

ITCS 6162 – Knowledge Discovery in Databases

Project Report

Team Members

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1) Introduction

Fragile State index is the process of considering twelve conflict risk indicators and measuring the condition of the state. A state is said to be in an ALERT state if the corresponding state legitimacy is weak. In this project, we are using classification techniques and extraction of action rules to estimate what steps to take in order to improve the condition of the State. Following is the list of indicators used for Fragile State Index and the approach we followed to achieve the estimate. We used WEKA tool for classification purposes and LISP Miner for extracting the action rules.

2) What is Fragile state index?

The **Fragile States Index** is an annual assessment of 178 countries based on a **measurement** of the social, economic, and political pressures that each country faces. A **fragile state** is termed as countries in which populations suffer from violence, extreme poverty and corruption. Fragile states can be influenced by many factors like for instance, some countries may have **weak** institutions and capacity, and are vulnerable to conflict, or are failing (or at the risk of failing) to deliver the basic functions of the **state**, these countries might end up in constant trap.



3) Existing Features

- **Security Apparatus:** The *Security Apparatus* indicator considers the security threats to a state, such as bombings, attacks and battle-related deaths, rebel movements etc
- **Factionalized Elites:** The *Factionalized Elites* indicator considers the fragmentation of state institutions using different categories along with ethnic, class, clan, racial or religious lines.
- **Group Grievance:** Group Grievance Indicator focuses on divisions and schisms between different groups in society – particularly divisions based on social or political characteristics.

- **Economy:** Economic Decline Indicator considers factors related to economic decline within a country. For example, the Indicator looks at patterns of progressive economic decline of the society as a whole as measured by per capita income, Gross National Product.
- **Economic Inequality:** considers inequality within the economy, irrespective of the actual performance of an economy.
- **Human Flight and Brain Drain:** considers the economic impact of human displacement (for economic or political reasons) and the consequences this may have on a country's development.
- **State Legitimacy:** considers the representativeness and openness of government and its relationship with its citizenry. The Indicator looks at the population's level of confidence in state institutions and processes, and assesses the effects where that confidence is absent.
- **Public Services:** refers to the presence of basic state functions that serve the people. On the one hand, this may include the provision of essential services.
- **Human Rights:** considers the relationship between the state and its population insofar as fundamental human rights are protected and freedoms are observed and respected.
- **Demographic Pressures:** considers pressures upon the state deriving from the population itself or the environment around it.
- **Refugees and IDPs:** measures the pressure upon states caused by the forced displacement of large communities as a result of social, political, environmental or other causes.
- **External Intervention:** considers the influence and impact of external actors in the functioning – particularly security and economic – of a state.

4) Extended Features

- **Education Index:** The education index has been measured by combining average adult years of schooling with expected years of schooling for children.
- **Life Expectancy at births:** Life expectancy at birth is defined as how long, on average, a newborn can expect to live, if current death rates do not change. If rates are falling, that is considered as a good sign for actual life spans.
- **Domestic Credit provided by financial sector:** Financial sector provides the Domestic credit includes all credit to various sectors on a gross basis, except for credit to the central government, which is net.
- **Exports and Imports:** An import is a good or service brought into one country from another. An export is an international trade where goods produced in one country are shipped to another country for future sale or trade. Exports are an important part of a country's economy, as the sale of such goods adds to the producing nation's gross output.
- **Infant Mortality Rate:** The infant mortality rate is defined as the number of deaths of children under one year of age, expressed per 1,000 live births.
- **Unemployment Rate:** Unemployment rate is the number of unemployed people as a percentage of the labor force, where the latter consists of the unemployed plus those in paid or self-employment

4) Data Extraction

The data for these extended features have been extracted from below mentioned website and then added to the original FSI dataset. The data for 3 consecutive years, i.e., 2014-2016 has been compiled and stored in an excel sheet for further processing & analysis.

<http://hdr.undp.org/en/data>

5) Data cleaning and Preprocessing

The original FSI dataset was not clean, so we have decided to preprocess the data before getting action rules. Following are the steps taken to preprocess data.

- Missing numeric values were replaced with mean values
- Outliers and Extreme values were removed
- Numeric values of Decision attribute were replaced with Nominal values

Now data is ready to perform classification and action rules.

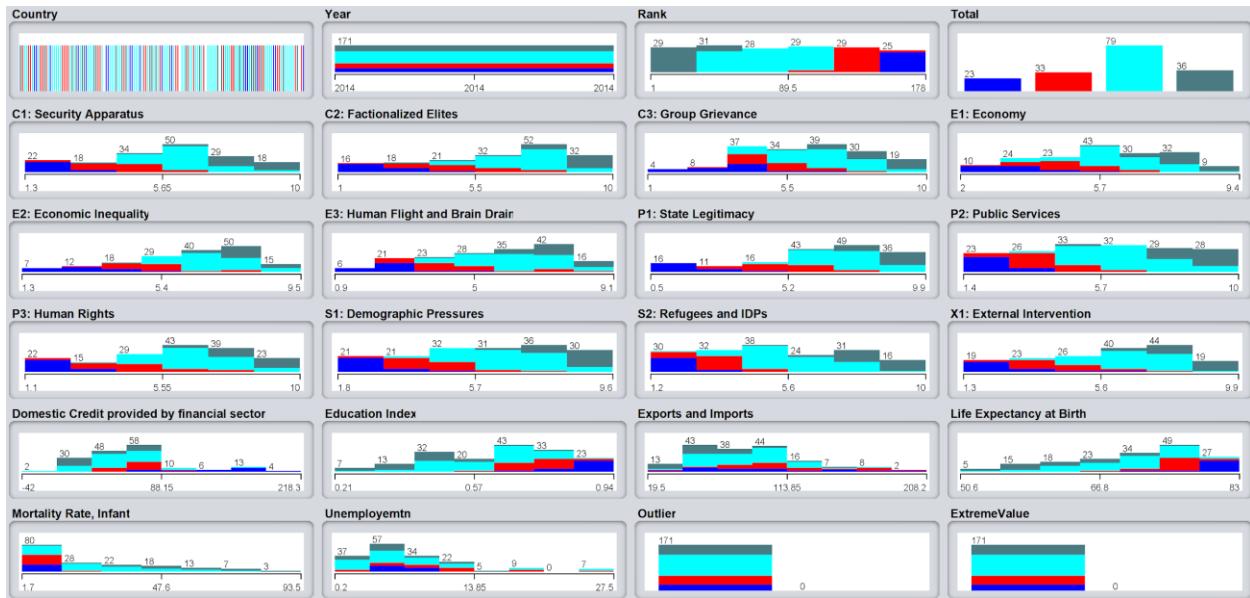
6) Data Discretization using WEKA

Discretization is a process of converting or partitioning continuous attributes, features to discretized or nominal attributes.

The decision attribute has various values throughout the dataset, we have discretized the total attribute to replace numeric values with nominal categories which are shown below.

Category	Total Range
Alert	(89.35 - INF)
Warning	(65.8 - 89.35]
Stable	(42.25 - 65.8]
Sustainable	[INF - 42.25]

Screenshot of discretization:



7) Data Classification using WEKA

For classification, we have used the following classifiers. Each classifier has been run for the dataset from the year 2014 – 2016. We have also calculated the accuracy for each classifier of the dataset before and also after adding extended features, to compare the efficiency of both types of datasets.

- **Random Tree:**

Random Tree is a supervised Classifier. It is an ensemble learning algorithm that generates many individual learners. It employs a bagging idea to produce a random set of data for constructing a decision tree. In standard tree each node is split using the best split among all variables. In a random forest, each node is split using the best among the subset of predictors randomly chosen at that node.

- **Bayes Net:**

Bayesian networks aim to model conditional dependence, and therefore causation, by representing conditional dependence by edges in a directed graph. Bayes Network learning uses various search algorithms and quality measures like:

Base class for a Bayes Network classifier, provides data-structures (network structure, conditional probability distributions, etc.) and facilities common to Bayes Network learning algorithms like K2 and B. Bayesian networks are a type of probabilistic graphical model that uses Bayesian inference for probability computations.

- **J48:**

J48 is an extension of ID3, which can be used for Tree pruning. The additional features of J48 are details for missing values, decision trees pruning, continuous attribute value ranges, derivation of rules, etc. In the WEKA data mining tool, J48 is an open source Java implementation of the C4.5 algorithm. In case of potential over fitting pruning can be used as a tool for précising. In other algorithms the classification is performed recursively till every single leaf is pure, that is the classification of the data should be as perfect as possible. This algorithm it generates the rules from which particular identity of that data is generated. The objective is progressively generalization of a decision tree until it gains equilibrium of flexibility and accuracy.

8) Classification Results before adding new features

2014 Dataset:

Classifier: Random Tree

```
==== Run information ====
Scheme:      weka.classifiers.trees.RandomTree -K 0 -M 1.0 -V 0.001 -S 1
Relation:    fsi-2014-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-weka.filte
rs.unsupervised.attribute.Discretize-B4-M-1.0-R4-precision6
Instances:   177
Attributes:  18
              Country
              Year
              Rank
              Total
              C1: Security Apparatus
              C2: Factionalized Elites
              C3: Group Grievance
              E1: Economy
              E2: Economic Inequality
              E3: Human Flight and Brain Drain
              P1: State Legitimacy
              P2: Public Services
              P3: Human Rights
              S1: Demographic Pressures
              S2: Refugees and IDPs
              X1: External Intervention
              Outlier
              ExtremeValue
Test mode:   10-fold cross-validation

==== Classifier model (full training set) ====
Time taken to build model: 0 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      115          64.9718 %
Incorrectly Classified Instances    62           35.0282 %
Kappa statistic                   0.44
Mean absolute error               0.216
Root mean squared error           0.341
Relative absolute error            62.0899 %
Root relative squared error       81.8154 %
Total Number of Instances         177

==== Detailed Accuracy By Class ====
           TP Rate  FP Rate  Precision  Recall   F-Measure  MCC     ROC Area  PRC Area  Class
          0.481   0.020   0.813   0.481   0.605    0.579   0.873   0.677  Sustainable
          0.353   0.049   0.632   0.353   0.453    0.387   0.806   0.545   Stable
          0.950   0.515   0.603   0.950   0.738    0.478   0.821   0.760   Warning
          0.389   0.014   0.875   0.389   0.538    0.526   0.839   0.644   Alert
Weighted Avg.   0.650   0.248   0.696   0.650   0.622    0.485   0.830   0.683

==== Confusion Matrix ====
 a  b  c  d  <-- classified as
13  5  9  0 | a = Sustainable
3 12 19  0 | b = Stable
0  2 76  2 | c = Warning
0  0 22 14 | d = Alert
```

