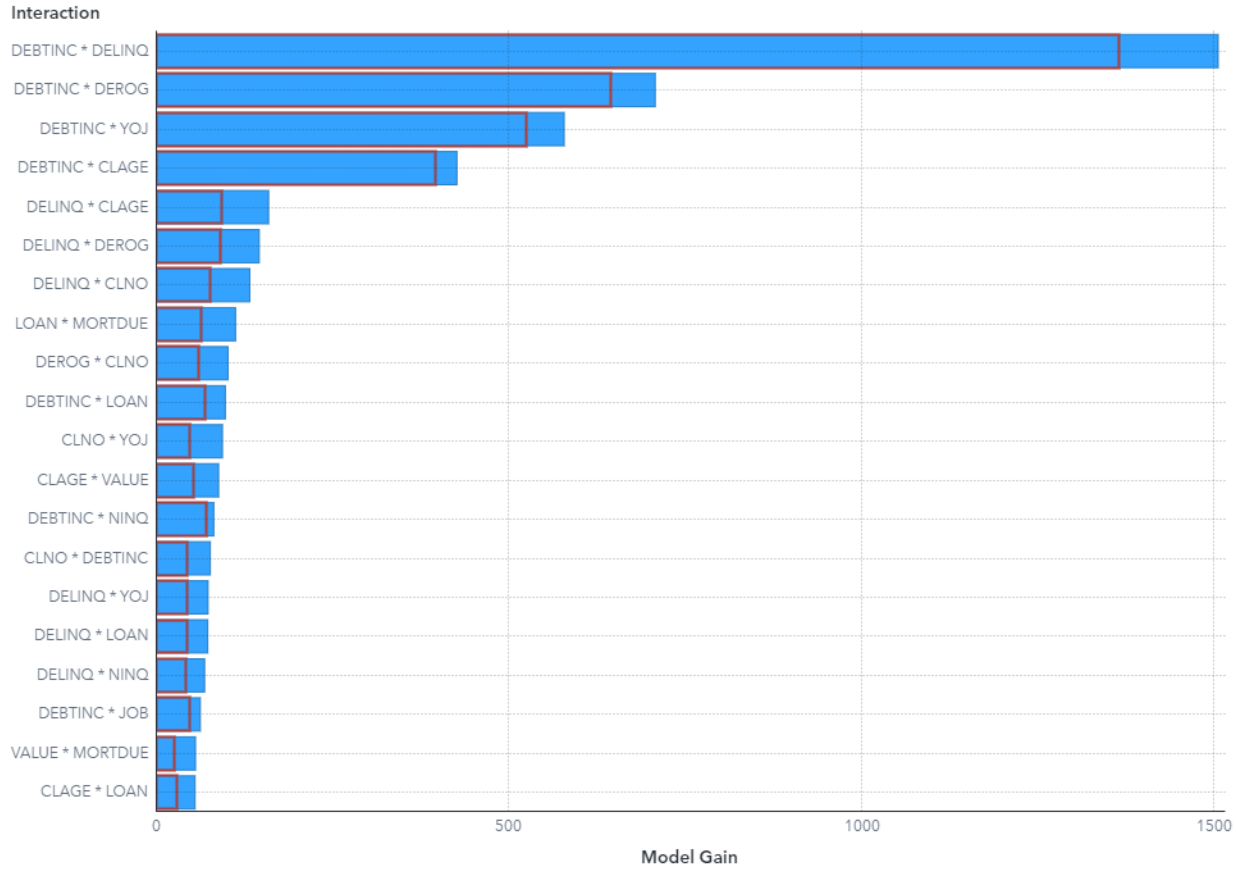
# HMEQ-Risk

## "Pairwise Selection" Results

by: David Weik

# Contents

# Pairwise Interaction Predictive Power



# Node Statistics

**Run Statistics**

| Last Run (UTC) | Setup (sec) | Run Duration (sec) | Pipeline Run | User |
|---|---|---|---|---|
| 24Jan2024:10:49:14 | 2.184 | 3.710 | True | gerdaw |

