205543 | 714868 | -250.1788  | 148 | -51.0000 | -363.6466 | 75306792 | 613.03% |
| 1207640 | 716798 | -324.8750  | 197 | -51.0000 | -363.6272 | 75347915 | 612.99% |
| 1209905 | 717923 | -274.8872  | 173 | -51.0000 | -363.6272 | 75381128 | 612.99% |
| 1211507 | 720196 | -128.8731  | 68  | -51.0000 | -363.6147 | 75451092 | 612.97% |
| 1212988 | 721254 | -185.9255  | 105 | -51.0000 | -363.6147 | 75476208 | 612.97% |

Elapsed time = 2430.66 sec. (1505753.18 ticks, tree = 65025.03 MB, solutions = 37)

Nodefile size = 62942.95 MB (54909.80 MB after compression)

|         |        |           |    |          |           |          |         |
|---------|--------|-----------|----|----------|-----------|----------|---------|
| 1214464 | 721679 | -114.8208 | 59 | -51.0000 | -363.6147 | 75481562 | 612.97% |
|---------|--------|-----------|----|----------|-----------|----------|---------|

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1216487 | 723625 | -345.3600 | 243 | -51.0000 | -363.6147 | 75547226 | 612.97% |
| 1218075 | 723995 | -323.9574 | 195 | -51.0000 | -363.6134 | 75552962 | 612.97% |
| 1219748 | 725238 | -302.7574 | 216 | -51.0000 | -363.6134 | 75612915 | 612.97% |
| 1221521 | 726612 | -361.9645 | 476 | -51.0000 | -363.5945 | 75637366 | 612.93% |
| 1222967 | 728865 | -342.9362 | 292 | -51.0000 | -363.5945 | 75726583 | 612.93% |
| 1224384 | 730826 | -247.8571 | 152 | -51.0000 | -363.5945 | 75797131 | 612.93% |
| 1225757 | 731044 | -330.0338 | 261 | -51.0000 | -363.5945 | 75791560 | 612.93% |
| 1226952 | 732586 | -258.1447 | 163 | -51.0000 | -363.5845 | 75882721 | 612.91% |
| 1228618 | 732872 | -321.9352 | 194 | -51.0000 | -363.5839 | 75927746 | 612.91% |

Elapsed time = 2489.07 sec. (1543964.51 ticks, tree = 66176.85 MB, solutions = 37)

Nodefile size = 64093.97 MB (55912.45 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1230703 | 733149 | -351.7396 | 436 | -51.0000 | -363.5839 | 75968280 | 612.91% |
| 1233278 | 735609 | -131.9364 | 71  | -51.0000 | -363.5839 | 76043170 | 612.91% |
| 1234652 | 737416 | -235.5213 | 139 | -51.0000 | -363.5839 | 76127813 | 612.91% |
| 1236454 | 738419 | -181.1871 | 107 | -51.0000 | -363.5549 | 76156762 | 612.85% |
| 1237699 | 740772 | -129.0000 | 66  | -51.0000 | -363.5549 | 76254593 | 612.85% |
| 1239535 | 740626 | -147.0000 | 76  | -51.0000 | -363.5501 | 76250246 | 612.84% |
| 1241284 | 742271 | -246.1793 | 138 | -51.0000 | -363.5421 | 76335355 | 612.83% |
| 1243215 | 744506 | -336.5570 | 217 | -51.0000 | -363.5421 | 76435943 | 612.83% |
| 1245194 | 745177 | -297.8112 | 177 | -51.0000 | -363.5421 | 76453687 | 612.83% |
| 1247711 | 747555 | -348.0724 | 218 | -51.0000 | -363.5421 | 76533897 | 612.83% |

Elapsed time = 2544.68 sec. (1582125.76 ticks, tree = 66528.97 MB, solutions = 37)

Nodefile size = 64413.10 MB (56160.38 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1250771 | 749319 | -339.8761 | 240 | -51.0000 | -363.5421 | 76568677 | 612.83% |
| 1253428 | 749875 | -124.3338 | 66  | -51.0000 | -363.5421 | 76582998 | 612.83% |
| 1255484 | 752046 | -313.9867 | 199 | -51.0000 | -363.5421 | 76616090 | 612.83% |
| 1257505 | 755090 | -350.9171 | 242 | -51.0000 | -363.5421 | 76681612 | 612.83% |
| 1260061 | 756810 | -221.2307 | 125 | -51.0000 | -363.5421 | 76709254 | 612.83% |
| 1262802 | 758964 | -239.4641 | 151 | -51.0000 | -363.5421 | 76823900 | 612.83% |
| 1266020 | 760556 | -67.0000  | 27  | -51.0000 | -363.5421 | 76853753 | 612.83% |
| 1268615 | 762001 | -360.4381 | 313 | -51.0000 | -363.5421 | 76882255 | 612.83% |
| 1270717 | 764173 | -272.7824 | 204 | -51.0000 | -363.5421 | 76921149 | 612.83% |
| 1273013 | 764966 | -349.1395 | 221 | -51.0000 | -363.5421 | 76934663 | 612.83% |

Elapsed time = 2612.51 sec. (1620287.49 ticks, tree = 68888.14 MB, solutions = 37)

Nodefile size = 66752.03 MB (58218.78 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1274910 | 766152 | -207.9977 | 119 | -51.0000 | -363.5421 | 76966938 | 612.83% |
| 1276895 | 767806 | -303.6618 | 187 | -51.0000 | -363.5421 | 77002202 | 612.83% |
| 1279341 | 770025 | -65.0000  | 32  | -51.0000 | -363.5421 | 77074936 | 612.83% |
| 1281908 | 771422 | -347.6908 | 259 | -51.0000 | -363.5421 | 77108674 | 612.83% |

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1284101 | 773070 | -177.3216 | 96  | -51.0000 | -363.5421 | 77190936 | 612.83% |
| 1286070 | 776897 | -256.3404 | 143 | -51.0000 | -363.5421 | 77312454 | 612.83% |
| 1287980 | 777168 | -310.7619 | 207 | -51.0000 | -363.5421 | 77318855 | 612.83% |
| 1290484 | 778922 | -188.5016 | 112 | -51.0000 | -363.5421 | 77387526 | 612.83% |
| 1293069 | 781489 | -349.1820 | 220 | -51.0000 | -363.5421 | 77460748 | 612.83% |
| 1296398 | 783285 | -98.9651  | 55  | -51.0000 | -363.4446 | 77499923 | 612.64% |

Elapsed time = 2669.17 sec. (1658442.71 ticks, tree = 70071.06 MB, solutions = 37)

Nodefile size = 67958.53 MB (59253.49 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1299543 | 786097 | -336.3001 | 223 | -51.0000 | -363.4300 | 77552721 | 612.61% |
| 1303025 | 787564 | -273.5397 | 156 | -51.0000 | -363.4226 | 77573312 | 612.59% |
| 1306367 | 789080 | -165.2899 | 99  | -51.0000 | -363.4165 | 77602295 | 612.58% |
| 1309683 | 790823 | -118.8209 | 58  | -51.0000 | -363.4165 | 77631755 | 612.58% |
| 1312927 | 792605 | -219.8976 | 134 | -51.0000 | -363.4015 | 77657849 | 612.55% |
| 1315995 | 795803 | -116.3636 | 55  | -51.0000 | -363.3930 | 77719274 | 612.54% |
| 1318964 | 798022 | -189.8624 | 104 | -51.0000 | -363.3865 | 77756398 | 612.52% |
| 1322287 | 801721 | -105.9631 | 46  | -51.0000 | -363.3788 | 77824176 | 612.51% |
| 1325904 | 803857 | -200.5226 | 112 | -51.0000 | -363.3710 | 77862574 | 612.49% |
| 1328164 | 806865 | -213.8837 | 137 | -51.0000 | -363.3676 | 77911316 | 612.49% |

Elapsed time = 2740.62 sec. (1696601.21 ticks, tree = 73281.65 MB, solutions = 37)

Nodefile size = 71175.40 MB (62084.28 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1330725 | 808432 | -253.4076 | 158 | -51.0000 | -363.3637 | 77946512 | 612.48% |
| 1333424 | 811368 | -83.0000  | 38  | -51.0000 | -363.3566 | 77996494 | 612.46% |
| 1335998 | 812588 | -207.2111 | 132 | -51.0000 | -363.3501 | 78032150 | 612.45% |
| 1338136 | 815838 | -262.3210 | 156 | -51.0000 | -363.3501 | 78120654 | 612.45% |
| 1340355 | 816178 | -79.0000  | 32  | -51.0000 | -363.3501 | 78126079 | 612.45% |
| 1342750 | 818717 | -179.9456 | 121 | -51.0000 | -363.3501 | 78197929 | 612.45% |
| 1344977 | 819655 | -64.0000  | 23  | -51.0000 | -363.3495 | 78246621 | 612.45% |
| 1347424 | 820968 | -220.0034 | 147 | -51.0000 | -363.3341 | 78263692 | 612.42% |
| 1350340 | 824500 | -337.0347 | 270 | -51.0000 | -363.3323 | 78361658 | 612.42% |
| 1353068 | 826086 | -218.3378 | 126 | -51.0000 | -363.3240 | 78392139 | 612.40% |

Elapsed time = 2808.76 sec. (1734769.59 ticks, tree = 75570.94 MB, solutions = 37)

Nodefile size = 73464.03 MB (64075.14 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1354929 | 828737 | -249.5033 | 167 | -51.0000 | -363.3240 | 78453276 | 612.40% |
| 1357188 | 828878 | -58.0000  | 31  | -51.0000 | -363.3240 | 78474265 | 612.40% |
| 1360989 | 829429 | -120.5256 | 54  | -51.0000 | -363.3071 | 78489831 | 612.37% |
| 1363767 | 832535 | -233.8816 | 139 | -51.0000 | -363.3009 | 78554923 | 612.35% |
| 1366058 | 836220 | -353.4513 | 283 | -51.0000 | -363.3009 | 78615429 | 612.35% |
| 1368168 | 836811 | -168.0117 | 96  | -51.0000 | -363.2916 | 78636188 | 612.34% |
| 1370621 | 838448 | -150.5858 | 71  | -51.0000 | -363.2852 | 78668575 | 612.32% |

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1373310 | 840832 | -192.6639 | 118 | -51.0000 | -363.2852 | 78723896 | 612.32% |
| 1376021 | 842744 | -116.0000 | 61  | -51.0000 | -363.2846 | 78755757 | 612.32% |
| 1378544 | 843891 | -303.4139 | 177 | -51.0000 | -363.2846 | 78798222 | 612.32% |

Elapsed time = 2876.38 sec. (1772947.12 ticks, tree = 78009.93 MB, solutions = 37)