Classifier: BayesNet

```
==== Run information ====
Scheme:      weka.classifiers.bayes.BayesNet -D -Q weka.classifiers.bayes.net.search.local.K2 -- -P 1 -S BAYES -E
weka.classifiers.bayes.net.estimate.SimpleEstimator -- -A 0.5
Relation:
fsi-2014-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-03.0-E6.0-weka.filte
rs.unsupervised.attribute.Discretize-B4-M-1.0-R4-precision6
Instances:    177
Attributes:   18
Country
Year
Rank
Total
C1: Security Apparatus
C2: Factionalized Elites
C3: Group Grievance
E1: Economy
E2: Economic Inequality
E3: Human Flight and Brain Drain
P1: State Legitimacy
P2: Public Services
P3: Human Rights
S1: Demographic Pressures
S2: Refugees and IDPs
X1: External Intervention
Outlier
ExtremeValue
Test mode:   10-fold cross-validation
==== Classifier model (full training set) ====
Bayes Network Classifier
not using ADTree
#attributes=18 #classindex=3
Network structure (nodes followed by parents)
Country(177): Total
Year(1): Total

|C1: Security Apparatus(4): Total
|C2: Factionalized Elites(5): Total
|C3: Group Grievance(4): Total
|E1: Economy(4): Total
|E2: Economic Inequality(4): Total
|E3: Human Flight and Brain Drain(3): Total
|P1: State Legitimacy(4): Total
|P2: Public Services(4): Total
|P3: Human Rights(4): Total
|S1: Demographic Pressures(4): Total
|S2: Refugees and IDPs(5): Total
|X1: External Intervention(4): Total
|Outlier(2): Total
|ExtremeValue(2): Total
LogScore Bayes: -2967.401060925386
LogScore BDeu: -8845.936268568328
LogScore MDL: -6955.706077321497
LogScore ENTROPY: -4691.140569320451
LogScore AIC: -5566.14056932045

Time taken to build model: 0 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      169          95.4802 %
Incorrectly Classified Instances     8           4.5198 %
Kappa statistic                      0.9346
Mean absolute error                  0.0218
Root mean squared error              0.125
Relative absolute error              6.2631 %

Root relative squared error          29.995 %
Total Number of Instances           177

==== Detailed Accuracy By Class ====


|               | TP Rate | FP Rate | Precision | Recall | F-Measure | MCC   | ROC Area | PRC Area | Class       |
|---------------|---------|---------|-----------|--------|-----------|-------|----------|----------|-------------|
| 0.963         | 0.007   | 0.963   | 0.963     | 0.963  | 0.956     | 0.996 | 0.984    | 0.996    | Sustainable |
| 0.912         | 0.014   | 0.939   | 0.912     | 0.925  | 0.908     | 0.991 | 0.956    | 0.991    | Stable      |
| 0.975         | 0.041   | 0.951   | 0.975     | 0.963  | 0.932     | 0.997 | 0.997    | 0.997    | Warning     |
| 0.944         | 0.007   | 0.971   | 0.944     | 0.958  | 0.947     | 1.000 | 0.998    | 1.000    | Alert       |
| Weighted Avg. | 0.955   | 0.024   | 0.955     | 0.955  | 0.955     | 0.934 | 0.997    | 0.987    |             |


==== Confusion Matrix ====
a  b  c  d  <-- classified as
26  1  0  0 | a = Sustainable
1 31  2  0 | b = Stable
0  1 78  1 | c = Warning
0  0  2 34 | d = Alert
```

Classifier: J48

```
==== Run information ====
Scheme:      weka.classifiers.trees.J48 -C 0.25 -M 2
Relation:
fsi-2014-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-weka.filte
rs.unsupervised.attribute.Discretize-B4-M-1.0-R4-precision6
Instances:   177
Attributes:  18
              Country
              Year
              Rank
              Total
              C1: Security Apparatus
              C2: Factionalized Elites
              C3: Group Grievance
              E1: Economy
              E2: Economic Inequality
              E3: Human Flight and Brain Drain
              P1: State Legitimacy
              P2: Public Services
              P3: Human Rights
              S1: Demographic Pressures
              S2: Refugees and IDPs
              X1: External Intervention
              Outlier
              ExtremeValue
Test mode:   10-fold cross-validation
==== Classifier model (full training set) ====
J48 pruned tree
-----
Rank <= 117
|  Rank <= 37: Alert (36.0)
|  Rank > 37: Warning (80.0)
Rank > 117

|  Rank <= 151: Stable (34.0)
|  Rank > 151: Sustainable (27.0)

Number of Leaves :      4
Size of the tree :    7

Time taken to build model: 0 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      173          97.7401 %
Incorrectly Classified Instances     4           2.2599 %
Kappa statistic                      0.9675
Mean absolute error                  0.0113
Root mean squared error              0.1063
Relative absolute error              3.248 %
Root relative squared error         25.5068 %
Total Number of Instances           177

==== Detailed Accuracy By Class ====


|               | TP Rate | FP Rate | Precision | Recall | F-Measure | MCC   | ROC Area | PRC Area | Class       |
|---------------|---------|---------|-----------|--------|-----------|-------|----------|----------|-------------|
| 1.000         | 0.013   | 0.931   | 1.000     | 0.964  | 0.958     | 0.993 | 0.931    | 0.924    | Sustainable |
| 0.941         | 0.007   | 0.970   | 0.941     | 0.955  | 0.945     | 0.967 | 0.924    | 0.924    | Stable      |
| 0.988         | 0.010   | 0.988   | 0.988     | 0.988  | 0.977     | 0.989 | 0.981    | 0.981    | Warning     |
| 0.972         | 0.000   | 1.000   | 0.972     | 0.986  | 0.983     | 0.986 | 0.978    | 0.978    | Alert       |
| Weighted Avg. | 0.977   | 0.008   | 0.978     | 0.977  | 0.977     | 0.969 | 0.985    | 0.962    |             |


==== Confusion Matrix ====


| a  | b  | c  | d  | <- classified as |
|----|----|----|----|------------------|
| 27 | 0  | 0  | 0  | a = Sustainable  |
| 2  | 32 | 0  | 0  | b = Stable       |
| 0  | 1  | 79 | 0  | c = Warning      |
| 0  | 0  | 1  | 35 | d = Alert        |


```

2015 Dataset:

Classifier: Random Tree

```
==== Run information ====
Scheme:      weka.classifiers.trees.RandomTree -K 0 -M 1.0 -V 0.001 -S 1
Relation:    fsi-2015-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-weka.filte
rs.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R19-46-weka.filters.unsupervised.attribut
e.Discretize-B4-M-1.0-R4-precision6
Instances:   177
Attributes:  18
              Country
              Year
              Rank
              Total
              C1: Security Apparatus
              C2: Factionalized Elites
              C3: Group Grievance
              E1: Economy
              E2: Economic Inequality
              E3: Human Flight and Brain Drain
              P1: State Legitimacy
              P2: Public Services
              P3: Human Rights
              S1: Demographic Pressures
              S2: Refugees and IDPs
              X1: External Intervention
              Outlier
              ExtremeValue
Test mode:   10-fold cross-validation

==== Classifier model (full training set) ====

Time taken to build model: 0 seconds

==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      90      50.8475 %
Incorrectly Classified Instances   87      49.1525 %
Kappa statistic                   0.1662
Mean absolute error               0.2986
Root mean squared error          0.3926
Relative absolute error           85.0383 %
Root relative squared error     93.7512 %
Total Number of Instances        177

==== Detailed Accuracy By Class ====


|               |  | TP Rate | FP Rate | Precision | Recall | F-Measure | MCC   | ROC Area | PRC Area | Class       |
|---------------|--|---------|---------|-----------|--------|-----------|-------|----------|----------|-------------|
|               |  | 0.172   | 0.014   | 0.714     | 0.172  | 0.278     | 0.302 | 0.760    | 0.427    | Sustainable |
|               |  | 0.171   | 0.042   | 0.500     | 0.171  | 0.255     | 0.205 | 0.574    | 0.315    | Stable      |
|               |  | 0.987   | 0.798   | 0.494     | 0.987  | 0.658     | 0.290 | 0.656    | 0.601    | Warning     |
|               |  | 0.057   | 0.000   | 1.000     | 0.057  | 0.108     | 0.215 | 0.689    | 0.398    | Alert       |
| Weighted Avg. |  | 0.508   | 0.362   | 0.631     | 0.508  | 0.407     | 0.260 | 0.664    | 0.476    |             |


==== Confusion Matrix ====
a  b  c  d  <-- classified as
5  5 19  0 |  a = Sustainable
2  6 27  0 |  b = Stable
0  1 77  0 |  c = Warning
0  0 33  2 |  d = Alert
```

Classifier: BayesNet

```
==== Run information ====
Scheme:      weka.classifiers.bayes.BayesNet -D -Q weka.classifiers.bayes.net.search.local.K2 -- -P 1 -S BAYES -E
weka.classifiers.bayes.net.estimate.SimpleEstimator -- -A 0.5
Relation:
fsi-2015-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-03.0-E6.0-weka.filte
rs.unsupervised.attribute.InterquartileRange-Rfirst-last-03.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R19-46-weka.filters.unsupervised.attribut
e.Discretize-B4-M-1.0-R4-precision6
Instances:   177
Attributes:  18
             Country
             Year
             Rank
             Total
             C1: Security Apparatus
             C2: Factionalized Elites
             C3: Group Grievance
             E1: Economy
             E2: Economic Inequality
             E3: Human Flight and Brain Drain
             P1: State Legitimacy
             P2: Public Services
             P3: Human Rights
             S1: Demographic Pressures
             S2: Refugees and IDPs
             X1: External Intervention
             Outlier
             ExtremeValue
Test mode:   10-fold cross-validation

==== Classifier model (full training set) ====
Time taken to build model: 0 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      159          89.8305 %
Incorrectly Classified Instances    18           10.1695 %
Kappa statistic                   0.8533
Mean absolute error               0.0573
Root mean squared error          0.2092
Relative absolute error           16.33 %
Root relative squared error      49.9696 %
Total Number of Instances         177

==== Detailed Accuracy By Class ====


|               | TP    | Rate  | FP    | Rate  | Precision | Recall | F-Measure | MCC   | ROC Area | PRC Area | Class       |
|---------------|-------|-------|-------|-------|-----------|--------|-----------|-------|----------|----------|-------------|
|               | 0.862 | 0.007 | 0.962 | 0.862 | 0.909     | 0.894  | 0.996     | 0.981 | 0.996    | 0.981    | Sustainable |
|               | 0.886 | 0.056 | 0.795 | 0.886 | 0.838     | 0.797  | 0.978     | 0.923 | 0.978    | 0.923    | Stable      |
|               | 0.949 | 0.091 | 0.892 | 0.949 | 0.919     | 0.853  | 0.983     | 0.978 | 0.983    | 0.978    | Warning     |
|               | 0.829 | 0.000 | 1.000 | 0.829 | 0.906     | 0.892  | 0.995     | 0.984 | 0.995    | 0.984    | Alert       |
| Weighted Avg. | 0.898 | 0.052 | 0.905 | 0.898 | 0.899     | 0.857  | 0.986     | 0.969 | 0.986    | 0.969    |             |


==== Confusion Matrix ====
a  b  c  d  <-- classified as
25  4  0  0 |  a = Sustainable
1 31  3  0 |  b = Stable
0  4 74  0 |  c = Warning
0  0  6 29 |  d = Alert
```

