Municipal Debt Restructuring:

design a tool for the evaluation of the long run sustainability of LG's financial structure

Lithuanian Municipalities Clustering

CLUSTERING

CLUSTER ANALYSIS OR CLUSTERING IS THE TASK OF GROUPING A SET OF OBJECTS IN SUCH A WAY THAT OBJECTS IN THE SAME GROUP (CLUSTER) ARE MORE SIMILAR TO EACH OTHER THAN TO THOSE IN OTHER GROUPS

MUNICIPAL DEBT RESTRUCTURING

Statistical classification technique

Data are sub-divided into groups (clusters)

Items in a cluster are very similar (but not identical) to one another and very different from the items in other clusters

It is a main task of exploratory data mining and a common technique for statistical data analysis used in many fields

It is a useful tool that reveals associations, patterns, relationships, and structures in masses of data

MUNICIPAL DEBT RESTRUCTURING

Lithuanian Municipalities

Cluster analysis or **clustering:**
identification of groups of Municipalities more similar to each other than to those in other groups

MUNICIPAL DEBT RESTRUCTURING

PANEL DATA

Strongly balanced dataset
of **CONTEXT** information
from 2013 to 2017

ANALYSIS

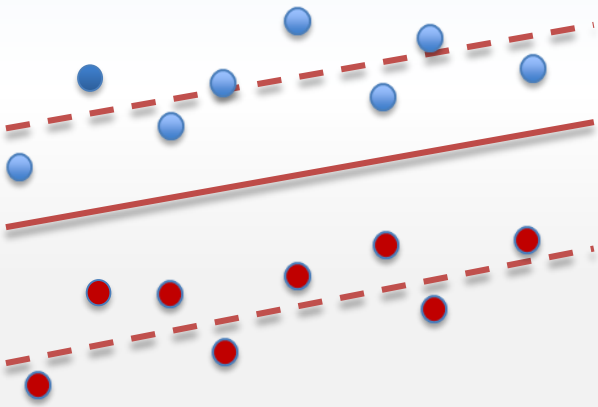
CLUSTERING ANALYSIS:

- ✓ ESTIMATION ON 2017
- ✓ CLUSTERS ARE TIME INVARIANT

MUNICIPAL DEBT RESTRUCTURING

SHIFTING EFFECT

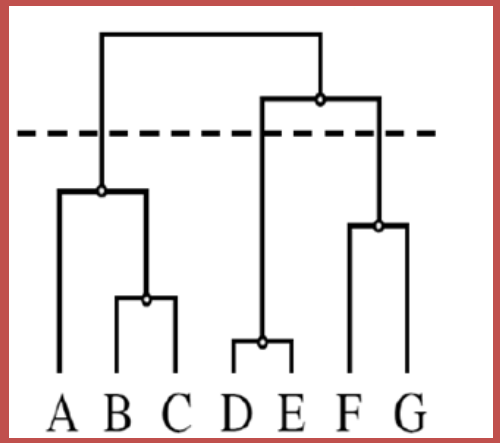
Different Cluster features can be estimated



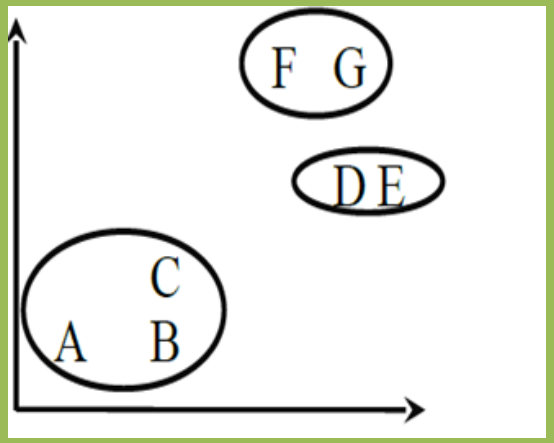
WHY CLUSTERS?