Nodefile size = 75864.31 MB (66187.42 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1380852 | 844714 | -104.8889 | 54  | -51.0000 | -363.2846 | 78805091 | 612.32% |
| 1382951 | 849567 | -266.2673 | 184 | -51.0000 | -363.2846 | 78916286 | 612.32% |
| 1385337 | 849918 | -354.9558 | 288 | -51.0000 | -363.2591 | 78921259 | 612.27% |
| 1387121 | 850980 | -220.9833 | 127 | -51.0000 | -363.2554 | 78943781 | 612.27% |
| 1388896 | 853784 | -311.5685 | 191 | -51.0000 | -363.2506 | 79021815 | 612.26% |
| 1390673 | 854058 | -319.6543 | 213 | -51.0000 | -363.2506 | 79027093 | 612.26% |
| 1392561 | 856415 | -215.9617 | 135 | -51.0000 | -363.2506 | 79109073 | 612.26% |
| 1394362 | 856773 | -336.7539 | 231 | -51.0000 | -363.2487 | 79114447 | 612.25% |
| 1396269 | 858330 | -314.7448 | 196 | -51.0000 | -363.2487 | 79170234 | 612.25% |
| 1398329 | 859496 | -278.4522 | 165 | -51.0000 | -363.2457 | 79188574 | 612.25% |

Elapsed time = 2939.17 sec. (1811109.90 ticks, tree = 80161.14 MB, solutions = 37)

Nodefile size = 77996.90 MB (68060.51 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1400362 | 861629 | -94.8928  | 60  | -51.0000 | -363.2457 | 79278236 | 612.25% |
| 1402182 | 863414 | -210.8249 | 123 | -51.0000 | -363.2457 | 79322997 | 612.25% |
| 1403647 | 864988 | -356.3679 | 277 | -51.0000 | -363.2134 | 79365317 | 612.18% |
| 1405435 | 865338 | -146.7865 | 78  | -51.0000 | -363.2088 | 79370410 | 612.17% |
| 1406589 | 867010 | -359.7785 | 358 | -51.0000 | -363.2088 | 79449597 | 612.17% |
| 1407357 | 867801 | -175.8509 | 103 | -51.0000 | -363.2088 | 79473735 | 612.17% |
| 1408480 | 869141 | -357.7632 | 286 | -51.0000 | -363.2060 | 79559155 | 612.17% |
| 1409072 | 869005 | -292.4575 | 185 | -51.0000 | -363.2030 | 79576725 | 612.16% |
| 1409931 | 870613 | -317.9388 | 207 | -51.0000 | -363.2030 | 79678668 | 612.16% |
| 1410846 | 871221 | -300.5855 | 191 | -51.0000 | -363.2030 | 79725732 | 612.16% |

Elapsed time = 3001.29 sec. (1849268.80 ticks, tree = 81426.69 MB, solutions = 37)

Nodefile size = 79340.13 MB (69235.09 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1412565 | 871839 | -198.5468 | 146 | -51.0000 | -363.1993 | 79794879 | 612.16% |
| 1414222 | 872610 | -355.1605 | 245 | -51.0000 | -363.1976 | 79824561 | 612.15% |
| 1416451 | 873746 | -136.8493 | 75  | -51.0000 | -363.1940 | 79887929 | 612.15% |
| 1418802 | 875876 | -262.7594 | 150 | -51.0000 | -363.1940 | 79985747 | 612.15% |
| 1420667 | 877986 | -120.8353 | 67  | -51.0000 | -363.1940 | 80044684 | 612.15% |
| 1422897 | 879153 | -68.0000  | 29  | -51.0000 | -363.1912 | 80105755 | 612.14% |
| 1424675 | 880527 | -102.5792 | 49  | -51.0000 | -363.1912 | 80124655 | 612.14% |
| 1426442 | 881127 | -214.1609 | 129 | -51.0000 | -363.1912 | 80157146 | 612.14% |
| 1428467 | 883401 | -182.3962 | 109 | -51.0000 | -363.1707 | 80225126 | 612.10% |
| 1430584 | 885240 | -157.4481 | 95  | -51.0000 | -363.1701 | 80286129 | 612.10% |

Elapsed time = 3060.58 sec. (1887439.56 ticks, tree = 82485.78 MB, solutions = 37)

Nodefile size = 80396.88 MB (70146.52 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1431870 | 886774 | -284.1700 | 176 | -51.0000 | -363.1701 | 80338190 | 612.10% |
| 1433655 | 887329 | -192.0080 | 106 | -51.0000 | -363.1701 | 80363893 | 612.10% |
| 1435683 | 887996 | -221.9601 | 130 | -51.0000 | -363.1701 | 80378007 | 612.10% |
| 1437806 | 890614 | -173.4306 | 90  | -51.0000 | -363.1701 | 80521614 | 612.10% |
| 1439772 | 890705 | -346.6358 | 222 | -51.0000 | -363.1634 | 80541956 | 612.09% |
| 1441413 | 894088 | -326.9882 | 225 | -51.0000 | -363.1634 | 80639579 | 612.09% |
| 1443300 | 893400 | -70.0000  | 28  | -51.0000 | -363.1542 | 80610357 | 612.07% |
| 1445035 | 896243 | -208.7591 | 119 | -51.0000 | -363.1453 | 80712144 | 612.05% |
| 1446281 | 897127 | -197.6167 | 112 | -51.0000 | -363.1419 | 80754887 | 612.04% |
| 1447762 | 898657 | -91.8217  | 40  | -51.0000 | -363.1419 | 80807489 | 612.04% |

Elapsed time = 3123.21 sec. (1925598.32 ticks, tree = 83544.11 MB, solutions = 37)

Nodefile size = 81452.99 MB (71050.24 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1449076 | 899736 | -322.1691 | 203 | -51.0000 | -363.1419 | 80869707 | 612.04% |
| 1450689 | 899823 | -232.5075 | 136 | -51.0000 | -363.1318 | 80862276 | 612.02% |
| 1452809 | 901413 | -225.7858 | 139 | -51.0000 | -363.1314 | 80941867 | 612.02% |
| 1454893 | 903274 | -358.8973 | 388 | -51.0000 | -363.1282 | 81042552 | 612.02% |
| 1457193 | 905392 | -173.3702 | 95  | -51.0000 | -363.1282 | 81100657 | 612.02% |
| 1459630 | 905749 | -248.7621 | 160 | -51.0000 | -363.1229 | 81106133 | 612.01% |
| 1462412 | 908405 | -327.4000 | 317 | -51.0000 | -363.1193 | 81191230 | 612.00% |
| 1465284 | 910018 | -269.0734 | 163 | -51.0000 | -363.1193 | 81234773 | 612.00% |
| 1467995 | 911192 | -127.3125 | 68  | -51.0000 | -363.1193 | 81272725 | 612.00% |
| 1470171 | 915051 | -214.2308 | 131 | -51.0000 | -363.1193 | 81338792 | 612.00% |

Elapsed time = 3185.87 sec. (1963768.00 ticks, tree = 85097.25 MB, solutions = 37)

Nodefile size = 82996.73 MB (72399.07 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1472123 | 915840 | -61.2873  | 25  | -51.0000 | -363.0963 | 81359705 | 611.95% |
| 1474944 | 917352 | -150.6935 | 103 | -51.0000 | -363.0963 | 81406102 | 611.95% |
| 1477413 | 918699 | -206.5598 | 113 | -51.0000 | -363.0963 | 81437361 | 611.95% |
| 1480258 | 921424 | -164.2992 | 111 | -51.0000 | -363.0819 | 81482776 | 611.93% |
| 1482580 | 921768 | -268.5418 | 165 | -51.0000 | -363.0819 | 81488923 | 611.93% |
| 1485060 | 924969 | -143.3574 | 86  | -51.0000 | -363.0736 | 81569087 | 611.91% |
| 1487196 | 925334 | -228.5638 | 136 | -51.0000 | -363.0736 | 81574482 | 611.91% |
| 1488705 | 927554 | -163.6258 | 104 | -51.0000 | -363.0736 | 81634624 | 611.91% |
| 1490312 | 928638 | -309.5214 | 190 | -51.0000 | -363.0642 | 81673852 | 611.89% |
| 1491785 | 929380 | -358.3981 | 270 | -51.0000 | -363.0642 | 81684293 | 611.89% |

Elapsed time = 3251.39 sec. (2001939.32 ticks, tree = 87079.65 MB, solutions = 37)

Nodefile size = 84914.94 MB (74090.46 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1493123 | 932100 | -361.1607 | 431 | -51.0000 | -363.0642 | 81782395 | 611.89% |
|---------|--------|-----------|-----|----------|-----------|----------|---------|

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1494409 | 933384 | -226.9344 | 133 | -51.0000 | -363.0459 | 81815947 | 611.85% |
| 1495695 | 934332 | -340.4590 | 462 | -51.0000 | -363.0412 | 81876672 | 611.85% |
| 1496875 | 935790 | -83.4127  | 43  | -51.0000 | -363.0360 | 81930955 | 611.84% |
| 1498611 | 936080 | -340.2493 | 219 | -51.0000 | -363.0359 | 81938184 | 611.84% |
| 1500352 | 938166 | -344.8650 | 243 | -51.0000 | -363.0359 | 82058846 | 611.84% |
| 1501886 | 939423 | -214.2697 | 147 | -51.0000 | -363.0359 | 82133186 | 611.84% |
| 1504021 | 940301 | -358.9608 | 298 | -51.0000 | -363.0299 | 82162519 | 611.82% |
| 1505915 | 940547 | -111.5071 | 60  | -51.0000 | -363.0219 | 82169070 | 611.81% |
| 1508308 | 942596 | -290.0645 | 164 | -51.0000 | -363.0181 | 82259386 | 611.80% |

Elapsed time = 3310.11 sec. (2040140.88 ticks, tree = 87780.04 MB, solutions = 37)

Nodefile size = 85628.88 MB (74705.56 MB after compression)

|         |        |            |     |          |           |          |         |
|---------|--------|------------|-----|----------|-----------|----------|---------|
| 1509877 | 943462 | -362.1250  | 345 | -51.0000 | -363.0181 | 82279281 | 611.80% |
| 1511487 | 944392 | -250.2819  | 153 | -51.0000 | -363.0181 | 82311234 | 611.80% |
| 1513253 | 946218 | -108.1399  | 52  | -51.0000 | -363.0181 | 82347204 | 611.80% |
| 1515387 | 948834 | -189.7285  | 105 | -51.0000 | -363.0181 | 82452582 | 611.80% |
| 1517182 | 949556 | -75.4540   | 32  | -51.0000 | -363.0181 | 82477198 | 611.80% |
| 1519399 | 949444 | infeasible |     | -51.0000 | -363.0181 | 82514269 | 611.80% |
| 1521136 | 952636 | -323.2530  | 196 | -51.0000 | -363.0181 | 82576083 | 611.80% |
| 1522540 | 953923 | -233.5832  | 139 | -51.0000 | -363.0181 | 82642685 | 611.80% |
| 1524673 | 955141 | -324.2844  | 195 | -51.0000 | -363.0181 | 82669446 | 611.80% |
| 1527134 | 957400 | -270.0783  | 153 | -51.0000 | -363.0181 | 82761101 | 611.80% |

Elapsed time = 3375.30 sec. (2078300.10 ticks, tree = 89832.75 MB, solutions = 37)