Classifier: J48

```
==== Run information ====
Scheme:      weka.classifiers.trees.J48 -C 0.25 -M 2
Relation:
fsi-2015-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-weka.filte
rs.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R19-46-weka.filters.unsupervised.attribut
e.Discretize-B4-M-1.0-R4-precision6
Instances:    177
Attributes:   18
Country
Year
Rank
Total
C1: Security Apparatus
C2: Factionalized Elites
C3: Group Grievance
E1: Economy
E2: Economic Inequality
E3: Human Flight and Brain Drain
P1: State Legitimacy
P2: Public Services
P3: Human Rights
S1: Demographic Pressures
S2: Refugees and IDPs
X1: External Intervention
Outlier
ExtremeValue
Test mode:    10-fold cross-validation
==== Classifier model (full training set) ====
Time taken to build model: 0 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      137           77.4011 %
Incorrectly Classified Instances   40            22.5989 %
Kappa statistic                   0.6753
Mean absolute error               0.1208
Root mean squared error          0.326
Relative absolute error           34.3956 %
Root relative squared error     77.8553 %
Total Number of Instances        177
==== Detailed Accuracy By Class ====


|               | TP Rate | FP Rate | Precision | Recall | F-Measure | MCC   | ROC Area | PRC Area    | Class |
|---------------|---------|---------|-----------|--------|-----------|-------|----------|-------------|-------|
| 0.793         | 0.020   | 0.885   | 0.793     | 0.836  | 0.808     | 0.944 | 0.803    | Sustainable |       |
| 0.714         | 0.085   | 0.676   | 0.714     | 0.694  | 0.617     | 0.821 | 0.590    | Stable      |       |
| 0.821         | 0.172   | 0.790   | 0.821     | 0.805  | 0.647     | 0.836 | 0.733    | Warning     |       |
| 0.714         | 0.056   | 0.758   | 0.714     | 0.735  | 0.673     | 0.848 | 0.616    | Alert       |       |
| Weighted Avg. | 0.774   | 0.107   | 0.777     | 0.774  | 0.775     | 0.672 | 0.853    | 0.693       |       |


==== Confusion Matrix ====


| a  | b  | c  | d  | <-- classified as |
|----|----|----|----|-------------------|
| 23 | 6  | 0  | 0  | a = Sustainable   |
| 3  | 25 | 7  | 0  | b = Stable        |
| 0  | 6  | 64 | 8  | c = Warning       |
| 0  | 0  | 10 | 25 | d = Alert         |


```

2016 Dataset:

Classifier: Random Tree

```
==== Run information ====
Scheme:      weka.classifiers.trees.RandomTree -K 0 -M 1.0 -V 0.001 -S 1
Relation:
fsi-2016-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-weka.filte
rs.unsupervised.attribute.Discretize-B4-M-1.0-R4-precision6
Instances:    177
Attributes:   18
Country
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C1: Security Apparatus
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E1: Economy
E2: Economic Inequality
E3: Human Flight and Brain Drain
P1: State Legitimacy
P2: Public Services
P3: Human Rights
S1: Demographic Pressures
S2: Refugees and IDPs
X1: External Intervention
Outlier
ExtremeValue
Test mode:    10-fold cross-validation
==== Classifier model (full training set) ====

```

```

Time taken to build model: 0 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      99      55.9322 %
Incorrectly Classified Instances   78      44.0678 %
Kappa statistic                   0.2975
Mean absolute error               0.2782
Root mean squared error           0.3834
Relative absolute error            78.6015 %
Root relative squared error       91.1826 %
Total Number of Instances         177

==== Detailed Accuracy By Class ====

          TP Rate  FP Rate  Precision  Recall   F-Measure  MCC    ROC Area  PRC Area  Class
          0.567   0.082   0.586     0.567   0.576     0.492   0.845   0.560   Sustainable
          0.057   0.007   0.667     0.057   0.105     0.155   0.650   0.310   Stable
          0.947   0.644   0.526     0.947   0.676     0.360   0.713   0.631   Warning
          0.222   0.000   1.000     0.222   0.364     0.431   0.713   0.484   Alert
Weighted Avg.      0.559   0.292   0.660     0.559   0.483     0.356   0.723   0.526

==== Confusion Matrix ====

  a  b  c  d  <-- classified as
17  0 13  0 |  a = Sustainable
 9  2 24  0 |  b = Stable
 3  1 72  0 |  c = Warning
 0  0 28  8 |  d = Alert

```

Classifier: BayesNet

```

==== Run information ====
Scheme:      weka.classifiers.bayes.BayesNet -D -Q weka.classifiers.bayes.net.search.local.K2 -- -P 1 -S BAYES -E
weka.classifiers.bayes.net.estimate.SimpleEstimator -- -A 0.5
Relation:
fsi-2016-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-03.0-E6.0-weka.filte
rs.unsupervised.attribute.Discretize-B4-M-1.0-R4-precision6
Instances:    177
Attributes:   18
              Country
              Year
              Rank
              Total
              C1: Security Apparatus
              C2: Factionalized Elites
              C3: Group Grievance
              E1: Economy
              E2: Economic Inequality
              E3: Human Flight and Brain Drain
              P1: State Legitimacy
              P2: Public Services
              P3: Human Rights
              S1: Demographic Pressures
              S2: Refugees and IDPs
              X1: External Intervention
              Outlier
              ExtremeValue
Test mode:    10-fold cross-validation

==== Classifier model (full training set) ====

Time taken to build model: 0 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      150      84.7458 %
Incorrectly Classified Instances   27      15.2542 %
Kappa statistic                   0.782
Mean absolute error               0.0792
Root mean squared error           0.2493
Relative absolute error            22.3806 %
Root relative squared error       59.2977 %
Total Number of Instances         177

==== Detailed Accuracy By Class ====

          TP Rate  FP Rate  Precision  Recall   F-Measure  MCC    ROC Area  PRC Area  Class
          0.800   0.027   0.857     0.800   0.828     0.795   0.993   0.969   Sustainable
          0.714   0.070   0.714     0.714   0.714     0.644   0.951   0.856   Stable
          0.921   0.109   0.864     0.921   0.892     0.807   0.956   0.932   Warning
          0.861   0.014   0.939     0.861   0.899     0.875   0.989   0.964   Alert
Weighted Avg.      0.847   0.068   0.849     0.847   0.847     0.786   0.968   0.930

==== Confusion Matrix ====

  a  b  c  d  <-- classified as
24  6  0  0 |  a = Sustainable
 4 25  6  0 |  b = Stable
 0  4 70  2 |  c = Warning
 0  0  5 31 |  d = Alert

```

Classifier: J48

```
==== Run information ====
Scheme:      weka.classifiers.trees.J48 -C 0.25 -M 2
Relation:
fsi-2016-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-weka.filte
rs.unsupervised.attribute.Discretize-B4-M-1.0-R4-precision6
Instances:   177
Attributes:  18
              Country
              Year
              Rank
              Total
              C1: Security Apparatus
              C2: Factionalized Elites
              C3: Group Grievance
              E1: Economy
              E2: Economic Inequality
              E3: Human Flight and Brain Drain
              P1: State Legitimacy
              P2: Public Services
              P3: Human Rights
              S1: Demographic Pressures
              S2: Refugees and IDPs
              X1: External Intervention
              Outlier
              ExtremeValue
Test mode:   10-fold cross-validation
==== Classifier model (full training set) ====
Time taken to build model: 0 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      140      79.096 %
Incorrectly Classified Instances    37      20.904 %
Kappa statistic                   0.7029
Mean absolute error               0.1096
Root mean squared error           0.3063
Relative absolute error            30.9677 %
Root relative squared error       72.8525 %
Total Number of Instances         177
==== Detailed Accuracy By Class ====
          TP Rate  FP Rate  Precision  Recall  F-Measure  MCC  ROC Area  PRC Area  Class
          0.733    0.034    0.815    0.733    0.772    0.730  0.944    0.785  Sustainable
          0.686    0.120    0.585    0.686    0.632    0.534  0.810    0.502  Stable
          0.855    0.129    0.833    0.855    0.844    0.724  0.878    0.801  Warning
          0.806    0.014    0.935    0.806    0.866    0.838  0.925    0.874  Alert
Weighted Avg.  0.791    0.088    0.802    0.791    0.794    0.711  0.885    0.754
==== Confusion Matrix ====
  a  b  c  d  <-- classified as
22  8  0  0 |  a = Sustainable
 5 24  6  0 |  b = Stable
 0  9 65  2 |  c = Warning
 0  0  7 29 |  d = Alert
```

9) Classification Results after adding new features

2014 Dataset:

Classifier: Random Tree

```
==== Run information ====
Scheme:      weka.classifiers.trees.RandomTree -K 0 -M 1.0 -V 0.001 -S 1
Relation:    fsi-2014_extended-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-w
eka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R25-54,56-58,60-66-weka.filters.
unsupervised.instance.RemoveWithValues-S0.0-C23-Llast-weka.filters.unsupervised.attribute.Discretize-B4-M-1.0-R4-precision6
Instances:   171
Attributes:  26
              Country
              Year
              Rank
              Total
              C1: Security Apparatus
              C2: Factionalized Elites
              C3: Group Grievance
              E1: Economy
              E2: Economic Inequality
              E3: Human Flight and Brain Drain
              P1: State Legitimacy
              P2: Public Services
              P3: Human Rights
              S1: Demographic Pressures
              S2: Refugees and IDPs
              X1: External Intervention
              Domestic Credit provided by financial sector
              Education Index
              Exports and Imports
              Life Expectancy at Birth
              Infant Mortality Rate
              Unemployment
              Outlier
              ExtremeValue
              Domestic Credit provided by financial sector_Outlier
              Exports and Imports_Outlier
Test mode:   10-fold cross-validation

Time taken to build model: 0.01 seconds

==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      118          69.0058 %
Incorrectly Classified Instances    53           30.9942 %
Kappa statistic                   0.5164
Mean absolute error               0.1807
Root mean squared error           0.3332
Relative absolute error            52.466 %
Root relative squared error       80.3708 %
Total Number of Instances         171

==== Detailed Accuracy By Class ====


|               | TP Rate | FP Rate | Precision | Recall | F-Measure | MCC   | ROC Area | PRC Area | Class       |
|---------------|---------|---------|-----------|--------|-----------|-------|----------|----------|-------------|
| 0.391         | 0.027   | 0.692   | 0.391     | 0.500  | 0.469     | 0.872 | 0.595    |          | Sustainable |
| 0.515         | 0.087   | 0.586   | 0.515     | 0.548  | 0.450     | 0.838 | 0.578    |          | Stable      |
| 0.924         | 0.370   | 0.682   | 0.924     | 0.785  | 0.571     | 0.860 | 0.819    |          | Warning     |
| 0.528         | 0.022   | 0.864   | 0.528     | 0.655  | 0.616     | 0.879 | 0.717    |          | Alert       |
| Weighted Avg. | 0.690   | 0.196   | 0.703     | 0.690  | 0.674     | 0.543 | 0.861    | 0.721    |             |


==== Confusion Matrix ====
a b c d  <-- classified as
9 9 5 0 | a = Sustainable
4 17 12 0 | b = Stable
0 3 73 3 | c = Warning
0 0 17 19 | d = Alert
```