## Properties

| Property Name | Property Value |
|---|---|
| _omitJsonListing | true |
| _omitSessionResults | true |
| _omitTextListing | true |
| analysisVariables | GROUP |
| casSessionId | abfce174-3fc1-ac44-adaa-1f411bada600 |
| codeFile | cs_pairwise.sas |
| codeFormat | FILE |
| codeLanguage | SAS |
| codeLocation | vriskmdsvr |
| component | cs_pairwise |
| dataMiningVersion | V2024.01 |
| defaultVarsPerTree | true |
| distribution | POISSON |
| earlyStop | true |
| earlyStopMethod | STAGNATION |
| esMetric | MCR |
| esMinimum | false |
| esThreshold | 0 |
| esThresholdIter | 0 |
| intBinMethod | QUANTILE |
| intervalBins | 50 |
| lasso | 0 |
| learningRate | 0.1000 |
| maxBranch | 2 |
| maxCategories | 128 |

| Property Name | Property Value |
|---|---|
| maxDepth | 4 |
| minLeafSize | 5 |
| minUseInSearch | 1 |
| missingValue | USEINSEARCH |
| modeling | false |
| ntrees | 100 |
| numInteractions | 20 |
| power | 1.5000 |
| prefix | cs_pairwise |
| reportingOnly | false |
| ridge | 1 |
| scoreCodeFormat | DS1 |
| seed | 12,345 |
| stagnation | 5 |
| subsampleRate | 0.5000 |
| templateRevision | 1 |
| tolerance | 0 |
| trainOnly | false |
| userDefined | false |
| varsToTry | 100 |
| version | 1 |

# Output

The SAS System

The GRADBOOST Procedure

| Model Information | |
|---|---|
| Number of Trees | 100 |
| Learning Rate | 0.1 |
| Subsampling Rate | 0.5 |
| Number of Variables Per Split | 12 |
| Number of Bins | 50 |
| Number of Input Variables | 12 |
| Maximum Number of Tree Nodes | 31 |
| Minimum Number of Tree Nodes | 15 |
| Maximum Number of Branches | 2 |
| Minimum Number of Branches | 2 |
| Maximum Depth | 4 |
| Minimum Depth | 4 |
| Maximum Number of Leaves | 16 |
| Minimum Number of Leaves | 8 |
| Maximum Leaf Size | 1550 |
| Minimum Leaf Size | 5 |
| Seed | 12345 |
| Lasso (L1) penalty | 0 |
| Ridge (L2) penalty | 1 |
| Actual Number of Trees | 74 |
| Average Number of Leaves | 14.2162162 |
| Early stopping stagnation | 5 |
| Early stopping threshold | 0 |
| Early stopping threshold iterations | 0 |
| Early stopping tolerance | 0 |

| | Training | Validation | Test | Total |
|---|---|---|---|---|
| Number of Observations Read | 3576 | 1788 | 596 | 5960 |
| Number of Observations Used | 3576 | 1788 | 596 | 5960 |

| Variable Importance | | | |
|---|---|---|---|
| Variable | Importance | Std Dev Importance | Relative Importance |
| DEBTINC | 23.6217 | 55.2378 | 1.0000 |
| DELINQ | 4.9407 | 5.4046 | 0.2092 |
| DEROG | 3.3581 | 3.8809 | 0.1422 |
| CLAGE | 3.3553 | 3.7591 | 0.1420 |
| CLNO | 3.0916 | 2.2078 | 0.1309 |
| YOJ | 2.9857 | 2.5802 | 0.1264 |
| MORTDUE | 2.8949 | 2.7574 | 0.1226 |
| LOAN | 2.5819 | 2.2558 | 0.1093 |
| NINQ | 2.4452 | 2.2628 | 0.1035 |
| VALUE | 2.3281 | 2.8072 | 0.0986 |
| JOB | 1.4253 | 1.8290 | 0.0603 |
| REASON | 0.3553 | 0.9411 | 0.0150 |