Nodefile size = 87735.09 MB (76556.10 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1529246 | 958614 | -201.0558 | 130 | -51.0000 | -362.9817 | 82793638 | 611.73% |
| 1531688 | 958996 | -161.7118 | 88  | -51.0000 | -362.9817 | 82798680 | 611.73% |
| 1533866 | 961145 | -311.7875 | 206 | -51.0000 | -362.9680 | 82872188 | 611.70% |
| 1536179 | 963907 | -186.8495 | 106 | -51.0000 | -362.9665 | 82919347 | 611.70% |
| 1538696 | 963676 | -352.0906 | 262 | -51.0000 | -362.9639 | 82919358 | 611.69% |
| 1541291 | 967962 | -352.4511 | 278 | -51.0000 | -362.9596 | 83060386 | 611.69% |
| 1543733 | 968242 | -357.3868 | 235 | -51.0000 | -362.9596 | 83066483 | 611.69% |
| 1546056 | 969753 | -131.0000 | 70  | -51.0000 | -362.9596 | 83094379 | 611.69% |
| 1548313 | 973663 | -358.5955 | 292 | -51.0000 | -362.9596 | 83188282 | 611.69% |
| 1550146 | 974076 | -337.6329 | 235 | -51.0000 | -362.9596 | 83193612 | 611.69% |

Elapsed time = 3438.78 sec. (2116458.32 ticks, tree = 91621.92 MB, solutions = 37)

Nodefile size = 89472.03 MB (78071.33 MB after compression)

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1552066 | 975198 | -257.4841 | 153 | -51.0000 | -362.9596 | 83217109 | 611.69% |
| 1554054 | 978192 | -362.7689 | 413 | -51.0000 | -362.9596 | 83329259 | 611.69% |
| 1555755 | 978851 | -143.0000 | 75  | -51.0000 | -362.9596 | 83355737 | 611.69% |
| 1557601 | 980081 | -111.0000 | 62  | -51.0000 | -362.9596 | 83402580 | 611.69% |

|         |        |           |     |          |           |          |         |
|---------|--------|-----------|-----|----------|-----------|----------|---------|
| 1559461 | 980883 | -65.5000  | 31  | -51.0000 | -362.9596 | 83416493 | 611.69% |
| 1561060 | 981959 | -95.2712  | 54  | -51.0000 | -362.9596 | 83457941 | 611.69% |
| 1563252 | 984242 | -362.0169 | 413 | -51.0000 | -362.9596 | 83525920 | 611.69% |
| 1565359 | 985051 | -357.4587 | 294 | -51.0000 | -362.9233 | 83550747 | 611.61% |
| 1567576 | 986032 | -149.0000 | 85  | -51.0000 | -362.9233 | 83574660 | 611.61% |
| 1569513 | 987717 | -279.5274 | 163 | -51.0000 | -362.9233 | 83634697 | 611.61% |

Elapsed time = 3504.02 sec. (2154615.60 ticks, tree = 93479.99 MB, solutions = 37)

Nodefile size = 91371.26 MB (79754.57 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1571974 | 990722  | -362.4365 | 380 | -51.0000 | -362.9233 | 83694670 | 611.61% |
| 1573897 | 992646  | -68.4032  | 28  | -51.0000 | -362.9114 | 83746398 | 611.59% |
| 1575392 | 992729  | -330.2044 | 206 | -51.0000 | -362.9114 | 83779146 | 611.59% |
| 1577047 | 993978  | -358.7650 | 359 | -51.0000 | -362.9057 | 83809952 | 611.58% |
| 1578890 | 995730  | -127.0000 | 61  | -51.0000 | -362.8989 | 83877449 | 611.57% |
| 1580686 | 998467  | -287.4760 | 169 | -51.0000 | -362.8989 | 83985755 | 611.57% |
| 1582486 | 998774  | -184.8990 | 96  | -51.0000 | -362.8989 | 83990762 | 611.57% |
| 1584991 | 998842  | -356.8110 | 390 | -51.0000 | -362.8859 | 84005528 | 611.54% |
| 1587493 | 999579  | -77.0000  | 35  | -51.0000 | -362.8859 | 84044828 | 611.54% |
| 1589567 | 1002790 | -131.3414 | 85  | -51.0000 | -362.8732 | 84134590 | 611.52% |

Elapsed time = 3565.26 sec. (2192780.39 ticks, tree = 94791.64 MB, solutions = 37)

Nodefile size = 92672.34 MB (80888.26 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1592670 | 1004787 | -297.9113 | 190 | -51.0000 | -362.8725 | 84180248 | 611.51% |
| 1595731 | 1005466 | -95.7042  | 50  | -51.0000 | -362.8672 | 84210720 | 611.50% |
| 1599386 | 1006137 | -255.3546 | 166 | -51.0000 | -362.8664 | 84220217 | 611.50% |
| 1602374 | 1011809 | -258.4069 | 167 | -51.0000 | -362.8652 | 84331862 | 611.50% |
| 1604997 | 1010524 | -360.4317 | 388 | -51.0000 | -362.8581 | 84307783 | 611.49% |
| 1607859 | 1015041 | -290.6650 | 167 | -51.0000 | -362.8530 | 84391761 | 611.48% |
| 1610787 | 1017262 | -348.8495 | 243 | -51.0000 | -362.8508 | 84436563 | 611.47% |
| 1613632 | 1021191 | -135.1203 | 72  | -51.0000 | -362.8508 | 84518537 | 611.47% |
| 1615516 | 1020433 | -216.2144 | 140 | -51.0000 | -362.8410 | 84504224 | 611.45% |
| 1617251 | 1022386 | -270.4581 | 162 | -51.0000 | -362.8333 | 84547261 | 611.44% |

Elapsed time = 3635.70 sec. (2230941.04 ticks, tree = 97508.37 MB, solutions = 37)

Nodefile size = 95355.95 MB (83241.89 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1619480 | 1026326 | -106.0000 | 53  | -51.0000 | -362.8282 | 84646400 | 611.43% |
| 1621653 | 1026348 | -355.3272 | 241 | -51.0000 | -362.8246 | 84638448 | 611.42% |
| 1624106 | 1028420 | -165.5907 | 118 | -51.0000 | -362.8246 | 84737509 | 611.42% |
| 1626046 | 1031119 | -197.2253 | 111 | -51.0000 | -362.8246 | 84803674 | 611.42% |
| 1628354 | 1031483 | -272.8441 | 187 | -51.0000 | -362.8182 | 84808486 | 611.41% |
| 1630900 | 1033785 | -136.0000 | 74  | -51.0000 | -362.8149 | 84879529 | 611.40% |
| 1633280 | 1035225 | -178.0256 | 106 | -51.0000 | -362.8095 | 84897759 | 611.39% |



|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1635519 | 1036730 | -352.3538 | 246 | -51.0000 | -362.8073 | 84951001 | 611.39% |
| 1637650 | 1037407 | -127.6583 | 75  | -51.0000 | -362.8062 | 84968280 | 611.38% |
| 1640581 | 1037971 | -353.0674 | 237 | -51.0000 | -362.8062 | 84995175 | 611.38% |

Elapsed time = 3699.91 sec. (2269105.18 ticks, tree = 99299.35 MB, solutions = 37)

Nodefile size = 97165.67 MB (84826.35 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1643113 | 1042917 | -123.0000 | 65  | -51.0000 | -362.7964 | 85104583 | 611.37% |
| 1645682 | 1045072 | -98.0000  | 43  | -51.0000 | -362.7915 | 85155504 | 611.36% |
| 1647968 | 1044321 | -247.7274 | 144 | -51.0000 | -362.7915 | 85146785 | 611.36% |
| 1649894 | 1048126 | -262.8989 | 152 | -51.0000 | -362.7845 | 85227817 | 611.34% |
| 1651814 | 1049151 | -186.8173 | 101 | -51.0000 | -362.7845 | 85253195 | 611.34% |
| 1653327 | 1049473 | -356.1169 | 318 | -51.0000 | -362.7795 | 85258164 | 611.33% |
| 1655002 | 1053056 | -355.6073 | 278 | -51.0000 | -362.7795 | 85359222 | 611.33% |
| 1656520 | 1053373 | -135.0000 | 67  | -51.0000 | -362.7795 | 85407938 | 611.33% |
| 1658361 | 1054656 | -101.0000 | 57  | -51.0000 | -362.7795 | 85449771 | 611.33% |
| 1659888 | 1055695 | -256.1699 | 146 | -51.0000 | -362.7795 | 85516761 | 611.33% |

Elapsed time = 3765.79 sec. (2307266.26 ticks, tree = 101441.55 MB, solutions = 37)

Nodefile size = 99318.60 MB (86720.36 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1661149 | 1056024 | -127.0000 | 72  | -51.0000 | -362.7795 | 85521668 | 611.33% |
| 1662587 | 1057258 | -353.0349 | 265 | -51.0000 | -362.7795 | 85568921 | 611.33% |
| 1663677 | 1059201 | -312.0521 | 192 | -51.0000 | -362.7795 | 85649252 | 611.33% |
| 1665018 | 1060718 | -346.8945 | 253 | -51.0000 | -362.7795 | 85699888 | 611.33% |
| 1667093 | 1061145 | -233.1731 | 124 | -51.0000 | -362.7795 | 85762078 | 611.33% |
| 1668662 | 1063518 | -185.8541 | 99  | -51.0000 | -362.7540 | 85814491 | 611.28% |
| 1670566 | 1063921 | -292.5807 | 179 | -51.0000 | -362.7471 | 85869834 | 611.27% |
| 1673003 | 1064269 | -93.0000  | 51  | -51.0000 | -362.7471 | 85876458 | 611.27% |
| 1674618 | 1066561 | -318.0390 | 230 | -51.0000 | -362.7460 | 85962658 | 611.27% |
| 1676422 | 1066460 | -355.5526 | 277 | -51.0000 | -362.7419 | 85956170 | 611.26% |

Elapsed time = 3822.33 sec. (2345444.75 ticks, tree = 102413.17 MB, solutions = 37)

Nodefile size = 100313.89 MB (87590.71 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1678428 | 1069357 | -120.0000 | 61  | -51.0000 | -362.7356 | 86082885 | 611.25% |
| 1680900 | 1070444 | -127.0000 | 79  | -51.0000 | -362.7356 | 86127269 | 611.25% |
| 1684018 | 1072004 | -195.2310 | 115 | -51.0000 | -362.7356 | 86162816 | 611.25% |
| 1686950 | 1074672 | -198.9341 | 121 | -51.0000 | -362.7213 | 86217540 | 611.22% |
| 1688817 | 1075569 | -344.0144 | 261 | -51.0000 | -362.7205 | 86234976 | 611.22% |
| 1690232 | 1077618 | -349.8671 | 358 | -51.0000 | -362.7205 | 86267376 | 611.22% |
| 1692562 | 1078890 | -230.6096 | 136 | -51.0000 | -362.7201 | 86305304 | 611.22% |
| 1694242 | 1081904 | -93.0000  | 43  | -51.0000 | -362.7066 | 86455402 | 611.19% |
| 1695461 | 1080671 | -211.5977 | 136 | -51.0000 | -362.7044 | 86405574 | 611.19% |
| 1697499 | 1082638 | -347.2280 | 227 | -51.0000 | -362.7018 | 86477065 | 611.18% |

Elapsed time = 3887.72 sec. (2383611.26 ticks, tree = 103831.56 MB, solutions = 37)