Classifier: BayesNet

```
==== Run information ====
Scheme:      weka.classifiers.bayes.BayesNet -D -Q weka.classifiers.bayes.net.search.local.K2 -- -P 1 -S BAYES -E
weka.classifiers.bayes.net.estimate.SimpleEstimator -- -A 0.5
Relation:
fsi-2014_extended-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-w
eka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R25-54,56-58,60-66-weka.filters.
unsupervised.instance.RemoveWithValues-S0.0-C23-Llast-weka.filters.unsupervised.attribute.Discretize-B4-M-1.0-R4-precision6
Instances:    171
Attributes:   26
Country
Year
Rank
Total
C1: Security Apparatus
C2: Factionalized Elites
C3: Group Grievance
E1: Economy
E2: Economic Inequality
E3: Human Flight and Brain Drain
P1: State Legitimacy
P2: Public Services
P3: Human Rights
S1: Demographic Pressures
S2: Refugees and IDPs
X1: External Intervention
Domestic Credit provided by financial sector
Education Index
Exports and Imports
Life Expectancy at Birth
Infant Mortality Rate
Unemployment
Outlier
ExtremeValue
Domestic Credit provided by financial sector_Outlier
Exports and Imports_Outlier
Test mode:    10-fold cross-validation

==== Classifier model (full training set) ====
Bayes Network Classifier
not using ADTree
#attributes=26 #classindex=3
Network structure (nodes followed by parents)
Country(177): Total
Year(1): Total
Rank(4): Total
Total(4):
C1: Security Apparatus(4): Total
C2: Factionalized Elites(4): Total
C3: Group Grievance(4): Total
E1: Economy(4): Total
E2: Economic Inequality(4): Total
E3: Human Flight and Brain Drain(3): Total
P1: State Legitimacy(4): Total
P2: Public Services(4): Total
P3: Human Rights(5): Total
S1: Demographic Pressures(5): Total
S2: Refugees and IDPs(5): Total
X1: External Intervention(4): Total
Domestic Credit provided by financial sector(3): Total
Education Index(3): Total
Exports and Imports(2): Total
Life Expectancy at Birth(4): Total
Infant Mortality Rate(4): Total
Unemployment(1): Total
Outlier(2): Total
ExtremeValue(2): Total
Domestic Credit provided by financial sector_Outlier(2): Total
Exports and Imports_Outlier(2): Total
LogScore Bayes: -3600.501142105035
LogScore BDeu: -9605.358403453425
LogScore MDL: -7714.041183749018
LogScore ENTROPY: -5320.596798197023
LogScore AIC: -6251.596798197025
```

```

Time taken to build model: 0.01 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      164          95.9064 %
Incorrectly Classified Instances    7           4.0936 %
Kappa statistic                      0.94
Mean absolute error                  0.022
Root mean squared error              0.1303
Relative absolute error              6.39 %
Root relative squared error         31.4323 %
Total Number of Instances           171

==== Detailed Accuracy By Class ====


|               | TP Rate | FP Rate | Precision | Recall | F-Measure | MCC   | ROC Area | PRC Area | Class       |
|---------------|---------|---------|-----------|--------|-----------|-------|----------|----------|-------------|
| 0.957         | 0.007   | 0.957   | 0.957     | 0.957  | 0.950     | 0.999 | 0.993    | 0.993    | Sustainable |
| 0.879         | 0.007   | 0.967   | 0.879     | 0.921  | 0.904     | 0.991 | 0.972    | 0.972    | Stable      |
| 0.987         | 0.043   | 0.951   | 0.987     | 0.969  | 0.942     | 0.992 | 0.987    | 0.987    | Warning     |
| 0.972         | 0.007   | 0.972   | 0.972     | 0.972  | 0.972     | 0.965 | 0.999    | 0.998    | Alert       |
| Weighted Avg. | 0.959   | 0.024   | 0.959     | 0.959  | 0.959     | 0.941 | 0.994    | 0.987    |             |


==== Confusion Matrix ====


| a  | b  | c  | d  | <-- classified as |
|----|----|----|----|-------------------|
| 22 | 1  | 0  | 0  | a = Sustainable   |
| 1  | 29 | 3  | 0  | b = Stable        |
| 0  | 0  | 78 | 1  | c = Warning       |
| 0  | 0  | 1  | 35 | d = Alert         |


```

Classifier: J48

```

==== Run information ====
Scheme:      weka.classifiers.trees.J48 -C 0.25 -M 2
Relation:
fsi-2014_extended-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-w
eka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R25-54,56-58,60-66-weka.filters.
unsupervised.instance.RemoveWithValues-S0.0-C23-Llast-weka.filters.unsupervised.attribute.Discretize-B4-M-1.0-R4-precision6
Instances:   171
Attributes:  26
Country
Year
Rank
Total
C1: Security Apparatus
C2: Factionalized Elites
C3: Group Grievance
E1: Economy
E2: Economic Inequality
E3: Human Flight and Brain Drain
P1: State Legitimacy
P2: Public Services
P3: Human Rights
S1: Demographic Pressures
S2: Refugees and IDPs
X1: External Intervention
Domestic Credit provided by financial sector
Education Index
Exports and Imports
Life Expectancy at Birth
Infant Mortality Rate
Unemployment
Outlier
ExtremeValue
Domestic Credit provided by financial sector_Outlier
Exports and Imports_Outlier
Test mode:   10-fold cross-validation

==== Classifier model (full training set) ====
J48 pruned tree
-----
Rank <= 117
|  Rank <= 37: Alert (36.0)
|  Rank > 37: Warning (79.0)
Rank > 117
|  Rank <= 150: Stable (33.0)
|  Rank > 150: Sustainable (23.0)

Number of Leaves :      4
Size of the tree :     7

Time taken to build model: 0.02 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      168          98.2456 %
Incorrectly Classified Instances    3           1.7544 %
Kappa statistic                      0.9745
Mean absolute error                  0.0088
Root mean squared error              0.0937
Relative absolute error              2.5471 %
Root relative squared error         22.5909 %
Total Number of Instances           171

```

```

==== Detailed Accuracy By Class ====


|               | TP Rate | FP Rate | Precision | Recall | F-Measure | MCC   | ROC Area | PRC Area    | Class |
|---------------|---------|---------|-----------|--------|-----------|-------|----------|-------------|-------|
| 1.000         | 0.007   | 0.958   | 1.000     | 0.979  | 0.976     | 0.997 | 0.958    | Sustainable |       |
| 0.970         | 0.007   | 0.970   | 0.970     | 0.970  | 0.962     | 0.981 | 0.946    | Stable      |       |
| 0.987         | 0.011   | 0.987   | 0.987     | 0.987  | 0.976     | 0.988 | 0.981    | Warning     |       |
| 0.972         | 0.000   | 1.000   | 0.972     | 0.986  | 0.982     | 0.986 | 0.978    | Alert       |       |
| Weighted Avg. | 0.982   | 0.007   | 0.983     | 0.982  | 0.982     | 0.975 | 0.988    | 0.970       |       |


==== Confusion Matrix ====


| a  | b  | c  | d  | <-- classified as |
|----|----|----|----|-------------------|
| 23 | 0  | 0  | 0  | a = Sustainable   |
| 1  | 32 | 0  | 0  | b = Stable        |
| 0  | 1  | 78 | 0  | c = Warning       |
| 0  | 0  | 1  | 35 | d = Alert         |


```

2015 Dataset:

Classifier: Random Tree

```

Scheme: weka.classifiers.trees.RandomTree -K 0 -M 1.0 -V 0.001 -S 1
Relation:
fsi-2015-extended-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-w
eka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R25-54,56-58,61-66-weka.filters.
unsupervised.instance.RemoveWithValues-S0.0-C23-Llast-weka.filters.unsupervised.instance.RemoveWithValues-S0.0-C24-Llast-weka.filters.unsupervised.attrib
ute.Discretize-B4-M-1.0-R4-precision6
Instances: 172
Attributes: 27
1»;Country
Year
Rank
Total
C1: Security Apparatus
C2: Factionalized Elites
C3: Group Grievance
E1: Economy
E2: Economic Inequality
E3: Human Flight and Brain Drain
P1: State Legitimacy
P2: Public Services
P3: Human Rights
S1: Demographic Pressures
S2: Refugees and IDPs
X1: External Intervention
Domestic Credit provided by financial sector
Education Index
Exports and Imports
Life Expectancy at Birth
Infant Mortality Rate
Unemployment
Outlier
ExtremeValue
Domestic Credit provided by financial sector_Outlier
Exports and Imports_Outlier
Exports and Imports_ExtremeValue
Test mode: 10-fold cross-validation

```

Time taken to build model: 0 seconds

```

==== Stratified cross-validation ====
==== Summary ====

```

Correctly Classified Instances	131	76.1628 %
Incorrectly Classified Instances	41	23.8372 %
Kappa statistic	0.6412	
Mean absolute error	0.1501	
Root mean squared error	0.3029	
Relative absolute error	43.0614 %	
Root relative squared error	72.6022 %	
Total Number of Instances	172	

```

==== Detailed Accuracy By Class ====

```

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
0.720	0.048	0.720	0.720	0.720	0.672	0.920	0.721	Sustainable	
0.514	0.051	0.720	0.514	0.600	0.529	0.865	0.637	Stable	
0.948	0.274	0.737	0.948	0.830	0.678	0.903	0.856	Warning	
0.629	0.007	0.957	0.629	0.759	0.735	0.884	0.760	Alert	
Weighted Avg.	0.762	0.141	0.776	0.762	0.752	0.659	0.894	0.773	

```

==== Confusion Matrix ====

```

a	b	c	d	<-- classified as
18	4	3	0	a = Sustainable
7	18	10	0	b = Stable
0	3	73	1	c = Warning
0	0	13	22	d = Alert

Classifier: BayesNet

```
Scheme:      weka.classifiers.bayes.BayesNet -D -Q weka.classifiers.bayes.net.search.local.K2 -- -P 1 -S BAYES -E
weka.classifiers.bayes.net.estimate.SimpleEstimator -- -A 0.5
Relation:
fsi-2015-extended-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-w
eka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R25-54,56-58,61-66-weka.filters.
unsupervised.instance.RemoveWithValues-S0.0-C23-Llast-weka.filters.unsupervised.instance.RemoveWithValues-S0.0-C24-Llast-weka.filters.unsupervised.attrib
ute.Discretize-B4-M-1.0-R4-precision6
Instances:   172
Attributes:  27
    1»;Country
    Year
    Rank
    Total
    C1: Security Apparatus
    C2: Factionalized Elites
    C3: Group Grievance
    E1: Economy
    E2: Economic Inequality
    E3: Human Flight and Brain Drain
    P1: State Legitimacy
    P2: Public Services
    P3: Human Rights
    S1: Demographic Pressures
    S2: Refugees and IDPs
    X1: External Intervention
    Domestic Credit provided by financial sector
    Education Index
    Exports and Imports
    Life Expectancy at Birth
    Infant Mortality Rate
    Unemployment
    Outlier
    ExtremeValue
    Domestic Credit provided by financial sector_Outlier
    Exports and Imports_Outlier
    Exports and Imports_ExtremeValue
Test mode:   10-fold cross-validation
```

```
Time taken to build model: 0.01 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      163          94.7674 %
Incorrectly Classified Instances     9           5.2326 %
Kappa statistic                      0.9241
Mean absolute error                  0.0273
Root mean squared error              0.1487
Relative absolute error              7.8314 %
Root relative squared error         35.6496 %
Total Number of Instances            172

==== Detailed Accuracy By Class ====

          TP Rate  FP Rate  Precision  Recall  F-Measure  MCC  ROC Area  PRC Area  Class
          0.840    0.007   0.955     0.840   0.894    0.879   0.997    0.985   Sustainable
          0.914    0.029   0.889     0.914   0.901    0.876   0.990    0.955   Stable
          1.000    0.042   0.951     1.000   0.975    0.954   0.998    0.997   Warning
          0.943    0.000   1.000     0.943   0.971    0.964   1.000    0.998   Alert
Weighted Avg.    0.948    0.026   0.949     0.948   0.947    0.929   0.996    0.987

==== Confusion Matrix ====

  a  b  c  d  <-- classified as
21  4  0  0 |  a = Sustainable
1 32  2  0 |  b = Stable
0  0 77  0 |  c = Warning
0  0  2 33 |  d = Alert
```