Fit Statistics

| Number of Trees | Training Average Square Error | Validation Average Square Error | Test Average Square Error | Training Misclassification Rate | Validation Misclassification Rate | Test Misclassification Rate | Training Log Loss | Validation Log Loss | Test Log Loss |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.1455 | 0.1472 | 0.1456 | 0.1994 | 0.200 | 0.1997 | 0.458 | 0.463 | 0.458 |
| 2 | 0.1340 | 0.1369 | 0.1345 | 0.1994 | 0.200 | 0.1997 | 0.427 | 0.435 | 0.429 |
| 3 | 0.1250 | 0.1290 | 0.1257 | 0.1994 | 0.200 | 0.1997 | 0.404 | 0.415 | 0.406 |
| 4 | 0.1179 | 0.1229 | 0.1177 | 0.1994 | 0.200 | 0.1997 | 0.385 | 0.399 | 0.385 |
| 5 | 0.1116 | 0.1176 | 0.1120 | 0.1994 | 0.200 | 0.1997 | 0.369 | 0.385 | 0.370 |
| 6 | 0.1063 | 0.1129 | 0.1068 | 0.1664 | 0.179 | 0.1695 | 0.355 | 0.373 | 0.356 |
| 7 | 0.1023 | 0.1095 | 0.1034 | 0.1552 | 0.163 | 0.1544 | 0.344 | 0.364 | 0.346 |
| 8 | 0.0986 | 0.1062 | 0.0995 | 0.1370 | 0.148 | 0.1426 | 0.334 | 0.355 | 0.336 |
| 9 | 0.0952 | 0.1034 | 0.0961 | 0.1230 | 0.140 | 0.1275 | 0.325 | 0.348 | 0.326 |
| 10 | 0.0925 | 0.1019 | 0.0939 | 0.1180 | 0.136 | 0.1275 | 0.317 | 0.343 | 0.319 |
| 11 | 0.0902 | 0.1000 | 0.0919 | 0.1121 | 0.131 | 0.1158 | 0.310 | 0.337 | 0.312 |
| 12 | 0.0881 | 0.0984 | 0.0902 | 0.1085 | 0.127 | 0.1158 | 0.304 | 0.333 | 0.307 |
| 13 | 0.0862 | 0.0973 | 0.0893 | 0.1071 | 0.124 | 0.1174 | 0.298 | 0.329 | 0.304 |
| 14 | 0.0847 | 0.0961 | 0.0883 | 0.1063 | 0.120 | 0.1124 | 0.293 | 0.326 | 0.300 |
| 15 | 0.0832 | 0.0950 | 0.0872 | 0.1051 | 0.120 | 0.1124 | 0.288 | 0.322 | 0.296 |
| 16 | 0.0822 | 0.0942 | 0.0861 | 0.1049 | 0.123 | 0.1107 | 0.285 | 0.320 | 0.293 |
| 17 | 0.0810 | 0.0934 | 0.0853 | 0.1021 | 0.121 | 0.1107 | 0.281 | 0.317 | 0.290 |
| 18 | 0.0797 | 0.0926 | 0.0841 | 0.1015 | 0.121 | 0.1107 | 0.277 | 0.314 | 0.286 |
| 19 | 0.0787 | 0.0917 | 0.0836 | 0.1010 | 0.120 | 0.1107 | 0.274 | 0.312 | 0.284 |
| 20 | 0.0778 | 0.0916 | 0.0831 | 0.1012 | 0.120 | 0.1158 | 0.270 | 0.311 | 0.281 |
| 21 | 0.0770 | 0.0915 | 0.0832 | 0.1007 | 0.121 | 0.1158 | 0.268 | 0.310 | 0.281 |
| 22 | 0.0762 | 0.0911 | 0.0829 | 0.0998 | 0.122 | 0.1191 | 0.265 | 0.309 | 0.279 |