Nodefile size = 101675.30 MB (88760.66 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1699409 | 1083919 | -347.0445 | 252 | -51.0000 | -362.7018 | 86523820 | 611.18% |
| 1701903 | 1087178 | -164.0000 | 86  | -51.0000 | -362.6903 | 86637076 | 611.16% |
| 1705244 | 1087473 | -111.0000 | 54  | -51.0000 | -362.6903 | 86641463 | 611.16% |
| 1708528 | 1091154 | -351.8627 | 327 | -51.0000 | -362.6816 | 86710675 | 611.14% |
| 1711345 | 1091455 | -305.5254 | 226 | -51.0000 | -362.6810 | 86716115 | 611.14% |
| 1714058 | 1093531 | -125.0000 | 68  | -51.0000 | -362.6810 | 86742733 | 611.14% |
| 1716044 | 1093882 | -270.4370 | 177 | -51.0000 | -362.6810 | 86747997 | 611.14% |
| 1717546 | 1096977 | -165.0000 | 85  | -51.0000 | -362.6732 | 86820470 | 611.12% |
| 1718830 | 1098665 | -355.7772 | 430 | -51.0000 | -362.6672 | 86862102 | 611.11% |
| 1720069 | 1100901 | -135.0000 | 80  | -51.0000 | -362.6656 | 86925829 | 611.11% |

Elapsed time = 3953.78 sec. (2421784.63 ticks, tree = 106417.14 MB, solutions = 37)

Nodefile size = 104319.82 MB (91096.33 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1721339 | 1101680 | -117.0000 | 56  | -51.0000 | -362.6656 | 86974958 | 611.11% |
| 1722319 | 1102272 | -218.3016 | 136 | -51.0000 | -362.6596 | 87030638 | 611.10% |
| 1723245 | 1103269 | -275.9999 | 162 | -51.0000 | -362.6596 | 87056591 | 611.10% |
| 1724223 | 1103312 | -96.0000  | 46  | -51.0000 | -362.6596 | 87073826 | 611.10% |
| 1725584 | 1104731 | -177.3169 | 117 | -51.0000 | -362.6596 | 87136461 | 611.10% |
| 1726911 | 1106217 | -188.3971 | 143 | -51.0000 | -362.6574 | 87241554 | 611.09% |
| 1728561 | 1106444 | -176.0748 | 89  | -51.0000 | -362.6574 | 87287791 | 611.09% |
| 1730521 | 1108181 | -327.5582 | 201 | -51.0000 | -362.6574 | 87316342 | 611.09% |
| 1732599 | 1108551 | -74.0000  | 35  | -51.0000 | -362.6574 | 87322004 | 611.09% |
| 1734632 | 1110364 | -337.1043 | 250 | -51.0000 | -362.6574 | 87399542 | 611.09% |

Elapsed time = 4014.37 sec. (2459957.65 ticks, tree = 107224.35 MB, solutions = 37)

Nodefile size = 105067.96 MB (91749.43 MB after compression)

|         |         |            |     |          |           |          |         |
|---------|---------|------------|-----|----------|-----------|----------|---------|
| 1737166 | 1112205 | -193.2310  | 114 | -51.0000 | -362.6459 | 87446556 | 611.07% |
| 1739419 | 1112996 | -173.7686  | 92  | -51.0000 | -362.6459 | 87486378 | 611.07% |
| 1741249 | 1114769 | -347.1913  | 214 | -51.0000 | -362.6401 | 87522106 | 611.06% |
| 1743358 | 1115064 | -192.2962  | 107 | -51.0000 | -362.6384 | 87515063 | 611.06% |
| 1744968 | 1118074 | -328.4236  | 210 | -51.0000 | -362.6359 | 87592968 | 611.05% |
| 1746865 | 1119076 | -191.1902  | 112 | -51.0000 | -362.6287 | 87643898 | 611.04% |
| 1748365 | 1121241 | -81.0000   | 37  | -51.0000 | -362.6225 | 87699408 | 611.02% |
| 1750085 | 1121481 | -324.0813  | 201 | -51.0000 | -362.6225 | 87705667 | 611.02% |
| 1752508 | 1124145 | -60.0000   | 19  | -51.0000 | -362.6205 | 87805130 | 611.02% |
| 1755390 | 1123880 | infeasible |     | -51.0000 | -362.6205 | 87785448 | 611.02% |

Elapsed time = 4081.48 sec. (2498117.32 ticks, tree = 109186.03 MB, solutions = 37)

Nodefile size = 107010.45 MB (93469.83 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1757833 | 1127056 | -215.2144 | 120 | -51.0000 | -362.6205 | 87862964 | 611.02% |
|---------|---------|-----------|-----|----------|-----------|----------|---------|

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1759906 | 1130330 | -126.6583 | 64  | -51.0000 | -362.6205 | 87942162 | 611.02% |
| 1761605 | 1131195 | -158.9016 | 98  | -51.0000 | -362.6205 | 87952404 | 611.02% |
| 1763935 | 1132655 | -353.8302 | 251 | -51.0000 | -362.6059 | 88000738 | 610.99% |
| 1766383 | 1135120 | -358.4267 | 298 | -51.0000 | -362.5995 | 88069117 | 610.98% |
| 1769340 | 1134674 | -351.0958 | 290 | -51.0000 | -362.5959 | 88065237 | 610.97% |
| 1770949 | 1137435 | -354.5922 | 298 | -51.0000 | -362.5959 | 88133999 | 610.97% |
| 1772901 | 1138195 | -317.6154 | 230 | -51.0000 | -362.5891 | 88152987 | 610.96% |
| 1774852 | 1138989 | -319.6824 | 186 | -51.0000 | -362.5858 | 88197180 | 610.95% |
| 1777181 | 1141667 | -228.0794 | 142 | -51.0000 | -362.5778 | 88238065 | 610.94% |

Elapsed time = 4149.17 sec. (2536284.58 ticks, tree = 111606.07 MB, solutions = 37)

Nodefile size = 109464.13 MB (95628.95 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1779471 | 1142822 | -356.9082 | 300 | -51.0000 | -362.5778 | 88301076 | 610.94% |
| 1781560 | 1145486 | -345.4786 | 300 | -51.0000 | -362.5709 | 88354961 | 610.92% |
| 1783964 | 1146383 | -142.0000 | 75  | -51.0000 | -362.5683 | 88384760 | 610.92% |
| 1786599 | 1149409 | -156.9016 | 93  | -51.0000 | -362.5632 | 88449409 | 610.91% |
| 1788528 | 1150674 | -286.3848 | 175 | -51.0000 | -362.5575 | 88476984 | 610.90% |
| 1790262 | 1152003 | -152.8889 | 82  | -51.0000 | -362.5554 | 88530369 | 610.89% |
| 1792157 | 1154316 | -312.5151 | 205 | -51.0000 | -362.5519 | 88608998 | 610.89% |
| 1794239 | 1155329 | -81.4111  | 38  | -51.0000 | -362.5519 | 88632851 | 610.89% |
| 1796795 | 1155687 | -226.8191 | 121 | -51.0000 | -362.5490 | 88638195 | 610.88% |
| 1798889 | 1157971 | -242.5105 | 141 | -51.0000 | -362.5490 | 88695455 | 610.88% |

Elapsed time = 4216.83 sec. (2574439.80 ticks, tree = 113971.04 MB, solutions = 37)

Nodefile size = 111820.30 MB (97713.78 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1801257 | 1160786 | -326.2609 | 217 | -51.0000 | -362.5476 | 88785387 | 610.88% |
| 1803904 | 1160584 | -197.5598 | 116 | -51.0000 | -362.5476 | 88778037 | 610.88% |
| 1806916 | 1163684 | -112.0000 | 59  | -51.0000 | -362.5476 | 88855097 | 610.88% |
| 1809860 | 1164061 | -164.0000 | 89  | -51.0000 | -362.5359 | 88860117 | 610.85% |
| 1812427 | 1167790 | -353.8110 | 266 | -51.0000 | -362.5338 | 88946081 | 610.85% |
| 1813938 | 1169137 | -355.4961 | 313 | -51.0000 | -362.5313 | 88984565 | 610.85% |
| 1815156 | 1169515 | -95.0000  | 50  | -51.0000 | -362.5280 | 88989276 | 610.84% |
| 1816884 | 1172293 | -109.0000 | 56  | -51.0000 | -362.5280 | 89054712 | 610.84% |
| 1819029 | 1172222 | -359.4854 | 274 | -51.0000 | -362.5165 | 89088292 | 610.82% |
| 1820702 | 1175341 | -101.0000 | 59  | -51.0000 | -362.5139 | 89172352 | 610.81% |

Elapsed time = 4283.62 sec. (2612607.16 ticks, tree = 116452.58 MB, solutions = 37)

Nodefile size = 114352.58 MB (99959.10 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1821717 | 1175520 | -316.6016 | 211 | -51.0000 | -362.5105 | 89178976 | 610.80% |
| 1822802 | 1175743 | -356.9446 | 302 | -51.0000 | -362.5105 | 89208707 | 610.80% |
| 1825186 | 1177728 | -359.8573 | 307 | -51.0000 | -362.5019 | 89292196 | 610.79% |
| 1828466 | 1178524 | -311.3564 | 177 | -51.0000 | -362.4955 | 89352642 | 610.78% |

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1831697 | 1179704 | -254.7012 | 147 | -51.0000 | -362.4947 | 89383091 | 610.77% |
| 1833684 | 1185363 | -346.5593 | 242 | -51.0000 | -362.4913 | 89494458 | 610.77% |
| 1835958 | 1185747 | -65.0000  | 35  | -51.0000 | -362.4905 | 89499237 | 610.77% |
| 1838222 | 1187800 | -349.6080 | 333 | -51.0000 | -362.4905 | 89556219 | 610.77% |
| 1840349 | 1189274 | -190.9810 | 106 | -51.0000 | -362.4891 | 89593726 | 610.76% |
| 1842574 | 1190077 | -131.0000 | 66  | -51.0000 | -362.4891 | 89607149 | 610.76% |

Elapsed time = 4348.73 sec. (2650771.96 ticks, tree = 118254.77 MB, solutions = 37)

Nodefile size = 116123.16 MB (101513.80 MB after compression)

|         |         |            |     |          |           |          |         |
|---------|---------|------------|-----|----------|-----------|----------|---------|
| 1844137 | 1190950 | -337.9764  | 239 | -51.0000 | -362.4773 | 89621043 | 610.74% |
| 1845868 | 1194067 | -163.0000  | 91  | -51.0000 | -362.4773 | 89702644 | 610.74% |
| 1847428 | 1194442 | infeasible |     | -51.0000 | -362.4773 | 89707519 | 610.74% |
| 1848545 | 1195399 | -338.9939  | 269 | -51.0000 | -362.4715 | 89749797 | 610.73% |
| 1849976 | 1197189 | -312.5297  | 186 | -51.0000 | -362.4715 | 89842164 | 610.73% |
| 1852539 | 1197765 | -172.7495  | 102 | -51.0000 | -362.4715 | 89864964 | 610.73% |
| 1855071 | 1199117 | -174.5109  | 95  | -51.0000 | -362.4673 | 89907349 | 610.72% |
| 1857581 | 1199427 | -79.0000   | 33  | -51.0000 | -362.4673 | 89912585 | 610.72% |
| 1860128 | 1204628 | -139.0000  | 78  | -51.0000 | -362.4673 | 90040175 | 610.72% |
| 1862424 | 1204806 | -92.0000   | 38  | -51.0000 | -362.4673 | 90046923 | 610.72% |