Classifier: J48

```
Scheme:      weka.classifiers.trees.J48 -C 0.25 -M 2
Relation:
fsi-2015-extended-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-w
eka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R25-54,56-58,61-66-weka.filters.
unsupervised.instance.RemoveWithValues-S0.0-C23-Llast-weka.filters.unsupervised.instance.RemoveWithValues-S0.0-C24-Llast-weka.filters.unsupervised.attrib
ute.Discretize-B4-M-1.0-R4-precision6
Instances:   172
Attributes:  27
    1>?Country
    Year
    Rank
    Total
    C1: Security Apparatus
    C2: Factionalized Elites
    C3: Group Grievance
    E1: Economy
    E2: Economic Inequality
    E3: Human Flight and Brain Drain
    P1: State Legitimacy
    P2: Public Services
    P3: Human Rights
    S1: Demographic Pressures
    S2: Refugees and IDPs
    X1: External Intervention
    Domestic Credit provided by financial sector
    Education Index
    Exports and Imports
    Life Expectancy at Birth
    Infant Mortality Rate
    Unemployment
    Outlier
    ExtremeValue
    Domestic Credit provided by financial sector_Outlier
    Exports and Imports_Outlier
    Exports and Imports_ExtremeValue
Test mode:   10-fold cross-validation

Time taken to build model: 0 seconds
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      170          98.8372 %
Incorrectly Classified Instances     2           1.1628 %
Kappa statistic                      0.9833
Mean absolute error                  0.0058
Root mean squared error              0.0762
Relative absolute error              1.6674 %
Root relative squared error         18.2744 %
Total Number of Instances           172

==== Detailed Accuracy By Class ====


|               | TP Rate | FP Rate | Precision | Recall | F-Measure | MCC   | ROC Area | PRC Area | Class       |
|---------------|---------|---------|-----------|--------|-----------|-------|----------|----------|-------------|
| 1.000         | 0.007   | 0.962   | 1.000     | 0.980  | 0.977     | 0.997 | 0.962    | 0.962    | Sustainable |
| 0.971         | 0.007   | 0.971   | 0.971     | 0.971  | 0.964     | 0.982 | 0.949    | 0.949    | Stable      |
| 0.987         | 0.000   | 1.000   | 0.987     | 0.993  | 0.988     | 0.994 | 0.993    | 0.993    | Warning     |
| 1.000         | 0.000   | 1.000   | 1.000     | 1.000  | 1.000     | 1.000 | 1.000    | 1.000    | Alert       |
| Weighted Avg. | 0.988   | 0.002   | 0.989     | 0.988  | 0.988     | 0.984 | 0.993    | 0.981    |             |


==== Confusion Matrix ====


| a  | b  | c  | d  | <-- classified as |
|----|----|----|----|-------------------|
| 25 | 0  | 0  | 0  | a = Sustainable   |
| 1  | 34 | 0  | 0  | b = Stable        |
| 0  | 1  | 76 | 0  | c = Warning       |
| 0  | 0  | 0  | 35 | d = Alert         |


```

2016 Dataset:

Classifier: Random Tree

```
Scheme:      weka.classifiers.trees.RandomTree -K 0 -M 1.0 -V 0.001 -S 1
Relation:    fsi-2016_extended-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R25-52,54-56,59-62,64-weka.filters.unsupervised.instance.RemoveWithValues-S0.0-C23-Llast-weka.filters.unsupervised.instance.RemoveWithValues-S0.0-C24-Llast-weka.filters.unsupervised.attribute.Discretize-B4-M-1.0-R4-precision6
Instances:   171
Attributes:  28
              Country
              Year
              Rank
              Total
              C1: Security Apparatus
              C2: Factionalized Elites
              C3: Group Grievance
              E1: Economy
              E2: Economic Inequality
              E3: Human Flight and Brain Drain
              P1: State Legitimacy
              P2: Public Services
              P3: Human Rights
              S1: Demographic Pressures
              S2: Refugees and IDPs
              X1: External Intervention
              Domestic credit provided by financial sector
              Education Index
              Exports and Imports
              Life Expectancy at Birth
              Infant Mortality Rate
              Unemployment
              Outlier
              ExtremeValue
              Domestic credit provided by financial sector_Outlier
              Exports and Imports_Outlier
              Exports and Imports_ExtremeValue
              Unemployment_Outlier
Test mode:   10-fold cross-validation

Time taken to build model: 0 seconds

==== Stratified cross-validation ====
==== Summary ====

Correctly Classified Instances          85           49.7076 %
Incorrectly Classified Instances        86           50.2924 %
Kappa statistic                         0.161
Mean absolute error                     0.2938
Root mean squared error                 0.3946
Relative absolute error                  84.0728 %
Root relative squared error            94.4577 %
Total Number of Instances               171

==== Detailed Accuracy By Class ====

          TP Rate  FP Rate  Precision  Recall  F-Measure  MCC  ROC Area  PRC Area  Class
          0.440    0.041    0.647    0.440    0.524    0.471  0.829    0.514  Sustainable
          0.059    0.044    0.250    0.059    0.095    0.028  0.601    0.255  Stable
          0.921    0.779    0.486    0.921    0.636    0.194  0.625    0.568  Warning
          0.056    0.000    1.000    0.056    0.105    0.211  0.718    0.395  Alert
Weighted Avg.   0.497    0.361    0.571    0.497    0.401    0.205  0.670    0.462

==== Confusion Matrix ====

     a   b   c   d   <-- classified as
11   2   12  0 |   a = Sustainable
4    2   28  0 |   b = Stable
2    4   70  0 |   c = Warning
0    0   34  2 |   d = Alert
```

Classifier: BayesNet

```
Scheme:      weka.classifiers.bayes.BayesNet -D -Q weka.classifiers.bayes.net.search.local.K2 -- -P 1 -S BAYES -E
weka.classifiers.bayes.net.estimate.SimpleEstimator -- -A 0.5
Relation:
fsi-2016_extended-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-w
eka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R25-52,54-56,59-62,64-weka.filte
rs.unsupervised.instance.RemoveWithValues-S0.0-C23-Llast-weka.filters.unsupervised.instance.RemoveWithValues-S0.0-C24-Llast-weka.filters.unsupervised.att
ribute.Discretize-B4-M-1.0-R4-precision6
Instances:   171
Attributes:  28
Country
Year
Rank
Total
C1: Security Apparatus
C2: Factionalized Elites
C3: Group Grievance
E1: Economy
E2: Economic Inequality
E3: Human Flight and Brain Drain
P1: State Legitimacy
P2: Public Services
P3: Human Rights
S1: Demographic Pressures
S2: Refugees and IDPs
X1: External Intervention
Domestic credit provided by financial sector
Education Index
Exports and Imports
Life Expectancy at Birth
Infant Mortality Rate
Unemployment
Outlier
ExtremeValue
Domestic credit provided by financial sector_Outlier
Exports and Imports_Outlier
Exports and Imports_ExtremeValue
Unemployment_Outlier

Time taken to build model: 0.01 seconds

==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      149          87.1345 %
Incorrectly Classified Instances    22           12.8655 %
Kappa statistic                      0.8141
Mean absolute error                  0.0739
Root mean squared error              0.2389
Relative absolute error              21.1538 %
Root relative squared error         57.1859 %
Total Number of Instances           171

==== Detailed Accuracy By Class ====


|               | TP Rate | FP Rate | Precision | Recall | F-Measure | MCC   | ROC Area | PRC Area | Class       |
|---------------|---------|---------|-----------|--------|-----------|-------|----------|----------|-------------|
|               | 0.800   | 0.014   | 0.909     | 0.800  | 0.851     | 0.830 | 0.990    | 0.952    | Sustainable |
|               | 0.794   | 0.058   | 0.771     | 0.794  | 0.783     | 0.728 | 0.959    | 0.838    | Stable      |
|               | 0.921   | 0.095   | 0.886     | 0.921  | 0.903     | 0.824 | 0.967    | 0.958    | Warning     |
|               | 0.889   | 0.022   | 0.914     | 0.889  | 0.901     | 0.876 | 0.987    | 0.964    | Alert       |
| Weighted Avg. | 0.871   | 0.060   | 0.873     | 0.871  | 0.871     | 0.816 | 0.973    | 0.935    |             |


==== Confusion Matrix ====
a b c d  <-- classified as
20 5 0 0 | a = Sustainable
2 27 5 0 | b = Stable
0 3 70 3 | c = Warning
0 0 4 32 | d = Alert
```

Classifier: J48

```
Scheme:      weka.classifiers.trees.J48 -C 0.25 -M 2
Relation:
fsi-2016 extended-weka.filters.unsupervised.attribute.ReplaceMissingValues-weka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-w
eka.filters.unsupervised.attribute.InterquartileRange-Rfirst-last-O3.0-E6.0-P-weka.filters.unsupervised.attribute.Remove-R25-52,54-56,59-62,64-weka.filte
rs.unsupervised.instance.RemoveWithValues-S0.0-C23-Llast-weka.filters.unsupervised.instance.RemoveWithValues-S0.0-C24-Llast-weka.filters.unsupervised.att
ribute.Discretize-B4-M-1.0-R4-precision6
Instances:   171
Attributes:  28
              Country
              Year
              Rank
              Total
              C1: Security Apparatus
              C2: Factionalized Elites
              C3: Group Grievance
              E1: Economy
              E2: Economic Inequality
              E3: Human Flight and Brain Drain
              P1: State Legitimacy
              P2: Public Services
              P3: Human Rights
              S1: Demographic Pressures
              S2: Refugees and IDPs
              X1: External Intervention
              Domestic credit provided by financial sector
              Education Index
              Exports and Imports
              Life Expectancy at Birth
              Infant Mortality Rate
              Unemployment
              Outlier
              ExtremeValue
              Domestic credit provided by financial sector_Outlier
              Exports and Imports_Outlier
              Exports and Imports_ExtremeValue
              Unemployment_Outlier
Test mode:   10-fold cross-validation

Time taken to build model: 0.01 seconds

==== Stratified cross-validation ====
==== Summary ====

Correctly Classified Instances      136          79.5322 %
Incorrectly Classified Instances    35           20.4678 %
Kappa statistic                      0.708
Mean absolute error                  0.1088
Root mean squared error              0.31
Relative absolute error              31.1398 %
Root relative squared error         74.2164 %
Total Number of Instances           171

==== Detailed Accuracy By Class ====

          TP Rate  FP Rate  Precision  Recall  F-Measure  MCC  ROC Area  PRC Area  Class
          0.760    0.027    0.826    0.760    0.792    0.759    0.864    0.639    Sustainable
          0.735    0.102    0.641    0.735    0.695    0.602    0.820    0.508    Stable
          0.816    0.116    0.849    0.816    0.832    0.703    0.878    0.810    Warning
          0.833    0.044    0.833    0.833    0.833    0.789    0.925    0.856    Alert
Weighted Avg.    0.795    0.085    0.801    0.795    0.797    0.709    0.874    0.735

==== Confusion Matrix ====

  a  b  c  d  <-- classified as
19  6  0  0 |  a = Sustainable
 4 25  5  0 |  b = Stable
 0  8 62  6 |  c = Warning
 0  0  6 30 |  d = Alert
```

10) Generation of Action rules using Lisp-Miner

We have classified our attributes into 3 different categories.