| 23 | 0.0752 | 0.0904 | 0.0822 | 0.1007 | 0.122 | 0.1191 | 0.261 | 0.306 | 0.276 |
| 24 | 0.0743 | 0.0895 | 0.0814 | 0.0998 | 0.119 | 0.1191 | 0.259 | 0.303 | 0.274 |
| 25 | 0.0736 | 0.0892 | 0.0807 | 0.0990 | 0.120 | 0.1174 | 0.256 | 0.303 | 0.272 |
| 26 | 0.0730 | 0.0888 | 0.0803 | 0.0973 | 0.120 | 0.1174 | 0.254 | 0.301 | 0.270 |
| 27 | 0.0724 | 0.0885 | 0.0803 | 0.0979 | 0.119 | 0.1191 | 0.252 | 0.300 | 0.269 |
| 28 | 0.0717 | 0.0879 | 0.0795 | 0.0968 | 0.118 | 0.1174 | 0.250 | 0.298 | 0.266 |
| 29 | 0.0708 | 0.0875 | 0.0788 | 0.0959 | 0.116 | 0.1174 | 0.247 | 0.296 | 0.264 |
| 30 | 0.0700 | 0.0873 | 0.0780 | 0.0954 | 0.117 | 0.1174 | 0.244 | 0.296 | 0.262 |
| 31 | 0.0695 | 0.0871 | 0.0779 | 0.0948 | 0.117 | 0.1174 | 0.242 | 0.295 | 0.261 |
| 32 | 0.0688 | 0.0866 | 0.0772 | 0.0937 | 0.114 | 0.1158 | 0.240 | 0.293 | 0.258 |
| 33 | 0.0679 | 0.0861 | 0.0764 | 0.0920 | 0.116 | 0.1158 | 0.237 | 0.291 | 0.256 |
| 34 | 0.0675 | 0.0858 | 0.0762 | 0.0903 | 0.115 | 0.1141 | 0.235 | 0.290 | 0.254 |
| 35 | 0.0670 | 0.0856 | 0.0762 | 0.0903 | 0.115 | 0.1124 | 0.234 | 0.289 | 0.254 |
| 36 | 0.0663 | 0.0851 | 0.0759 | 0.0892 | 0.116 | 0.1158 | 0.231 | 0.288 | 0.252 |
| 37 | 0.0655 | 0.0849 | 0.0761 | 0.0892 | 0.113 | 0.1141 | 0.228 | 0.286 | 0.252 |
| 38 | 0.0650 | 0.0844 | 0.0755 | 0.0886 | 0.113 | 0.1141 | 0.227 | 0.285 | 0.250 |
| 39 | 0.0642 | 0.0840 | 0.0748 | 0.0859 | 0.113 | 0.1141 | 0.224 | 0.284 | 0.249 |
| 40 | 0.0636 | 0.0834 | 0.0748 | 0.0839 | 0.110 | 0.1124 | 0.222 | 0.282 | 0.249 |
| 41 | 0.0631 | 0.0832 | 0.0745 | 0.0836 | 0.110 | 0.1124 | 0.220 | 0.281 | 0.248 |
| 42 | 0.0625 | 0.0829 | 0.0739 | 0.0842 | 0.111 | 0.1141 | 0.219 | 0.280 | 0.246 |
| 43 | 0.0620 | 0.0826 | 0.0738 | 0.0845 | 0.110 | 0.1124 | 0.217 | 0.280 | 0.246 |
| 44 | 0.0613 | 0.0822 | 0.0738 | 0.0828 | 0.111 | 0.1091 | 0.214 | 0.278 | 0.246 |
| 45 | 0.0608 | 0.0818 | 0.0737 | 0.0819 | 0.112 | 0.1091 | 0.213 | 0.277 | 0.245 |
| 46 | 0.0606 | 0.0818 | 0.0735 | 0.0822 | 0.112 | 0.1124 | 0.212 | 0.277 | 0.244 |
| 47 | 0.0601 | 0.0816 | 0.0733 | 0.0814 | 0.111 | 0.1107 | 0.211 | 0.276 | 0.244 |
| 48 | 0.0595 | 0.0813 | 0.0729 | 0.0811 | 0.110 | 0.1091 | 0.209 | 0.275 | 0.243 |