Elapsed time = 4412.31 sec. (2688942.58 ticks, tree = 119835.92 MB, solutions = 37)

Nodefile size = 117703.76 MB (102891.72 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1864012 | 1205110 | -334.7566 | 231 | -51.0000 | -362.4673 | 90052032 | 610.72% |
| 1865715 | 1206430 | -248.0777 | 143 | -51.0000 | -362.4673 | 90089209 | 610.72% |
| 1867880 | 1208849 | -360.7170 | 315 | -51.0000 | -362.4673 | 90124930 | 610.72% |
| 1869710 | 1210002 | -253.9861 | 148 | -51.0000 | -362.4461 | 90184073 | 610.68% |
| 1871605 | 1212587 | -271.6025 | 172 | -51.0000 | -362.4461 | 90320048 | 610.68% |
| 1873471 | 1213584 | -156.0000 | 98  | -51.0000 | -362.4461 | 90347220 | 610.68% |
| 1875249 | 1215234 | -346.3866 | 246 | -51.0000 | -362.4461 | 90387853 | 610.68% |
| 1876789 | 1216880 | -136.0000 | 70  | -51.0000 | -362.4317 | 90467261 | 610.65% |
| 1878428 | 1216583 | -360.9537 | 396 | -51.0000 | -362.4300 | 90462464 | 610.65% |
| 1879496 | 1218118 | -271.7228 | 172 | -51.0000 | -362.4300 | 90528095 | 610.65% |

Elapsed time = 4475.52 sec. (2727125.87 ticks, tree = 121765.60 MB, solutions = 37)

Nodefile size = 119662.56 MB (104632.68 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1879927 | 1219133 | -331.2837 | 228 | -51.0000 | -362.4208 | 90557727 | 610.63% |
| 1881200 | 1219700 | -354.6783 | 283 | -51.0000 | -362.4206 | 90586562 | 610.63% |
| 1882723 | 1221442 | -339.9416 | 253 | -51.0000 | -362.4201 | 90642101 | 610.63% |
| 1883876 | 1222681 | -353.1613 | 241 | -51.0000 | -362.4167 | 90733610 | 610.62% |
| 1884976 | 1222419 | -356.8062 | 237 | -51.0000 | -362.4167 | 90727814 | 610.62% |
| 1885808 | 1224246 | -174.6478 | 96  | -51.0000 | -362.4148 | 90820647 | 610.62% |
| 1887127 | 1224675 | -96.0000  | 47  | -51.0000 | -362.4143 | 90824870 | 610.62% |

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1888119 | 1226301 | -354.7976 | 297 | -51.0000 | -362.4143 | 90942207 | 610.62% |
| 1889542 | 1227449 | -292.9870 | 200 | -51.0000 | -362.4143 | 90980258 | 610.62% |
| 1891491 | 1227878 | -201.0640 | 120 | -51.0000 | -362.4065 | 90984614 | 610.60% |

Elapsed time = 4533.80 sec. (2765317.84 ticks, tree = 122538.28 MB, solutions = 37)

Nodefile size = 120337.04 MB (105215.91 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1893792 | 1227996 | -162.0000 | 91  | -51.0000 | -362.4065 | 91035314 | 610.60% |
| 1896328 | 1230354 | -246.3380 | 142 | -51.0000 | -362.4053 | 91099099 | 610.60% |
| 1898667 | 1232386 | -348.0567 | 224 | -51.0000 | -362.4034 | 91151758 | 610.59% |
| 1900424 | 1234216 | -202.3876 | 116 | -51.0000 | -362.3982 | 91202203 | 610.58% |
| 1902409 | 1235516 | -146.0000 | 82  | -51.0000 | -362.3963 | 91228751 | 610.58% |
| 1904297 | 1236559 | -294.4467 | 221 | -51.0000 | -362.3939 | 91256879 | 610.58% |
| 1905946 | 1237273 | -169.0000 | 91  | -51.0000 | -362.3926 | 91297562 | 610.57% |
| 1908247 | 1238212 | -359.1546 | 327 | -51.0000 | -362.3923 | 91327857 | 610.57% |
| 1910238 | 1241889 | -93.0000  | 43  | -51.0000 | -362.3840 | 91454153 | 610.56% |
| 1912123 | 1242108 | -253.7352 | 161 | -51.0000 | -362.3840 | 91443338 | 610.56% |

Elapsed time = 4597.07 sec. (2803482.88 ticks, tree = 124122.99 MB, solutions = 37)

Nodefile size = 121915.48 MB (106601.21 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1913823 | 1244810 | -293.5904 | 165 | -51.0000 | -362.3840 | 91560056 | 610.56% |
| 1915261 | 1242831 | -348.9132 | 224 | -51.0000 | -362.3840 | 91487721 | 610.56% |
| 1917087 | 1245691 | -357.7825 | 398 | -51.0000 | -362.3736 | 91596278 | 610.54% |
| 1919377 | 1247859 | -350.8520 | 301 | -51.0000 | -362.3727 | 91640207 | 610.53% |
| 1920957 | 1249365 | -349.1644 | 264 | -51.0000 | -362.3727 | 91704716 | 610.53% |
| 1922448 | 1251919 | -241.0255 | 135 | -51.0000 | -362.3727 | 91787046 | 610.53% |
| 1924299 | 1251385 | -139.0000 | 89  | -51.0000 | -362.3727 | 91745691 | 610.53% |
| 1925928 | 1254633 | -335.5796 | 212 | -51.0000 | -362.3727 | 91864879 | 610.53% |
| 1927733 | 1253942 | -248.7582 | 148 | -51.0000 | -362.3727 | 91863422 | 610.53% |
| 1929800 | 1254954 | -161.5000 | 98  | -51.0000 | -362.3727 | 91914276 | 610.53% |

Elapsed time = 4665.96 sec. (2841657.11 ticks, tree = 125876.31 MB, solutions = 37)

Nodefile size = 123736.62 MB (108198.02 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1932915 | 1257567 | -356.6930 | 308 | -51.0000 | -362.3727 | 91971230 | 610.53% |
| 1935557 | 1257895 | -235.1592 | 138 | -51.0000 | -362.3485 | 91975728 | 610.49% |
| 1937930 | 1259507 | -133.0000 | 76  | -51.0000 | -362.3470 | 92043433 | 610.48% |
| 1939112 | 1262952 | -268.7837 | 146 | -51.0000 | -362.3423 | 92119640 | 610.48% |
| 1941120 | 1263559 | -336.0770 | 228 | -51.0000 | -362.3380 | 92141033 | 610.47% |
| 1943317 | 1266134 | -78.0000  | 38  | -51.0000 | -362.3380 | 92201328 | 610.47% |
| 1945343 | 1266470 | -81.0000  | 35  | -51.0000 | -362.3380 | 92230682 | 610.47% |
| 1947101 | 1268368 | -140.3414 | 74  | -51.0000 | -362.3309 | 92291980 | 610.45% |
| 1948917 | 1269242 | -223.0782 | 125 | -51.0000 | -362.3309 | 92327936 | 610.45% |
| 1950788 | 1269706 | -57.0000  | 25  | -51.0000 | -362.3309 | 92331814 | 610.45% |

Elapsed time = 4731.66 sec. (2879825.80 ticks, tree = 127608.51 MB, solutions = 37)

Nodefile size = 125386.48 MB (109656.60 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1952593 | 1272828 | -163.0000 | 86  | -51.0000 | -362.3309 | 92422770 | 610.45% |
| 1955188 | 1273992 | -348.8436 | 266 | -51.0000 | -362.3309 | 92476904 | 610.45% |
| 1957494 | 1273935 | -179.5526 | 97  | -51.0000 | -362.3309 | 92458164 | 610.45% |
| 1958998 | 1275371 | -357.5784 | 362 | -51.0000 | -362.3309 | 92499131 | 610.45% |
| 1960528 | 1278994 | -183.2555 | 100 | -51.0000 | -362.3309 | 92595513 | 610.45% |
| 1962501 | 1279390 | -143.0000 | 79  | -51.0000 | -362.3309 | 92614185 | 610.45% |
| 1963753 | 1279515 | -181.5109 | 103 | -51.0000 | -362.3309 | 92622257 | 610.45% |
| 1965266 | 1282516 | -101.0000 | 45  | -51.0000 | -362.3309 | 92718093 | 610.45% |
| 1966607 | 1283982 | -337.5188 | 281 | -51.0000 | -362.3309 | 92799904 | 610.45% |
| 1968190 | 1282938 | -315.7303 | 204 | -51.0000 | -362.3309 | 92761351 | 610.45% |

Elapsed time = 4795.38 sec. (2917991.21 ticks, tree = 129154.59 MB, solutions = 37)

Nodefile size = 127050.39 MB (111116.43 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1970548 | 1286382 | -334.5310 | 206 | -51.0000 | -362.3309 | 92905255 | 610.45% |
| 1972793 | 1287538 | -249.0323 | 140 | -51.0000 | -362.3309 | 92945474 | 610.45% |
| 1974081 | 1286958 | -223.8645 | 140 | -51.0000 | -362.3309 | 92914229 | 610.45% |
| 1975090 | 1289465 | -301.1046 | 172 | -51.0000 | -362.3309 | 93018059 | 610.45% |
| 1976045 | 1288874 | -355.0767 | 231 | -51.0000 | -362.3309 | 92974520 | 610.45% |
| 1977011 | 1292121 | -361.9902 | 290 | -51.0000 | -362.3309 | 93088426 | 610.45% |
| 1978501 | 1293014 | -358.8972 | 302 | -51.0000 | -362.3309 | 93119372 | 610.45% |
| 1980427 | 1292664 | -196.8761 | 136 | -51.0000 | -362.3074 | 93113119 | 610.41% |
| 1981659 | 1294107 | -96.5679  | 44  | -51.0000 | -362.3074 | 93290304 | 610.41% |
| 1982761 | 1295504 | -257.0260 | 157 | -51.0000 | -362.3074 | 93318116 | 610.41% |

Elapsed time = 4857.33 sec. (2956165.23 ticks, tree = 130261.01 MB, solutions = 37)

Nodefile size = 128107.74 MB (112032.73 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 1984197 | 1296305 | -228.6609 | 123 | -51.0000 | -362.3074 | 93336345 | 610.41% |
| 1985492 | 1296197 | -177.2575 | 101 | -51.0000 | -362.3074 | 93393577 | 610.41% |
| 1986946 | 1298745 | -119.0000 | 59  | -51.0000 | -362.3074 | 93460887 | 610.41% |
| 1988715 | 1298777 | -360.0183 | 343 | -51.0000 | -362.3074 | 93496963 | 610.41% |
| 1990344 | 1301907 | -355.9441 | 253 | -51.0000 | -362.3074 | 93607408 | 610.41% |
| 1992706 | 1302258 | -120.0000 | 62  | -51.0000 | -362.2874 | 93612558 | 610.37% |
| 1995018 | 1304182 | -225.4859 | 128 | -51.0000 | -362.2874 | 93683921 | 610.37% |
| 1997601 | 1303431 | -155.8836 | 85  | -51.0000 | -362.2874 | 93659824 | 610.37% |
| 1999960 | 1306782 | -179.7059 | 100 | -51.0000 | -362.2874 | 93741768 | 610.37% |
| 2001806 | 1307133 | -277.2162 | 157 | -51.0000 | -362.2534 | 93746417 | 610.30% |