Stable attributes:

- Country
- Rank
- Year

Attribute	Used	DBColumn	Categories	XCat	Sample categories
Country	171	* Country	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Azerbaijan, Bahrain, Bangladesh, Belarus, Bolivia, Brazil, Bulgaria, Cambodia, Chile, China, Colombia, Costa Rica, Côte d'Ivoire, Ecuador, Egypt, El Salvador, Georgia, Greece, Guatemala, Honduras, India, Indonesia, Iran, Iraq, Israel, Italy, Jordan, Kenya, Kyrgyzstan, Lebanon, Libya, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Senegal, Sri Lanka, Sudan, Turkey, Turkmenistan, Ukraine, United Arab Emirates, Uruguay, Venezuela, Vietnam, Yemen, Zimbabwe
Rank	155	* Rank	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Year	1	* Year	1	2014	2014

Flexible attributes:

- Domestic Credit provided by financial sector
- Education Index
- Exports and Imports
- Life Expectancy at Birth
- Infant Mortality Rate
- Unemployment

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- W. Workspace

Tables Attributes Tasks Overview Rules Rules Total

Matrix: fsi_2014_ext_disc

Groups of attributes tree	Attribute	Used	DBColumn	Categories	XCat	Sample categories
Root group of attributes	Unemployment	110		0,2,0,3,0,5,0,6,0,7,0,8,1,2,1,8,1,8,1,9...		
Decision	x_C1_Security_Apparatus_	72	x_C1_Security_Ag	1,3,14,17,18,19,2,2,1,2,3,2,4,2,6...		
Flexible	x_C2_Factionaliz	71	x_C2_Factionaliz	1,1,1,13,14,16,1,7,18,19,2,2,5...		
Stable	x_C3_Group_Grie	66	x_C3_Group_Grie	1,1,3,16,2,3,2,7,3,1,3,4,3,5,3,6,3,7...		
	x_Domestic_Credit_provided_by_financial	143	x_Domestic_Credit	-42,-26,2,-0,6,-0,4,0,3,0,6,0,8,1,8,3,3,7...		
	x_E1_Economy_	63	x_E1_Economy_	2,2,1,2,2,3,2,4,2,9,3,1,3,3,3,4,3,5...		
	x_E2_Economic_Inequality	65	x_E2_Economic_	1,3,1,7,1,8,1,9,2,4,2,1,3,3,1,3,2,3,3...		
	x_E3_Human_Fight_and_Brain_Drain_	70	x_E3_Human_Fit	0,9,1,8,1,9,2,2,1,2,2,2,3,2,4,2,5,2,7...		
	x_Education_Index_	154	x_Education_Index	0,207,0,266,0,274,0,285,0,292,0,297,0,307...		
	x_Exports_and_Imports_	150	x_Exports_and_Im	19,5,24,7,28,4,29,8,30,9,36,9,37,3,39,3,40...		
	x_Infant_Mortality_Rate	141	x_Infant_Mortality_	1,7,2,2,3,2,4,2,5,2,6,2,8,2,9,3,3,1...		
	x_Life_Expectancy_at_Birth_	121	x_Life_Expectancy	50,6,51,52,2,52,5,53,3,55,5,56,8,56,6,56,7...		
	x_P1_State_Legitimacy_	74	x_P1_State_Legit	0,5,0,8,0,9,1,1,2,1,5,1,6,1,7,1,8,2...		
	x_P2_Public_Services_	76	x_P2_Public_Ser	14,1,7,1,8,1,9,2,1,2,2,2,3,2,4,2,5,2,6...		
	x_P3_Human_Rights	78	x_P3_Human_Rig	1,1,2,1,3,14,1,4,1,5,1,6,1,7,1,8,2,2,1...		
	x_S1_Demographic_Pressures_	68	x_S1_Demograph	1,8,19,2,3,2,4,2,5,2,7,2,8,2,9,3,3,1...		
	x_S2_Refugees_and_IDPs_	77	x_S2_Refugees_i	1,2,1,4,1,5,1,6,1,8,1,9,2,2,1,2,2,3...		
	x_X1_External_Intervention_	65	x_X1_External_In	1,3,1,5,1,6,1,7,1,9,2,2,5,2,9,3,3,1...		

Show Attribute Show Matrix Add attribute Del Attribute Clone

Export Group detail Quick Assign Add group Del group

Decision attributes:

- Sustainable
- Stable
- Warning
- Alert

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Tables Attributes Tasks Overview Rules Rules Total

Matrix: fsi_2014_ext_disc

Groups of attributes tree	Attribute	Used	DBColumn	Categories	XCat	Sample categories
Root group of attributes	Total	+ Total		4		Alert, Stable, Sustainable, Warning

Show Attribute Show Matrix Add attribute Del Attribute Clone

Export Group detail Quick Assign Add group Del group

Antecedent stable part:

Assigned all stable attributes into this section

Antecedent variable part:

Assigned all flexible attributes into this section

Succedent variable part:

Assigned 'Total' decision attribute into this section, with coefficient as 'one category'

Quantifiers:

a (BASE) Before ≥ 4.0 Abs

a (BASE) After ≥ 4.0 Abs

2014 Dataset:

Alert -> Stable:

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Tables Attributes Tasks Overview Rules Rules Total

Data-mining Task basic parameters

Name: Rules ID: 1

Comment: -

Taskgroup: Default group of tasks

Task type: Ac45-Miner Data matrix: fsi_2014_ext_disc Edit

ANTECEDENT STABLE PART		QUANTIFIERS			SUCCEDENT STABLE PART		
Default Partial Cedent	Con, 1 - 5	Type	Rel.	Value	Units	Default Partial Cedent	Con, 0 - 5
> Country (subset), 1 - 1	B, pos	a (BASE) Before	\geq	2.00	Abs		
> Rank_ (subset), 1 - 1	B, pos	a (BASE) After	\geq	2.00	Abs		
> Year_ (subset), 1 - 1	B, pos						

Generation information

Status: Solved, 16 run(s)

Mode: Standard

Total length: 0 - 5 {1 - 3} Total length: 0

(1) ANTECEDENT VARIABLE PART		CONDITION		(2) SUCCEDENT VARIABLE PART	
Default Partial Cedent	Con, 1 - 5	Default Partial Cedent	Con, 0 - 5	Default Partial Cedent	Con, 1 - 5
> x_Domestic_Credit_provided_by	B, pos			> Total Alert -> Stable	B, pos
> x_Education_Index_(subset), 1 -	B, pos				
> x_Exports_and_imports_(subset)	B, pos				
> x_Infant_Mortality_Rate_(subset)	B, pos				

Total length: 0 - 5 {1 - 4} Total length: 0 Total length: 1

Task parameters

Strict action: States must be represented by the same sets of attributes which differ in coefficients only (the strict meaning of an action)

Sets overlapping: Sets must differ in all rows (i.e. not overlapping sets)

Maximal number of hypotheses: 1000

Params	Switch	Validate	Task Clone
On	Off	On	On

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Tables -> Attributes -> Tasks Overview -> Rules -> Rules -> Total

Task: Rules
Comment: -
Taskgroup: Default group of tasks
Data matrix: fsl_2014_ext_disc
Task type: Acaft-Miner
Task run
Start: 27.4.2019 12:45:24 Total time: 0h 0m 1s
Number of verifications: 792 Number of hypotheses: 16 Mode: Standard

Show all Show not in group Highlight

Actual group of hypotheses: All hypotheses Hypotheses in group: 16 Shown hypotheses: 16 Highlighted: 0 Delete hypotheses

Nr.	ID	Of-Conf	B-Conf	A-Conf	Hypothesis
1	8	0.500	1.000	0.500	Year_(2014) : (x_Infant_Mortality_Rate_(44.4) >< (empty) : (Total(Alert) > Total(Stable))
2	5	0.500	1.000	0.500	Year_(2014) : (x_Infant_Mortality_Rate_(57) > x_Infant_Mortality_Rate_(7.4)) >< (empty) : (Total(Alert) > Total(Stable))
3	9	0.333	1.000	0.667	Year_(2014) : (x_Infant_Mortality_Rate_(44.4) > x_Infant_Mortality_Rate_(4.7)) >< (empty) : (Total(Alert) > Total(Stable))
4	6	0.333	1.000	0.667	Year_(2014) : (x_Infant_Mortality_Rate_(57) > x_Infant_Mortality_Rate_(4.7)) >< (empty) : (Total(Alert) > Total(Stable))
5	15	0.000	1.000	1.000	Year_(2014) : (x_Education_Index_(0.431) > x_Education_Index_(0.821)) >< (empty) : (Total(Alert) > Total(Stable))
6	16	0.000	1.000	1.000	Year_(2014) : (x_Education_Index_(0.431) > x_Education_Index_(0.698)) >< (empty) : (Total(Alert) > Total(Stable))
7	13	0.000	1.000	1.000	Year_(2014) : (x_Exports_and_Imports_(30.9) > x_Exports_and_Imports_(119.1)) >< (empty) : (Total(Alert) > Total(Stable))
8	14	0.000	1.000	1.000	Year_(2014) : (x_Exports_and_Imports_(30.9) > x_Exports_and_Imports_(104.2)) >< (empty) : (Total(Alert) > Total(Stable))
9	11	0.000	1.000	1.000	Year_(2014) : (x_Exports_and_Imports_(52.3) > x_Exports_and_Imports_(119.1)) >< (empty) : (Total(Alert) > Total(Stable))
10	12	0.000	1.000	1.000	Year_(2014) : (x_Exports_and_Imports_(52.3) > x_Exports_and_Imports_(104.2)) >< (empty) : (Total(Alert) > Total(Stable))
11	10	0.000	1.000	1.000	Year_(2014) : (x_Infant_Mortality_Rate_(44.4) > x_Infant_Mortality_Rate_(4.2)) >< (empty) : (Total(Alert) > Total(Stable))
12	7	0.000	1.000	1.000	Year_(2014) : (x_Infant_Mortality_Rate_(57) > x_Infant_Mortality_Rate_(4.2)) >< (empty) : (Total(Alert) > Total(Stable))
13	3	-0.600	0.400	1.000	Year_(2014) : (x_Education_Index_(0.638471) > x_Education_Index_(0.821)) >< (empty) : (Total(Alert) > Total(Stable))
14	4	-0.600	0.400	1.000	Year_(2014) : (x_Education_Index_(0.638471) > x_Education_Index_(0.698)) >< (empty) : (Total(Alert) > Total(Stable))
15	1	-0.700	0.300	1.000	Year_(2014) : (x_Exports_and_Imports_(91.008383) > x_Exports_and_Imports_(119.1)) >< (empty) : (Total(Alert) > Total(Stable))
16	2	-0.700	0.300	1.000	Year_(2014) : (x_Exports_and_Imports_(91.008383) > x_Exports_and_Imports_(104.2)) >< (empty) : (Total(Alert) > Total(Stable))

Detail Goto ID Copy Remove Filter Sorting Export

Action rule Generated:

**Year_(2014) : (x_Infant_Mortality_Rate_(44.4) -> x_Infant_Mortality_Rate_(7.4)) >< (Total(Alert)
-> Total(Stable))**

If infant mortality rate changes from 44.4 index to 7.4, then the country can become stable from alert state.