| 49 | 0.0589 | 0.0807 | 0.0726 | 0.0805 | 0.109 | 0.1057 | 0.207 | 0.273 | 0.242 |
| 50 | 0.0584 | 0.0805 | 0.0726 | 0.0794 | 0.109 | 0.1074 | 0.205 | 0.273 | 0.242 |
| 51 | 0.0581 | 0.0802 | 0.0723 | 0.0797 | 0.107 | 0.1040 | 0.205 | 0.272 | 0.241 |
| 52 | 0.0577 | 0.0800 | 0.0720 | 0.0789 | 0.107 | 0.1023 | 0.203 | 0.271 | 0.240 |
| 53 | 0.0574 | 0.0799 | 0.0720 | 0.0791 | 0.105 | 0.1023 | 0.202 | 0.271 | 0.240 |
| 54 | 0.0570 | 0.0795 | 0.0715 | 0.0772 | 0.103 | 0.1040 | 0.201 | 0.270 | 0.239 |
| 55 | 0.0564 | 0.0790 | 0.0715 | 0.0769 | 0.102 | 0.1040 | 0.199 | 0.269 | 0.239 |
| 56 | 0.0562 | 0.0789 | 0.0713 | 0.0758 | 0.102 | 0.1040 | 0.198 | 0.268 | 0.238 |
| 57 | 0.0558 | 0.0786 | 0.0711 | 0.0755 | 0.103 | 0.1057 | 0.197 | 0.267 | 0.237 |
| 58 | 0.0553 | 0.0785 | 0.0708 | 0.0752 | 0.103 | 0.1007 | 0.196 | 0.266 | 0.236 |
| 59 | 0.0550 | 0.0781 | 0.0711 | 0.0752 | 0.102 | 0.1023 | 0.194 | 0.265 | 0.236 |
| 60 | 0.0544 | 0.0775 | 0.0710 | 0.0749 | 0.102 | 0.1007 | 0.193 | 0.263 | 0.236 |
| 61 | 0.0540 | 0.0774 | 0.0709 | 0.0735 | 0.102 | 0.0990 | 0.191 | 0.263 | 0.236 |
| 62 | 0.0536 | 0.0769 | 0.0704 | 0.0733 | 0.102 | 0.0990 | 0.190 | 0.261 | 0.235 |
| 63 | 0.0532 | 0.0766 | 0.0703 | 0.0741 | 0.102 | 0.0973 | 0.189 | 0.260 | 0.234 |
| 64 | 0.0528 | 0.0766 | 0.0703 | 0.0730 | 0.101 | 0.0990 | 0.187 | 0.260 | 0.234 |
| 65 | 0.0525 | 0.0764 | 0.0700 | 0.0719 | 0.101 | 0.0990 | 0.186 | 0.259 | 0.234 |
| 66 | 0.0521 | 0.0763 | 0.0700 | 0.0716 | 0.100 | 0.0990 | 0.185 | 0.258 | 0.233 |
| 67 | 0.0518 | 0.0760 | 0.0699 | 0.0719 | 0.100 | 0.0990 | 0.184 | 0.257 | 0.233 |
| 68 | 0.0514 | 0.0758 | 0.0697 | 0.0713 | 0.101 | 0.0990 | 0.183 | 0.257 | 0.233 |
| 69 | 0.0511 | 0.0758 | 0.0696 | 0.0710 | 0.101 | 0.0940 | 0.182 | 0.256 | 0.232 |
| 70 | 0.0508 | 0.0757 | 0.0694 | 0.0702 | 0.101 | 0.0956 | 0.181 | 0.256 | 0.231 |
| 71 | 0.0504 | 0.0754 | 0.0695 | 0.0691 | 0.102 | 0.0923 | 0.179 | 0.255 | 0.232 |
| 72 | 0.0500 | 0.0752 | 0.0691 | 0.0682 | 0.101 | 0.0956 | 0.178 | 0.254 | 0.231 |
| 73 | 0.0497 | 0.0751 | 0.0691 | 0.0688 | 0.102 | 0.0973 | 0.177 | 0.254 | 0.230 |
| 74 | 0.0493 | 0.0748 | 0.0686 | 0.0680 | 0.102 | 0.0973 | 0.176 | 0.253 | 0.229 |