Elapsed time = 4924.31 sec. (2994343.65 ticks, tree = 131623.21 MB, solutions = 37)

Nodefile size = 129402.80 MB (113165.07 MB after compression)

|         |         |        |  |          |           |          |         |
|---------|---------|--------|--|----------|-----------|----------|---------|
| 2003608 | 1310011 | cutoff |  | -51.0000 | -362.2505 | 93852745 | 610.30% |
|---------|---------|--------|--|----------|-----------|----------|---------|

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2005876 | 1311929 | -360.7152 | 340 | -51.0000 | -362.2420 | 93872511 | 610.28% |
| 2007520 | 1314349 | -361.2690 | 324 | -51.0000 | -362.2401 | 93949400 | 610.27% |
| 2010050 | 1315474 | -358.1109 | 347 | -51.0000 | -362.2348 | 93980261 | 610.26% |
| 2012141 | 1314837 | -121.0000 | 78  | -51.0000 | -362.2319 | 93967126 | 610.26% |
| 2014117 | 1316900 | -210.4484 | 137 | -51.0000 | -362.2319 | 94047490 | 610.26% |
| 2016539 | 1320203 | -301.7363 | 185 | -51.0000 | -362.2225 | 94177706 | 610.24% |
| 2018363 | 1319559 | -90.0000  | 35  | -51.0000 | -362.2210 | 94148369 | 610.24% |
| 2019749 | 1322440 | -109.2500 | 66  | -51.0000 | -362.2210 | 94261607 | 610.24% |
| 2021774 | 1322860 | -353.5627 | 239 | -51.0000 | -362.2210 | 94250994 | 610.24% |

Elapsed time = 4990.11 sec. (3032511.21 ticks, tree = 133163.44 MB, solutions = 37)

Nodefile size = 130977.97 MB (114541.34 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2023532 | 1324766 | -201.9114 | 114 | -51.0000 | -362.2210 | 94318165 | 610.24% |
| 2025242 | 1327799 | -353.9849 | 299 | -51.0000 | -362.2100 | 94439879 | 610.22% |
| 2026170 | 1326401 | -158.0000 | 94  | -51.0000 | -362.2098 | 94361700 | 610.22% |
| 2026901 | 1329537 | -287.7297 | 180 | -51.0000 | -362.2078 | 94472233 | 610.21% |
| 2028133 | 1330094 | -58.4032  | 26  | -51.0000 | -362.2078 | 94513762 | 610.21% |
| 2029923 | 1331143 | -65.4032  | 29  | -51.0000 | -362.2065 | 94618610 | 610.21% |
| 2031440 | 1331107 | -318.8100 | 196 | -51.0000 | -362.2065 | 94607266 | 610.21% |
| 2032934 | 1332754 | -265.4758 | 167 | -51.0000 | -362.2058 | 94669472 | 610.21% |
| 2034589 | 1334098 | -153.0000 | 81  | -51.0000 | -362.2021 | 94746572 | 610.20% |
| 2036138 | 1334328 | -243.3282 | 168 | -51.0000 | -362.2021 | 94751540 | 610.20% |

Elapsed time = 5053.58 sec. (3070737.59 ticks, tree = 134474.79 MB, solutions = 37)

Nodefile size = 132323.41 MB (115713.57 MB after compression)

|         |         |            |     |          |           |          |         |
|---------|---------|------------|-----|----------|-----------|----------|---------|
| 2038712 | 1333925 | -78.5139   | 50  | -51.0000 | -362.2021 | 94744505 | 610.20% |
| 2040376 | 1337795 | infeasible |     | -51.0000 | -362.1926 | 94873080 | 610.18% |
| 2042249 | 1338711 | -95.0000   | 53  | -51.0000 | -362.1918 | 94889167 | 610.18% |
| 2043289 | 1339688 | -196.9467  | 171 | -51.0000 | -362.1918 | 94930297 | 610.18% |
| 2044354 | 1340831 | -339.2202  | 210 | -51.0000 | -362.1918 | 94959160 | 610.18% |
| 2045538 | 1341759 | -316.6392  | 222 | -51.0000 | -362.1891 | 94978591 | 610.17% |
| 2047212 | 1344458 | -298.5127  | 183 | -51.0000 | -362.1891 | 95116161 | 610.17% |
| 2048192 | 1343500 | -315.8810  | 205 | -51.0000 | -362.1891 | 95075051 | 610.17% |
| 2050162 | 1346617 | -258.7810  | 146 | -51.0000 | -362.1891 | 95248518 | 610.17% |
| 2052107 | 1347065 | -209.5024  | 121 | -51.0000 | -362.1834 | 95285696 | 610.16% |

Elapsed time = 5113.04 sec. (3108900.99 ticks, tree = 135743.20 MB, solutions = 37)

Nodefile size = 133587.80 MB (116827.78 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2054327 | 1347767 | -179.1118 | 105 | -51.0000 | -362.1834 | 95328232 | 610.16% |
| 2056734 | 1350306 | -355.7437 | 324 | -51.0000 | -362.1701 | 95403631 | 610.14% |
| 2057895 | 1349123 | -285.9940 | 159 | -51.0000 | -362.1701 | 95387785 | 610.14% |
| 2059298 | 1353824 | -177.2253 | 104 | -51.0000 | -362.1701 | 95512857 | 610.14% |

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2061571 | 1354213 | -235.3818 | 137 | -51.0000 | -362.1701 | 95517218 | 610.14% |
| 2062721 | 1354490 | -178.5830 | 101 | -51.0000 | -362.1701 | 95521973 | 610.14% |
| 2063887 | 1354683 | -359.1123 | 335 | -51.0000 | -362.1619 | 95552808 | 610.12% |
| 2066171 | 1357304 | -216.6867 | 128 | -51.0000 | -362.1588 | 95666338 | 610.12% |
| 2068842 | 1358733 | -338.9059 | 219 | -51.0000 | -362.1540 | 95690539 | 610.11% |
| 2071197 | 1359079 | -151.0000 | 86  | -51.0000 | -362.1505 | 95694410 | 610.10% |

Elapsed time = 5183.43 sec. (3147063.12 ticks, tree = 137247.59 MB, solutions = 37)

Nodefile size = 135065.62 MB (118120.50 MB after compression)

|         |         |            |     |          |           |          |         |
|---------|---------|------------|-----|----------|-----------|----------|---------|
| 2073960 | 1362024 | infeasible |     | -51.0000 | -362.1492 | 95770534 | 610.10% |
| 2076419 | 1362562 | -356.2101  | 269 | -51.0000 | -362.1458 | 95796757 | 610.09% |
| 2078532 | 1365651 | -229.5769  | 161 | -51.0000 | -362.1441 | 95842208 | 610.09% |
| 2080519 | 1367251 | -81.0000   | 42  | -51.0000 | -362.1406 | 95880610 | 610.08% |
| 2082831 | 1367594 | -215.7704  | 129 | -51.0000 | -362.1361 | 95886294 | 610.07% |
| 2085431 | 1371304 | -165.5000  | 93  | -51.0000 | -362.1349 | 95986118 | 610.07% |
| 2087706 | 1371516 | -311.5010  | 186 | -51.0000 | -362.1292 | 95993806 | 610.06% |
| 2090838 | 1372474 | -196.4747  | 136 | -51.0000 | -362.1266 | 96028276 | 610.05% |
| 2093888 | 1376175 | -268.9368  | 163 | -51.0000 | -362.1222 | 96150851 | 610.04% |
| 2097037 | 1376513 | -93.0000   | 48  | -51.0000 | -362.1195 | 96156174 | 610.04% |

Elapsed time = 5252.06 sec. (3185223.84 ticks, tree = 139227.82 MB, solutions = 37)

Nodefile size = 137044.02 MB (119868.56 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2099977 | 1377822 | -309.5230 | 191 | -51.0000 | -362.1194 | 96195538 | 610.04% |
| 2102737 | 1383997 | -216.9528 | 122 | -51.0000 | -362.1141 | 96313606 | 610.03% |
| 2105386 | 1382784 | -357.4801 | 259 | -51.0000 | -362.1109 | 96296349 | 610.02% |
| 2107072 | 1384958 | -243.3201 | 190 | -51.0000 | -362.1080 | 96353624 | 610.02% |
| 2109715 | 1389908 | -91.0000  | 41  | -51.0000 | -362.1018 | 96431278 | 610.00% |
| 2112892 | 1389386 | -237.2620 | 142 | -51.0000 | -362.1014 | 96428949 | 610.00% |
| 2116344 | 1392877 | -76.0000  | 37  | -51.0000 | -362.0952 | 96518047 | 609.99% |
| 2119601 | 1396055 | -239.8675 | 163 | -51.0000 | -362.0902 | 96571138 | 609.98% |
| 2122701 | 1397588 | -162.0000 | 92  | -51.0000 | -362.0878 | 96597500 | 609.98% |
| 2125585 | 1399419 | -107.0000 | 56  | -51.0000 | -362.0837 | 96623631 | 609.97% |

Elapsed time = 5323.57 sec. (3223386.22 ticks, tree = 142291.72 MB, solutions = 37)

Nodefile size = 140136.28 MB (122587.56 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2127637 | 1401788 | -98.9772  | 55  | -51.0000 | -362.0837 | 96673819 | 609.97% |
| 2129462 | 1403019 | -101.0000 | 53  | -51.0000 | -362.0777 | 96689106 | 609.96% |
| 2130967 | 1403384 | -180.0312 | 103 | -51.0000 | -362.0736 | 96694336 | 609.95% |
| 2132398 | 1407650 | -249.8456 | 150 | -51.0000 | -362.0716 | 96832474 | 609.94% |
| 2134190 | 1407911 | -259.4266 | 153 | -51.0000 | -362.0716 | 96840144 | 609.94% |
| 2136287 | 1409592 | -347.6216 | 223 | -51.0000 | -362.0716 | 96926465 | 609.94% |
| 2138800 | 1410407 | -107.4540 | 54  | -51.0000 | -362.0673 | 96963154 | 609.94% |



|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2140533 | 1410269 | -356.8189 | 314 | -51.0000 | -362.0623 | 96948737 | 609.93% |
| 2141817 | 1413348 | -314.1180 | 205 | -51.0000 | -362.0608 | 97027902 | 609.92% |
| 2143712 | 1415198 | -361.9409 | 378 | -51.0000 | -362.0608 | 97076664 | 609.92% |

Elapsed time = 5387.73 sec. (3261572.73 ticks, tree = 144059.10 MB, solutions = 37)

Nodefile size = 141929.99 MB (124151.38 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2145303 | 1415470 | -243.6396 | 140 | -51.0000 | -362.0548 | 97110721 | 609.91% |
| 2147224 | 1415864 | -346.9044 | 241 | -51.0000 | -362.0548 | 97087785 | 609.91% |
| 2149106 | 1420398 | -353.5467 | 272 | -51.0000 | -362.0502 | 97254799 | 609.90% |
| 2151211 | 1420743 | -195.9210 | 100 | -51.0000 | -362.0502 | 97260086 | 609.90% |
| 2153737 | 1421083 | -290.3449 | 215 | -51.0000 | -362.0502 | 97264392 | 609.90% |
| 2155994 | 1424276 | -173.5964 | 95  | -51.0000 | -362.0502 | 97359502 | 609.90% |
| 2157424 | 1423832 | -188.4168 | 116 | -51.0000 | -362.0502 | 97352625 | 609.90% |
| 2158038 | 1425742 | -231.6470 | 143 | -51.0000 | -362.0502 | 97404097 | 609.90% |
| 2159500 | 1428123 | -166.8025 | 112 | -51.0000 | -362.0502 | 97507292 | 609.90% |
| 2161270 | 1427691 | -233.3973 | 129 | -51.0000 | -362.0502 | 97484141 | 609.90% |