Alert -> Sustainable:

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Tables -> Attributes -> Tasks Overview -> Rules -> Rules -> Total

Data-mining Task basic parameters
Name: Rules
Comment: -
Taskgroup: Default group of tasks
Task type: Acaft-Miner
Data matrix: fsl_2014_ext_disc

ID: 1

ANTECEDENT STABLE PART		QUANTIFIERS		SUCCEDENT STABLE PART	
Default Partial Cedent	Con, 1 - 5	Type	Rel.	Value	Units
» Country (subset), 1 - 1	B, pos	a (BASE) Before	>=	2.00	Abs
» Rank_(subset), 1 - 1	B, pos	a (BASE) After	>=	2.00	Abs
» Year_(subset), 1 - 1	B, pos				
Generation information					
Status: Solved, 17 run(s)					
Mode: Standard					
Total length: 0 - 5 (1 - 3)				Total length: 0	
(1) ANTECEDENT VARIABLE PART		CONDITION		(2) SUCCEDENT VARIABLE PART	
Default Partial Cedent	Con, 1 - 5	Default Partial Cedent	Con, 0 + 5	Default Partial Cedent	Con, 1 - 5
» x_Domestic_Credit_provided_by_	B, pos			» Total(Alert -> Sustainable)	B, pos
» x_Education_Index_(subset), 1 -	B, pos				
» x_Exports_and_Imports_(subset)	B, pos				
» x_Infant_Mortality_Rate_(subset)	B, pos				
Total length: 0 - 5 (1 - 4)		Total length: 0		Total length: 1	
Task parameters					
Strict action: States must be represented by the same sets of attributes which differ in coefficients only (the strict meaning of an action)					
Sets overlapping: Sets must differ in all rows (i.e. not overlapping sets)					
Maximal number of hypotheses: 1000					
Params	Switch	Validate	Task Clone		
On	Rinned On	Grid On	Close Details		

File Data Introduction Preprocessing Interactive Analysis Data-mining Tasks Domain Knowledge Window Help

Tab Tree Hide = Tables > Attributes > Tasks Overview > Rules > Rules > Total

Task: Rules
 Comment: -
 Taskgroup: Default group of tasks
 Data matrix: fsi_2014_ext_disc
 Task type: Acaft-Miner
 Task run
 Start: 27.4.2019 12:48:05 Total time: 0h 0m 0s
 Number of verifications: 792
 Number of hypotheses: 9 Mode: Standard

Show all Show not in group Highlight
 Show hypotheses just from group:

Add group Del group Edit group

Actual group of hypotheses: All hypotheses
 Hypotheses in group: 9 Shown hypotheses: 9 Highlighted: 0 Delete hypotheses

Nr.	Id	Dt-Conf	B-Conf	A-Conf	Hypothesis
1	9	0.850	1.000	0.150	Year_(2014) : (x_Domestic_Credit_provided_by_financial_sector_(28.9) -> x_Domestic_Credit_provided_by_financial_sector_(71.084076)) ><(empty) : (Total Alert) -> Total Sustainable)
2	8	0.000	1.000	1.000	Year_(2014) : (x_Education_Index_(0.431) -> x_Education_Index_(0.907)) ><(empty) : (Total Alert) -> Total Sustainable)
3	5	0.000	1.000	1.000	Year_(2014) : (x_Infant_Mortality_Rate_(44.4) -> x_Infant_Mortality_Rate_(3.3)) ><(empty) : (Total Alert) -> Total Sustainable)
4	6	0.000	1.000	1.000	Year_(2014) : (x_Infant_Mortality_Rate_(44.4) -> x_Infant_Mortality_Rate_(3.4)) ><(empty) : (Total Alert) -> Total Sustainable)
5	7	0.000	1.000	1.000	Year_(2014) : (x_Infant_Mortality_Rate_(44.4) -> x_Infant_Mortality_Rate_(2)) ><(empty) : (Total Alert) -> Total Sustainable)
6	2	0.000	1.000	1.000	Year_(2014) : (x_Infant_Mortality_Rate_(57) -> x_Infant_Mortality_Rate_(3.3)) ><(empty) : (Total Alert) -> Total Sustainable)
7	3	0.000	1.000	1.000	Year_(2014) : (x_Infant_Mortality_Rate_(57) -> x_Infant_Mortality_Rate_(3.4)) ><(empty) : (Total Alert) -> Total Sustainable)
8	4	0.000	1.000	1.000	Year_(2014) : (x_Infant_Mortality_Rate_(57) -> x_Infant_Mortality_Rate_(2)) ><(empty) : (Total Alert) -> Total Sustainable)
9	1	-0.600	0.400	1.000	Year_(2014) : (x_Education_Index_(0.638477) -> x_Education_Index_(0.907)) ><(empty) : (Total Alert) -> Total Sustainable)

Detail Goto ID Copy Remove Filter Sorting Export

Action Rule Generated:

Year_(2014) : (x_Domestic_Credit_provided_by_financial_sector_(28.9) -> x_Domestic_Credit_provided_by_financial_sector_(71.084076)) ><(Total|Alert) -> Total|Sustainable)

If domestic credit provided by financial sector increases from 28.9 to 71.08, then the country can become sustainable from alert state.

2015 Dataset:

Alert -> Stable:

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Tables > Attributes > Tasks Overview > Rules > Rules > Total

Data-mining Task basic parameters

Name: Rules

Comment: -

Taskgroup: Default group of tasks

Task type: Adft-Miner

Data matrix: fsl_2015_ext_disc

ID: 1

ANTECEDENT STABLE PART		QUANTIFIERS			SUCCEDED STABLE PART	
Default Partial Cedent Con, 1 - 5 = d_Country (subset), 1 - 1 = Rank_(subset), 1 - 1 = Year_(subset), 1 - 1		Type	Rel. Value	Units	Default Partial Cedent Con, 0 - 5	
		a (BASE) Before	>=	2.00 Abs		
		a (BASE) After	>=	2.00 Abs		
Generation information Status: Solved, 8 run(s) Mode: Standard						
Total length: 0 - 5 (1 - 3)					Total length: 0	
(1) ANTECEDENT VARIABLE PART		CONDITION			(2) SUCCEDED VARIABLE PART	
Default Partial Cedent Con, 1 - 5 = x_Domestic_Credit_provided_by_B_pos = x_Education_Index_(subset), B_pos = x_Exports_and_Imports_(subset), B_pos = x_Infant_Mortality_Rate_(subset), B_pos		Default Partial Cedent Con, 0 - 5			Default Partial Cedent Con, 1 - 5 = Total(Alert -> Stable) B_pos	
Total length: 0 - 5 (1 - 4)		Total length: 0			Total length: 1	
Task parameters Strict actions: States must be represented by the same sets of attributes which differ in coefficients only (the strict meaning of an action) Sets overlapping: Sets must differ in all rows (i.e. not overlapping sets) Maximal number of hypotheses: 1000						
Params	Switch	Validate	Task Clone			
Plan	Replan Plan	Find Plan	Plan Plan			

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- W. Workspace

Tables > Attributes > Tasks Overview > Rules > Rules > Total

Task: Rules

Comment: -

Taskgroup: Default group of tasks

Data matrix: fsl_2015_ext_disc

Task type: Adft-Miner

Task run

Start: 27.4.2019 14:37:08 Total time: 0h 0m 1s

Number of verifications: 938

Number of hypotheses: 13 Mode: Standard

Show all Show not in group Highlight

Show hypotheses just from group

Actual group of hypotheses: All hypotheses

Hypotheses in group: 13 Shown hypotheses: 13 Highlighted: 0

Delete hypotheses

Nr.	Id	D-Conf	B-Conf	A-Conf	Hypothesis
1	7	0.700	1.000	0.300	Year_(2015) : (x_Exports_and_Imports_(49.9) -> x_Exports_and_Imports_(87.272455)) >=< (empty) : (Total(Alert) -> Total(Stable))
2	4	0.333	1.000	0.667	Year_(2015) : (x_Infant_Mortality_Rate_(39.2) -> x_Infant_Mortality_Rate_(12.5)) >=< (empty) : (Total(Alert) -> Total(Stable))
3	11	0.000	1.000	1.000	Year_(2015) : (x_Education_Index_(0.297) -> x_Education_Index_(0.754)) >=< (empty) : (Total(Alert) -> Total(Stable))
4	12	0.000	1.000	1.000	Year_(2015) : (x_Education_Index_(0.297) -> x_Education_Index_(0.721)) >=< (empty) : (Total(Alert) -> Total(Stable))
5	13	0.000	1.000	1.000	Year_(2015) : (x_Education_Index_(0.297) -> x_Education_Index_(0.717)) >=< (empty) : (Total(Alert) -> Total(Stable))
6	8	0.000	1.000	1.000	Year_(2015) : (x_Education_Index_(0.339) -> x_Education_Index_(0.754)) >=< (empty) : (Total(Alert) -> Total(Stable))
7	9	0.000	1.000	1.000	Year_(2015) : (x_Education_Index_(0.339) -> x_Education_Index_(0.721)) >=< (empty) : (Total(Alert) -> Total(Stable))
8	10	0.000	1.000	1.000	Year_(2015) : (x_Education_Index_(0.339) -> x_Education_Index_(0.717)) >=< (empty) : (Total(Alert) -> Total(Stable))
9	5	0.000	1.000	1.000	Year_(2015) : (x_Infant_Mortality_Rate_(39.2) -> x_Infant_Mortality_Rate_(4.7)) >=< (empty) : (Total(Alert) -> Total(Stable))
10	6	0.000	1.000	1.000	Year_(2015) : (x_Infant_Mortality_Rate_(39.2) -> x_Infant_Mortality_Rate_(4.7)) >=< (empty) : (Total(Alert) -> Total(Stable))
11	1	-0.333	0.667	1.000	Year_(2015) : (x_Education_Index_(0.643197) -> x_Education_Index_(0.754)) >=< (empty) : (Total(Alert) -> Total(Stable))
12	2	-0.333	0.667	1.000	Year_(2015) : (x_Education_Index_(0.643197) -> x_Education_Index_(0.721)) >=< (empty) : (Total(Alert) -> Total(Stable))
13	3	-0.333	0.667	1.000	Year_(2015) : (x_Education_Index_(0.643197) -> x_Education_Index_(0.717)) >=< (empty) : (Total(Alert) -> Total(Stable))

Detail Goto ID Copy Remove Filter Sorting Export

Action Rule Generated:

Year_(2015) : (x_Exports_and_Imports_(49.9) -> x_Exports_and_Imports_(87.272455)) >=<
(Total(Alert) -> Total(Stable))

If exports and imports index changes from 49.9 to 87.27, then country can become stable from alert according to 2015 dataset.

Alert -> Sustainable:

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Data-mining Task basic parameters

Name: Rules

Comment: -

Taskgroup: Default group of tasks

Task type: Ac4ft-Miner

ID: 1

Data matrix: fsi_2015_ext_disc

Edit

ANTECEDENT STABLE PART		QUANTIFIERS			SUCCEDENT STABLE PART		
Default Partial Cedent	Con. 1 - 5	Type	Rel.	Value	Units	Default Partial Cedent	Con. 0 - 5
> d_Country (subset), 1 - 1	B, pos	a (BASE) Before	>=	2.00	Abs		
> Rank_(subset), 1 - 1	B, pos	a (BASE) After	>=	2.00	Abs		
> Year_(subset), 1 - 1	B, pos						
Generation information							
Status: Solved, 9 run(s)							
Mode: Standard							
Total length: 0 - 5 {1 - 3}				Total length: 0			
(1) ANTECEDENT VARIABLE PART				CONDITION			
Default Partial Cedent	Con. 1 - 5	Default Partial Cedent	Con. 0 - 5	(2) SUCCEDENT VARIABLE PART			
> x_Domestic_Credit_provided_by	B, pos	> Total(Alert -> Sustainable)	B, pos				
> x_Education_Index_(subset), 1 -	B, pos						
> x_Exports_and_imports_(subset)	B, pos						
> x_Infant_Mortality_Rate_(subset)	B, pos						
Total length: 0 - 5 {1 - 4}		Total length: 0		Total length: 1			
Task parameters							
Strict action: States must be represented by the same sets of attributes which differ in coefficients only (the strict meaning of an action)							
Sets overlapping: Sets must differ in all rows (i.e. not overlapping sets)							
Maximal number of hypotheses: 1000							
Params		Switch		Validate		Task Clone	
Ok	Revert Ok	Find Ok	Close	Ok	Revert Ok	Find Ok	Close

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= Tables <- Attributes <- Tasks Overview >- Rules Rules >- Total

Task: Rules

Comment: -

Taskgroup: Default group of tasks

Data matrix: fsi_2015_ext_disc

Task type: Ac4ft-Miner

Edit

Show all Show not in group Show hypotheses just from group

Actual group of hypotheses: All hypotheses

Hypotheses in group: 6 Shown hypotheses: 6 Highlighted: 0

Nr. Id Df-Conf B:Conf A:Conf Hypothesis

1	6	0.000	1.000	1.000	Year_(2015) : (x_Education_Index_(3.297) -> x_Education_Index_(0.86)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
2	5	0.000	1.000	1.000	Year_(2015) : (x_Education_Index_(0.339) -> x_Education_Index_(0.89)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
3	2	0.000	1.000	1.000	Year_(2015) : (x_Infant_Mortality_Rate_(39.2) -> x_Infant_Mortality_Rate_(3.2)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
4	3	0.000	1.000	1.000	Year_(2015) : (x_Infant_Mortality_Rate_(39.2) -> x_Infant_Mortality_Rate_(3.6)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
5	4	0.000	1.000	1.000	Year_(2015) : (x_Infant_Mortality_Rate_(39.2) -> x_Infant_Mortality_Rate_(3.3)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
6	1	-0.333	0.667	1.000	Year_(2015) : (x_Education_Index_(0.643197) -> x_Education_Index_(0.89)) >=< (empty) : (Total(Alert) -> Total(Sustainable))

Delete hypotheses

Detail Goto ID Copy Remove Filter Sorting Export

Action Rule Generated:

Year_(2015) : (x_Infant_Mortality_Rate_(39.2) -> x_Infant_Mortality_Rate_(3.2)) >=< (Total(Alert) -> Total(Sustainable))

If Infant mortality rate decreases from 39.2 to 3.2, then country can become sustainable from alert state.