Output CAS Tables

| CAS Library | Name | Number of Rows | Number of Columns |
|---|---|---|---|
| Analytics_Project_3f4025ca-aed2-40f2-861a-3d2fcfd49a33 | _DTVM07PY3LYEKKI7PH4IEYEQ5_AST | 1 | 2 |
| Analytics_Project_3f4025ca-aed2-40f2-861a-3d2fcfd49a33 | _DTVM07PY3LYEKKI7PH4IEYEQ5_MODEL | 2030 | 45 |

| Predicted Probability Variables | |
|---|---|
| BAD | Variable |
| 1 | P_BAD1 |
| 0 | P_BAD0 |

| Predicted Target Variable | |
|---|---|
| Level Index | Variable |
| | I_BAD |

The SAS System

Pairwise Interaction Predictive Power

| Obs | Interaction | Feature 1 Gain | Feature 2 Gain | Model Gain |
|---|---|---|---|---|
| 1 | DEBTINC * DELINQ | 1364.52 | 141.317 | 1505.84 |
| 2 | DEBTINC * DEROG | 645.39 | 62.526 | 707.92 |
| 3 | DEBTINC * YOJ | 525.74 | 53.119 | 578.86 |
| 4 | DEBTINC * CLAGE | 396.93 | 29.955 | 426.88 |
| 5 | DELINQ * CLAGE | 92.66 | 67.258 | 159.92 |
| 6 | DELINQ * DEROG | 91.22 | 55.430 | 146.65 |
| 7 | DELINQ * CLNO | 77.45 | 55.790 | 133.24 |
| 8 | LOAN * MORTDUE | 63.53 | 49.565 | 113.09 |
| 9 | DEROG * CLNO | 60.57 | 41.892 | 102.46 |
| 10 | DEBTINC * LOAN | 69.61 | 29.012 | 98.62 |
| 11 | CLNO * YOJ | 48.19 | 46.304 | 94.50 |
| 12 | CLAGE * VALUE | 53.81 | 35.276 | 89.09 |
| 13 | DEBTINC * NINQ | 70.79 | 11.472 | 82.27 |
| 14 | CLNO * DEBTINC | 43.63 | 33.697 | 77.33 |
| 15 | DELINQ * YOJ | 44.48 | 29.654 | 74.13 |
| 16 | DELINQ * LOAN | 44.91 | 28.776 | 73.68 |
| 17 | DELINQ * NINQ | 42.61 | 26.628 | 69.24 |
| 18 | DEBTINC * JOB | 47.55 | 15.609 | 63.16 |
| 19 | VALUE * MORTDUE | 26.54 | 29.755 | 56.30 |
| 20 | CLAGE * LOAN | 29.06 | 26.647 | 55.71 |
| 21 | YOJ * NINQ | 34.67 | 17.937 | 52.61 |
| 22 | DEROG * CLAGE | 32.73 | 19.762 | 52.49 |
| 23 | CLNO * CLAGE | 28.39 | 22.199 | 50.59 |
| 24 | DEROG * NINQ | 32.69 | 16.242 | 48.94 |
| 25 | DEROG * JOB | 30.23 | 17.945 | 48.18 |
| 26 | VALUE * LOAN | 25.75 | 20.216 | 45.96 |
| 27 | DELINQ * VALUE | 26.42 | 19.246 | 45.66 |
| 28 | DEBTINC * MORTDUE | 26.91 | 16.883 | 43.79 |
| 29 | NINQ * MORTDUE | 24.09 | 19.038 | 43.13 |
| 30 | CLAGE * YOJ | 28.74 | 13.610 | 42.35 |
| 31 | DEROG * LOAN | 24.50 | 17.323 | 41.82 |
| 32 | CLNO * MORTDUE | 20.11 | 21.375 | 41.48 |
| 33 | YOJ * LOAN | 22.26 | 17.252 | 39.51 |
| 34 | DEROG * MORTDUE | 21.92 | 16.968 | 38.89 |
| 35 | CLNO * JOB | 19.28 | 17.943 | 37.22 |
| 36 | DEROG * YOJ | 23.70 | 13.465 | 37.17 |
| 37 | CLNO * NINQ | 22.80 | 14.271 | 37.08 |
| 38 | DELINQ * MORTDUE | 24.26 | 12.251 | 36.51 |
| 39 | MORTDUE * CLAGE | 20.57 | 15.114 | 35.69 |
| 40 | CLNO * LOAN | 16.91 | 18.525 | 35.43 |
| 41 | VALUE * YOJ | 20.93 | 13.995 | 34.92 |
| 42 | DEROG * VALUE | 20.59 | 14.166 | 34.75 |
| 43 | MORTDUE * JOB | 21.25 | 12.473 | 33.73 |
| 44 | LOAN * NINQ | 18.55 | 15.142 | 33.69 |
| 45 | YOJ * MORTDUE | 15.69 | 15.888 | 31.58 |
| 46 | CLNO * REASON | 16.04 | 14.970 | 31.01 |
| 47 | CLNO * VALUE | 15.11 | 11.249 | 26.36 |
| 48 | JOB * YOJ | 13.89 | 10.415 | 24.31 |
| 49 | VALUE * JOB | 13.93 | 8.209 | 22.14 |
| 50 | DEBTINC * VALUE | 11.43 | 8.416 | 19.84 |
| 51 | VALUE * NINQ | 11.30 | 8.484 | 19.79 |
| 52 | JOB * NINQ | 11.80 | 5.882 | 17.68 |
| 53 | CLAGE * NINQ | 9.91 | 5.035 | 14.95 |
| 54 | CLAGE * JOB | 8.09 | 6.399 | 14.49 |
| 55 | REASON * YOJ | 11.20 | 1.664 | 12.87 |
| 56 | LOAN * JOB | 6.51 | 5.945 | 12.46 |
| 57 | JOB * DELINQ | 5.53 | 4.388 | 9.92 |
| 58 | DELINQ * REASON | 6.59 | 2.704 | 9.30 |
| 59 | REASON * MORTDUE | 4.65 | 2.668 | 7.32 |
| 60 | REASON * NINQ | 4.34 | 2.624 | 6.96 |
| 61 | DEBTINC * REASON | 3.69 | 2.070 | 5.76 |
| 62 | REASON * DEROG | 2.89 | 2.492 | 5.38 |
| 63 | LOAN * REASON | 2.38 | 2.886 | 5.26 |