Elapsed time = 5455.78 sec. (3299734.67 ticks, tree = 145843.98 MB, solutions = 37)

Nodefile size = 143666.89 MB (125689.91 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2163098 | 1428744 | -310.5486 | 196 | -51.0000 | -362.0502 | 97518331 | 609.90% |
| 2164625 | 1429691 | -72.0000  | 29  | -51.0000 | -362.0502 | 97530450 | 609.90% |
| 2166592 | 1430389 | -262.9791 | 183 | -51.0000 | -362.0502 | 97612273 | 609.90% |
| 2168915 | 1431725 | -356.9467 | 343 | -51.0000 | -362.0502 | 97621871 | 609.90% |
| 2170713 | 1434358 | -258.5424 | 166 | -51.0000 | -362.0502 | 97704062 | 609.90% |
| 2172463 | 1434714 | -357.2590 | 274 | -51.0000 | -362.0502 | 97708705 | 609.90% |
| 2174588 | 1437891 | -344.3184 | 227 | -51.0000 | -362.0284 | 97794992 | 609.86% |
| 2176317 | 1438251 | -145.9176 | 80  | -51.0000 | -362.0284 | 97800479 | 609.86% |
| 2177202 | 1438198 | -333.6357 | 210 | -51.0000 | -362.0284 | 97815908 | 609.86% |
| 2179165 | 1439916 | -353.4805 | 424 | -51.0000 | -362.0284 | 97872104 | 609.86% |

Elapsed time = 5521.06 sec. (3337907.15 ticks, tree = 147605.70 MB, solutions = 37)

Nodefile size = 145495.21 MB (127311.62 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2181324 | 1440866 | -283.2540 | 176 | -51.0000 | -362.0284 | 97891679 | 609.86% |
| 2182556 | 1442766 | -158.4380 | 82  | -51.0000 | -362.0284 | 97941562 | 609.86% |
| 2184500 | 1444493 | -314.4764 | 222 | -51.0000 | -362.0284 | 97994623 | 609.86% |
| 2186406 | 1444801 | -224.1898 | 124 | -51.0000 | -362.0284 | 98013376 | 609.86% |
| 2188871 | 1447973 | -339.4077 | 214 | -51.0000 | -362.0284 | 98109830 | 609.86% |
| 2190940 | 1449999 | -290.2922 | 199 | -51.0000 | -361.9977 | 98233021 | 609.80% |
| 2193520 | 1449073 | -361.5637 | 435 | -51.0000 | -361.9977 | 98128061 | 609.80% |
| 2196434 | 1451931 | -314.6463 | 224 | -51.0000 | -361.9971 | 98276855 | 609.80% |
| 2199381 | 1453652 | -185.5070 | 97  | -51.0000 | -361.9971 | 98315726 | 609.80% |
| 2201426 | 1454807 | -117.0000 | 60  | -51.0000 | -361.9971 | 98362893 | 609.80% |

Elapsed time = 5587.16 sec. (3376070.73 ticks, tree = 149537.40 MB, solutions = 37)

Nodefile size = 147385.66 MB (128968.65 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2204276 | 1456451 | -225.5052 | 131 | -51.0000 | -361.9971 | 98391992 | 609.80% |
| 2206451 | 1460380 | -271.7723 | 166 | -51.0000 | -361.9904 | 98473773 | 609.79% |
| 2209077 | 1462514 | -361.1800 | 374 | -51.0000 | -361.9904 | 98527678 | 609.79% |
| 2212458 | 1462879 | -197.8400 | 113 | -51.0000 | -361.9809 | 98522461 | 609.77% |
| 2215420 | 1467461 | -259.2272 | 145 | -51.0000 | -361.9735 | 98624285 | 609.75% |
| 2218387 | 1468647 | -123.6583 | 67  | -51.0000 | -361.9723 | 98654373 | 609.75% |
| 2221372 | 1471853 | -350.9130 | 263 | -51.0000 | -361.9667 | 98702789 | 609.74% |
| 2225070 | 1470218 | -121.0000 | 64  | -51.0000 | -361.9636 | 98673690 | 609.73% |
| 2228119 | 1471931 | -201.6745 | 126 | -51.0000 | -361.9572 | 98699736 | 609.72% |
| 2230869 | 1478734 | -305.8009 | 190 | -51.0000 | -361.9524 | 98808636 | 609.71% |

Elapsed time = 5661.26 sec. (3414225.98 ticks, tree = 153064.91 MB, solutions = 37)

Nodefile size = 150931.10 MB (132094.45 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2232763 | 1478343 | -189.2024 | 111 | -51.0000 | -361.9492 | 98802610 | 609.70% |
| 2234988 | 1480112 | -312.4234 | 187 | -51.0000 | -361.9440 | 98828947 | 609.69% |
| 2237925 | 1484751 | -313.7701 | 180 | -51.0000 | -361.9388 | 98937741 | 609.68% |
| 2240558 | 1486010 | -87.0000  | 43  | -51.0000 | -361.9364 | 98964759 | 609.68% |
| 2242539 | 1487781 | -275.2400 | 187 | -51.0000 | -361.9309 | 99031246 | 609.67% |
| 2245035 | 1487728 | -219.6291 | 122 | -51.0000 | -361.9281 | 99003844 | 609.66% |
| 2246529 | 1491934 | -179.1228 | 94  | -51.0000 | -361.9255 | 99095848 | 609.66% |
| 2247954 | 1491580 | -351.5553 | 243 | -51.0000 | -361.9245 | 99089066 | 609.66% |
| 2249384 | 1491991 | -291.4054 | 198 | -51.0000 | -361.9245 | 99093972 | 609.66% |
| 2250277 | 1494816 | -344.8796 | 224 | -51.0000 | -361.9245 | 99189716 | 609.66% |

Elapsed time = 5727.78 sec. (3452393.37 ticks, tree = 155438.60 MB, solutions = 37)

Nodefile size = 153292.60 MB (134181.29 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2251810 | 1495637 | -112.0000 | 58  | -51.0000 | -361.9219 | 99235307 | 609.65% |
| 2252985 | 1496849 | -242.5733 | 165 | -51.0000 | -361.9219 | 99290827 | 609.65% |
| 2253778 | 1497620 | -345.1575 | 417 | -51.0000 | -361.9219 | 99333352 | 609.65% |
| 2254166 | 1498135 | -355.5885 | 305 | -51.0000 | -361.9157 | 99318850 | 609.64% |
| 2254590 | 1497715 | -156.6532 | 90  | -51.0000 | -361.9157 | 99344381 | 609.64% |
| 2255374 | 1499614 | -341.7492 | 301 | -51.0000 | -361.9143 | 99483056 | 609.64% |
| 2256612 | 1499695 | -256.9245 | 148 | -51.0000 | -361.9143 | 99461630 | 609.64% |
| 2258131 | 1500600 | -112.0000 | 59  | -51.0000 | -361.9143 | 99521815 | 609.64% |
| 2259968 | 1502063 | -74.0000  | 31  | -51.0000 | -361.9143 | 99596909 | 609.64% |
| 2261589 | 1501021 | -217.7357 | 145 | -51.0000 | -361.9143 | 99544139 | 609.64% |

Elapsed time = 5789.89 sec. (3490642.38 ticks, tree = 156097.56 MB, solutions = 37)

Nodefile size = 153881.77 MB (134701.90 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2263540 | 1503689 | -351.0484 | 271 | -51.0000 | -361.9143 | 99662117 | 609.64% |
|---------|---------|-----------|-----|----------|-----------|----------|---------|

|         |         |            |     |          |           |          |         |
|---------|---------|------------|-----|----------|-----------|----------|---------|
| 2265593 | 1505294 | -257.5113  | 150 | -51.0000 | -361.9143 | 99690177 | 609.64% |
| 2267732 | 1505621 | -77.0000   | 31  | -51.0000 | -361.9143 | 99694602 | 609.64% |
| 2269137 | 1508711 | -65.5679   | 35  | -51.0000 | -361.9071 | 99827984 | 609.62% |
| 2270876 | 1509033 | -240.1320  | 134 | -51.0000 | -361.9071 | 99832992 | 609.62% |
| 2272906 | 1509090 | -314.8264  | 233 | -51.0000 | -361.9071 | 99822254 | 609.62% |
| 2274629 | 1511601 | -189.8173  | 101 | -51.0000 | -361.9002 | 99916173 | 609.61% |
| 2275232 | 1511926 | -147.0000  | 73  | -51.0000 | -361.9002 | 99933267 | 609.61% |
| 2276649 | 1513432 | infeasible |     | -51.0000 | -361.9002 | 99961904 | 609.61% |
| 2284484 | 1518423 | -347.9256  | 237 | -51.0000 | -361.8881 | 1.00e+08 | 609.58% |

Elapsed time = 5869.03 sec. (3540255.65 ticks, tree = 158053.08 MB, solutions = 37)

Nodefile size = 155868.06 MB (136448.34 MB after compression)

|         |         |            |     |          |           |          |         |
|---------|---------|------------|-----|----------|-----------|----------|---------|
| 2293888 | 1523878 | -359.4920  | 234 | -51.0000 | -361.8779 | 1.00e+08 | 609.56% |
| 2300244 | 1531155 | -143.7059  | 77  | -51.0000 | -361.8641 | 1.01e+08 | 609.54% |
| 2305495 | 1533878 | -312.1851  | 184 | -51.0000 | -361.8641 | 1.01e+08 | 609.54% |
| 2310737 | 1538466 | -359.9087  | 375 | -51.0000 | -361.8504 | 1.01e+08 | 609.51% |
| 2319427 | 1544696 | -187.5489  | 104 | -51.0000 | -361.8504 | 1.01e+08 | 609.51% |
| 2329798 | 1548090 | -351.7499  | 300 | -51.0000 | -361.8348 | 1.01e+08 | 609.48% |
| 2340901 | 1560129 | -303.0342  | 183 | -51.0000 | -361.8223 | 1.01e+08 | 609.46% |
| 2352039 | 1567246 | -183.5988  | 116 | -51.0000 | -361.8057 | 1.02e+08 | 609.42% |
| 2362020 | 1573455 | infeasible |     | -51.0000 | -361.7982 | 1.02e+08 | 609.41% |
| 2374073 | 1581038 | -228.1897  | 133 | -51.0000 | -361.7858 | 1.02e+08 | 609.38% |

Elapsed time = 6146.10 sec. (3692873.43 ticks, tree = 166163.23 MB, solutions = 37)