2016 Dataset:

Alert -> Stable:

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Tables Attributes Tasks Overview Rules Rules Total

Data-mining Task basic parameters

Name: Rules ID: 1

Comment: -

Taskgroup: Default group of tasks

Task type: Ac4ft-Miner Data matrix: fsi_2016_extended_disc

ANTECEDENT STABLE PART

Default Partial Cedent Con, 1 - 5

Type	Rel.	Value	Units
a (BASE) Before	>=	2.00	Abs
a (BASE) After	>=	2.00	Abs

Generation information

Status: Solved, 2 run(s)

Mode: Standard

Total length: 0 - 5 {1 - 3}

QUANTIFIERS

SUCCEDED STABLE PART

Default Partial Cedent Con, 0 - 5

ANTECEDENT VARIABLE PART

(1) ANTECEDENT VARIABLE PART

Default Partial Cedent Con, 1 - 5

CONDITION	
Default Partial Cedent	Con, 0 - 5

Default Partial Cedent Con, 1 - 5

(2) SUCCEDENT VARIABLE PART	
Default Partial Cedent	Con, 1 - 5
> Total(Alert -> Stable)	B, pos

Total length: 0 - 5 {1 - 4}

Total length: 0

Total length: 1

Task parameters

Strict action: States must be represented by the same sets of attributes which differ in coefficients only (the strict meaning of an action)

Sets overlapping: Sets must differ in all rows (i.e. not overlapping sets)

Maximal number of hypotheses: 1000

Params Switch Validate Task Clone

Run Blend Run Grid Run Show Details

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Task: Rules Edit

Comment: -

Taskgroup: Default group of tasks

Data matrix: fsi_2016_extended_disc

Task type: Ac4ft-Miner

Task run

Start: 27.4.2019 21:45:40 Total time: 0h 0m 0s

Number of verifications: 710

Number of hypotheses: 9 Mode: Standard

Show all Show not in group Highlight

Show hypotheses just from group:

Actual group of hypotheses: All hypotheses

Hypotheses in group: 9 Shown hypotheses: 9 Highlighted: 0 Delete hypotheses

Nr. Id Df-Conf B:Conf A:Conf Hypothesis

1	9	0.885	1.000	0.115	Year_(2016) : (x_Domestic_credit_provided_by_financial_sector_(23.4) -> x_Domestic_credit_provided_by_financial_sector_(26.6)) >=< (empty) : (Total(Alert) -> Total(Stable))
2	8	0.885	1.000	0.115	Year_(2016) : (x_Domestic_credit_provided_by_financial_sector_(26.6) -> x_Domestic_credit_provided_by_financial_sector_(28.7)) >=< (empty) : (Total(Alert) -> Total(Stable))
3	6	0.000	1.000	1.000	Year_(2016) : (x_Infant_Mortality_Rate_(50.9) -> x_Infant_Mortality_Rate_(57.7)) >=< (empty) : (Total(Alert) -> Total(Stable))
4	7	0.000	1.000	1.000	Year_(2016) : (x_Infant_Mortality_Rate_(50.9) -> x_Infant_Mortality_Rate_(6.5)) >=< (empty) : (Total(Alert) -> Total(Stable))
5	4	-0.500	0.500	1.000	Year_(2016) : (x_Education_Index_(0.502) -> x_Education_Index_(0.791)) >=< (empty) : (Total(Alert) -> Total(Stable))
6	5	-0.500	0.500	1.000	Year_(2016) : (x_Education_Index_(0.502) -> x_Education_Index_(0.758)) >=< (empty) : (Total(Alert) -> Total(Stable))
7	2	-0.667	0.333	1.000	Year_(2016) : (x_Education_Index_(0.646947) -> x_Education_Index_(0.791)) >=< (empty) : (Total(Alert) -> Total(Stable))
8	3	-0.667	0.333	1.000	Year_(2016) : (x_Education_Index_(0.646947) -> x_Education_Index_(0.758)) >=< (empty) : (Total(Alert) -> Total(Stable))
9	1	-0.765	0.235	1.000	Year_(2016) : (x_Exports_and_Imports_(85.60625) -> x_Exports_and_Imports_(87.3)) >=< (empty) : (Total(Alert) -> Total(Stable))

Detail Goto ID Copy Remove Filter Sorting Export

Action Rule Generated:

Year_(2016) : (x_Exports_and_Imports_(85.60625) -> x_Exports_and_Imports_(87.3)) >=< (Total(Alert) -> Total(Stable))

If exports and imports increases to 87.3 from 85.6, then country can become stable according to 2016 dataset.

Alert -> Sustainable:

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Tables Attributes Tasks Overview Rules Total

Data-mining Task basic parameters

Name: Rules ID: 1

Comment: -

Taskgroup: Default group of tasks

Task type: Ac4ft-Miner Data matrix: fsi_2016_extended_disc Edit

ANTECEDENT STABLE PART		QUANTIFIERS			SUCCEDEDNT STABLE PART		
Default Partial Cedent	Con, 1 - 5	Type	Rel.	Value	Units	Default Partial Cedent	Con, 0 - 5
» Country (subset), 1 - 1	B, pos	a (BASE) Before	>=	2.00	Abs		
» Rank_(subset), 1 - 1	B, pos	a (BASE) After	>=	2.00	Abs		
» Year_(subset), 1 - 1	B, pos						
Generation information							
Status: Solved, 3 run(s)							
Mode: Standard							
Total length: 0 - 5 {1 - 3}				Total length: 0			
(1) ANTECEDENT VARIABLE PART				CONDITION			
Default Partial Cedent	Con, 1 - 5	Default Partial Cedent	Con, 0 - 5	Default Partial Cedent	Con, 1 - 5	Default Partial Cedent	Con, 1 - 5
» x_Domestic_credit_provided_by_financial_sector_(subset), 1 - 5	B, pos			» Total(Alert -> Sustainable)	B, pos		
» x_Education_Index_(subset), 1 - 5	B, pos						
» x_Exports_and_imports_(subset), 1 - 5	B, pos						
» x_Infant_Mortality_Rate_(subset), 1 - 5	B, pos						
Total length: 0 - 5 {1 - 4}				Total length: 0			
Task parameters							
Strict action: States must be represented by the same sets of attributes which differ in coefficients only (the strict meaning of an action)							
Sets overlapping: Sets must differ in all rows (i.e. not overlapping sets)							
Maximal number of hypotheses: 1000							
Params		Switch		Validate		Task Clone	
One	Shared One	Old One	Show Details				

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Tables Attributes Tasks Overview Rules Total

Task: Rules

Comment: -

Taskgroup: Default group of tasks

Data matrix: fsi_2016_extended_disc

Task type: Ac4ft-Miner

Task run: Start: 27.4.2019 21:48:01 Total time: 0h 0m 0s

Number of verifications: 710

Number of hypotheses: 11 Mode: Standard

Actual group of hypotheses: All hypotheses

Hypotheses in group: 11 Shown hypotheses: 11 Highlighted: 0

Nr. Id Df-Conf B:Conf Hypothesis Delete hypotheses

1	11	0.885	1.000	0.115	Year_(2016): (x_Domestic_credit_provided_by_financial_sector_(23.4) -> x_Domestic_credit_provided_by_financial_sector_(26.6)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
2	10	0.885	1.000	0.115	Year_(2016): (x_Domestic_credit_provided_by_financial_sector_(26.6) -> x_Domestic_credit_provided_by_financial_sector_(26.6)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
3	5	0.500	1.000	0.500	Year_(2016): (x_Infant_Mortality_Rate_(50.9) -> x_Infant_Mortality_Rate_(2.9)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
4	7	0.333	1.000	0.667	Year_(2016): (x_Infant_Mortality_Rate_(50.9) -> x_Infant_Mortality_Rate_(3.1)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
5	6	0.000	1.000	1.000	Year_(2016): (x_Infant_Mortality_Rate_(50.9) -> x_Infant_Mortality_Rate_(3.2)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
6	8	0.000	1.000	1.000	Year_(2016): (x_Infant_Mortality_Rate_(50.9) -> x_Infant_Mortality_Rate_(4.3)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
7	9	0.000	1.000	1.000	Year_(2016): (x_Infant_Mortality_Rate_(50.9) -> x_Infant_Mortality_Rate_(3.7)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
8	3	-0.500	0.500	1.000	Year_(2016): (x_Education_Index_(0.502) -> x_Education_Index_(0.905)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
9	4	-0.500	0.500	1.000	Year_(2016): (x_Education_Index_(0.502) -> x_Education_Index_(0.893)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
10	1	-0.667	0.333	1.000	Year_(2016): (x_Education_Index_(0.646947) -> x_Education_Index_(0.905)) >=< (empty) : (Total(Alert) -> Total(Sustainable))
11	2	-0.667	0.333	1.000	Year_(2016): (x_Education_Index_(0.646947) -> x_Education_Index_(0.893)) >=< (empty) : (Total(Alert) -> Total(Sustainable))

Detail Goto ID Copy Remove Filter Sorting Export

Action Rule Generated:

Year_(2016) : (x_Domestic_credit_provided_by_financial_sector_(26.6) -> x_Domestic_credit_provided_by_financial_sector_(76.125828)) >=< (Total(Alert) -> Total(Sustainable))

If domestic provided by financial sector increases to 76.12 from 26.6, then country can become sustainable from alert state.

11) Conclusion

Extended features were extracted and then were added to the original FSI dataset. Which were then preprocessed, discretized and classification was done using WEKA. And then action rules were generated and analyzed using LispMiner. This experiment primarily focuses on economic aspects of a state. The generated rules indicate that the economic aspects have direct impact on Exports and Imports, demographic pressures, etc., It is known fact that the economy is the base for all. Therefore, if the state has to alleviate its issues and want to provide better services, then it should clearly work towards economic stability.

12) References

<https://fragilestatesindex.org/excel/>

<http://hdr.undp.org/en/data>

<https://webpages.uncc.edu/ras/Paper-AR.pdf>

<http://weka.sourceforge.net/doc.dev/weka/classifiers/bayes/BayesNet.html>

<http://weka.sourceforge.net/doc.dev/weka/classifiers/trees/RandomTree.html>

<http://weka.sourceforge.net/doc.dev/weka/classifiers/trees/J48.html>