Nodefile size = 163955.13 MB (143560.66 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2383552 | 1588797 | -311.2394 | 181 | -51.0000 | -361.7788 | 1.02e+08 | 609.37% |
| 2391426 | 1596592 | -100.0000 | 67  | -51.0000 | -361.7660 | 1.02e+08 | 609.35% |
| 2399501 | 1604465 | -353.4838 | 253 | -51.0000 | -361.7523 | 1.03e+08 | 609.32% |
| 2406212 | 1609092 | -187.2150 | 110 | -51.0000 | -361.7359 | 1.03e+08 | 609.29% |
| 2414023 | 1613458 | -99.6122  | 48  | -51.0000 | -361.7213 | 1.03e+08 | 609.26% |
| 2423894 | 1621187 | -346.7928 | 202 | -51.0000 | -361.7141 | 1.03e+08 | 609.24% |
| 2432402 | 1623753 | -181.7823 | 93  | -51.0000 | -361.7031 | 1.03e+08 | 609.22% |
| 2441756 | 1636254 | -339.1537 | 432 | -51.0000 | -361.6890 | 1.03e+08 | 609.19% |
| 2448558 | 1638942 | -357.1295 | 284 | -51.0000 | -361.6797 | 1.03e+08 | 609.18% |
| 2454329 | 1646493 | -207.1387 | 147 | -51.0000 | -361.6752 | 1.04e+08 | 609.17% |

Elapsed time = 6408.01 sec. (3845475.54 ticks, tree = 173640.02 MB, solutions = 37)

Nodefile size = 171517.61 MB (150199.52 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2458581 | 1647298 | -162.0000 | 89  | -51.0000 | -361.6752 | 1.04e+08 | 609.17% |
| 2466444 | 1654276 | -315.4581 | 198 | -51.0000 | -361.6752 | 1.04e+08 | 609.17% |
| 2470355 | 1658826 | -353.0127 | 356 | -51.0000 | -361.6752 | 1.04e+08 | 609.17% |
| 2473616 | 1660657 | -169.0000 | 93  | -51.0000 | -361.6752 | 1.04e+08 | 609.17% |

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2477627 | 1664097 | -293.9190 | 163 | -51.0000 | -361.6752 | 1.05e+08 | 609.17% |
| 2482952 | 1664957 | -317.8915 | 228 | -51.0000 | -361.6626 | 1.05e+08 | 609.14% |
| 2490159 | 1670626 | -299.0124 | 185 | -51.0000 | -361.6626 | 1.05e+08 | 609.14% |
| 2496441 | 1674807 | -179.6537 | 100 | -51.0000 | -361.6489 | 1.05e+08 | 609.12% |
| 2499857 | 1680158 | -360.0926 | 333 | -51.0000 | -361.6489 | 1.05e+08 | 609.12% |
| 2503644 | 1682909 | -223.7228 | 137 | -51.0000 | -361.6489 | 1.05e+08 | 609.12% |

Elapsed time = 6660.25 sec. (3998105.33 ticks, tree = 177713.50 MB, solutions = 37)

Nodefile size = 175582.00 MB (153769.34 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2508133 | 1685701 | -351.1965 | 242 | -51.0000 | -361.6489 | 1.05e+08 | 609.12% |
| 2513566 | 1689957 | -315.2063 | 204 | -51.0000 | -361.6489 | 1.06e+08 | 609.12% |
| 2522621 | 1692554 | -159.2441 | 88  | -51.0000 | -361.6054 | 1.06e+08 | 609.03% |
| 2531222 | 1701571 | -351.4425 | 327 | -51.0000 | -361.6054 | 1.06e+08 | 609.03% |
| 2537166 | 1707313 | -344.7554 | 276 | -51.0000 | -361.6054 | 1.06e+08 | 609.03% |
| 2543854 | 1710306 | -288.1213 | 179 | -51.0000 | -361.6054 | 1.06e+08 | 609.03% |
| 2548956 | 1715402 | -352.9752 | 266 | -51.0000 | -361.6054 | 1.06e+08 | 609.03% |
| 2556366 | 1719215 | -90.8929  | 53  | -51.0000 | -361.6054 | 1.07e+08 | 609.03% |
| 2563936 | 1724929 | -348.9798 | 269 | -51.0000 | -361.5820 | 1.07e+08 | 608.98% |
| 2572853 | 1730095 | -143.0000 | 96  | -51.0000 | -361.5413 | 1.07e+08 | 608.90% |

Elapsed time = 6920.25 sec. (4150726.32 ticks, tree = 184835.85 MB, solutions = 37)

Nodefile size = 182651.48 MB (160032.23 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2580724 | 1735982 | -348.7664 | 273 | -51.0000 | -361.5161 | 1.07e+08 | 608.86% |
| 2585129 | 1742238 | -340.2640 | 247 | -51.0000 | -361.5073 | 1.07e+08 | 608.84% |
| 2592516 | 1746730 | -357.0770 | 344 | -51.0000 | -361.4975 | 1.07e+08 | 608.82% |
| 2598719 | 1750962 | -323.6565 | 219 | -51.0000 | -361.4916 | 1.08e+08 | 608.81% |
| 2606882 | 1756673 | -120.0000 | 64  | -51.0000 | -361.4748 | 1.08e+08 | 608.77% |
| 2611677 | 1761982 | -164.3744 | 85  | -51.0000 | -361.4690 | 1.08e+08 | 608.76% |
| 2619177 | 1766883 | -178.8411 | 97  | -51.0000 | -361.4666 | 1.08e+08 | 608.76% |
| 2627954 | 1770167 | -107.0000 | 47  | -51.0000 | -361.4526 | 1.08e+08 | 608.73% |
| 2635043 | 1780029 | -123.1203 | 62  | -51.0000 | -361.4435 | 1.09e+08 | 608.71% |
| 2639585 | 1781709 | -314.0933 | 199 | -51.0000 | -361.4365 | 1.09e+08 | 608.70% |

Elapsed time = 7185.81 sec. (4303333.35 ticks, tree = 191557.34 MB, solutions = 37)

Nodefile size = 189428.39 MB (166019.78 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2647726 | 1786498 | -104.0000 | 54  | -51.0000 | -361.4335 | 1.09e+08 | 608.69% |
| 2653388 | 1791883 | -89.0000  | 45  | -51.0000 | -361.4254 | 1.09e+08 | 608.68% |
| 2659559 | 1796095 | -248.7363 | 154 | -51.0000 | -361.4195 | 1.09e+08 | 608.67% |
| 2664920 | 1800003 | -208.3245 | 115 | -51.0000 | -361.4124 | 1.09e+08 | 608.65% |
| 2671339 | 1803572 | -242.4922 | 143 | -51.0000 | -361.4098 | 1.09e+08 | 608.65% |
| 2679485 | 1809454 | -163.4830 | 93  | -51.0000 | -361.4098 | 1.10e+08 | 608.65% |
| 2687816 | 1818604 | -161.0000 | 82  | -51.0000 | -361.4098 | 1.10e+08 | 608.65% |

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2692818 | 1820449 | -106.8889 | 48  | -51.0000 | -361.3861 | 1.10e+08 | 608.60% |
| 2698954 | 1825943 | -120.0000 | 69  | -51.0000 | -361.3847 | 1.10e+08 | 608.60% |
| 2705641 | 1829933 | -340.4938 | 220 | -51.0000 | -361.3663 | 1.10e+08 | 608.56% |

Elapsed time = 7443.22 sec. (4455943.64 ticks, tree = 197301.95 MB, solutions = 37)

Nodefile size = 195152.26 MB (171064.80 MB after compression)

|         |         |           |     |          |           |          |         |
|---------|---------|-----------|-----|----------|-----------|----------|---------|
| 2716311 | 1836247 | -164.0000 | 97  | -51.0000 | -361.3485 | 1.11e+08 | 608.53% |
| 2724612 | 1841495 | -209.1877 | 122 | -51.0000 | -361.3366 | 1.11e+08 | 608.50% |
| 2736277 | 1851272 | -354.5079 | 276 | -51.0000 | -361.3239 | 1.11e+08 | 608.48% |
| 2746256 | 1859680 | -304.4639 | 194 | -51.0000 | -361.3177 | 1.11e+08 | 608.47% |
| 2752715 | 1865169 | -314.2210 | 188 | -51.0000 | -361.3065 | 1.11e+08 | 608.44% |
| 2760747 | 1868729 | -334.1027 | 236 | -51.0000 | -361.2981 | 1.11e+08 | 608.43% |
| 2767824 | 1874686 | -358.6653 | 314 | -51.0000 | -361.2860 | 1.12e+08 | 608.40% |
| 2776708 | 1879875 | -108.5139 | 58  | -51.0000 | -361.2798 | 1.12e+08 | 608.39% |
| 2780036 | 1883524 | -346.3044 | 728 | -51.0000 | -361.2798 | 1.12e+08 | 608.39% |

GUB cover cuts applied: 2067

Clique cuts applied: 60

Cover cuts applied: 5679

Implied bound cuts applied: 140

Flow cuts applied: 220

Mixed integer rounding cuts applied: 7001

Zero-half cuts applied: 147

Lift and project cuts applied: 28

Gomory fractional cuts applied: 187

Root node processing (before b&c):

Real time = 0.01 sec. (4.06 ticks)

Parallel b&c, 8 threads:

Real time = 7674.31 sec. (4597796.80 ticks)

Sync time (average) = 2890.35 sec.

Wait time (average) = 0.00 sec.

-----

Total (root+branch&cut) = 7674.31 sec. (4597800.86 ticks)

-----

Iteration 15

Bounds on # of cuts = 8 with [3 3 2]

Error = 49 (out of 100 instances)

Accuracy = 51

Solving time = 127.905276652 min (minutes)  
Accumulated time = 209.928617383 min (minutes)

Solution status code = 111  
LB on error = -261.279772855  
Relative objective gap = 6.083917115

Selected variables:  
A\_AGE (Continuous)  
PEMLR (Categorical)

Number of selected variables = 2 (1 continuous + 1 categorical)

-----

main returns 0

<<< main

<<< done

## Biography

Songkomkrit Chaiyakan was born in Hatyai, Thailand, on August 12, 1991. He had been studying Mathematics and Applied Mathematics-Economics at Brown University, United States of America, from 2011 to 2013. In 2014, he transferred to a university in Thailand and received the Bachelor of Science (B.Sc.) degree in Mathematics from Prince of Songkla University, Thailand, in 2017. The Master of Science (M.Sc.) degree in Applied Mathematics and Computational Science was conferred by Chulalongkorn University, Thailand, in 2020. Currently, he is pursuing the Doctor of Philosophy (Ph.D.) program in Business Analytics and Data Science at National Institute of Development Administration (NIDA), Thailand.

Regarding work experience, he served as a homework grader for two undergraduate-level courses in calculus and microeconomics at Brown University from September 2012 to May 2013. He also worked as an academic officer at Learn Corporation from June 2019 to November 2019. At Chulalongkorn University, he served as a teaching assistant for two graduate-level courses in mathematical programming and real analysis in addition to three undergraduate-level courses in calculus and stochastic processes from January 2018 to April 2020. At National Institute of Development Administration, he assisted professors with their graduate classes in basic programming and database management, applied machine learning, and data streaming and real-time analytics from August 2022 to May 2024.

His research interest is to develop quantitative tools and achieve a breakthrough in finance, optimization, statistics and artificial intelligence (AI). In his spare time, he enjoys tackling unsolvable problems and also proving or providing interesting insights into commonly used, yet partially theoretically substantiated, statements.