COST SHIFT ESTIMATION FOR MUNICIPALITIES WITH DIFFERENT CONTEXT FEATURES

Cluster TAXONOMY



Hierarchical Cluster analysis

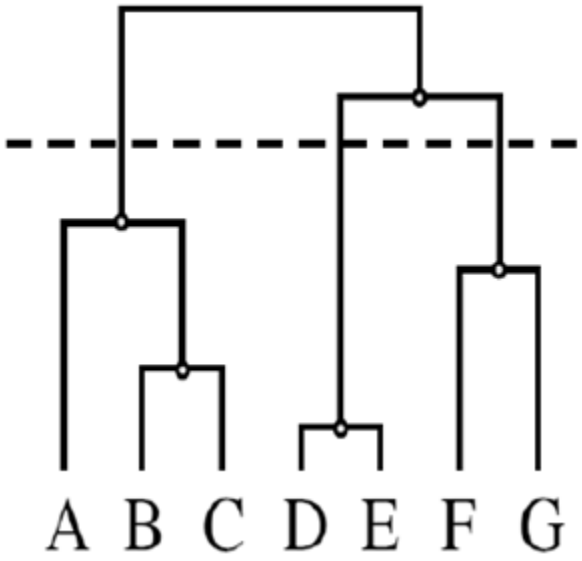


Partitional algorithm

MUNICIPAL DEBT RESTRUCTURING

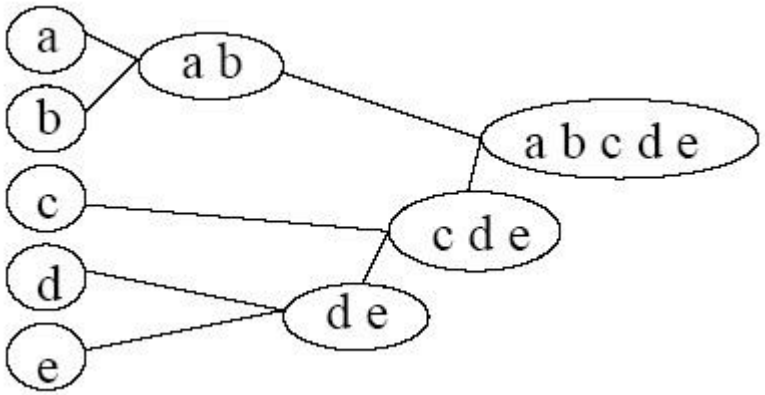
Hierarchical Cluster analysis

- Sequence of hierarchies
- Focused on the relations between dataset patterns
- Requires a matrix of proximity
- Results are presented with DENDOGRAMS



Hierarchical Cluster analysis

- **Strategies:**
  - **AGGLOMERATIVE: all units disjoint (bottom up)**
  - **DISJUNCTIVE: all units grouped together (top- own)**



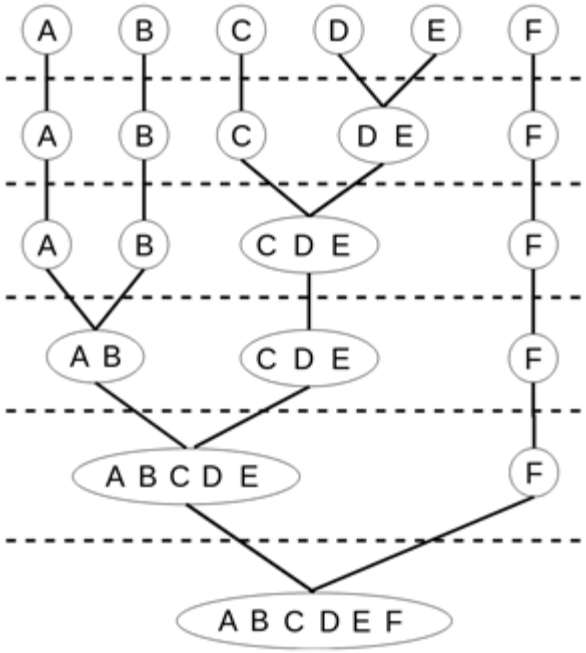
Bottom Up strategy

Dendogram

MUNICIPAL DEBT RESTRUCTURING

Hierarchical Cluster analysis

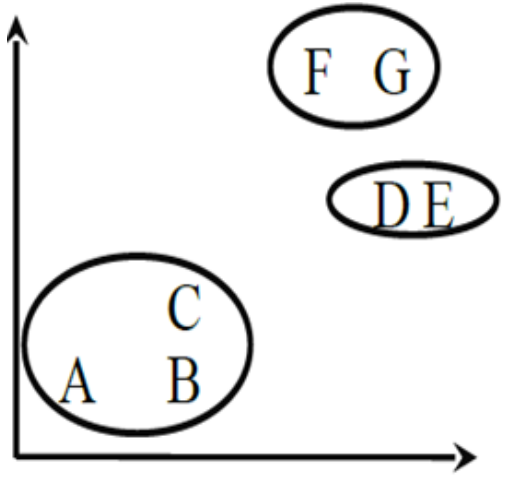
- **Strategies:**
  - **AGGLOMERATIVE: all units disjoint (bottom up)**
  - **DISJUNCTIVE: all units grouped together (top- own)**



Top Down strategy

Dendogram

MUNICIPAL DEBT RESTRUCTURING



Partitional algorithm

- The result is a single partition of data
- Identify natural grups present in the data
- Identify a group of disjoint cluster
- The union of disjoint clusters gives back the initial data set

Mixture Models

Model-Based Clustering

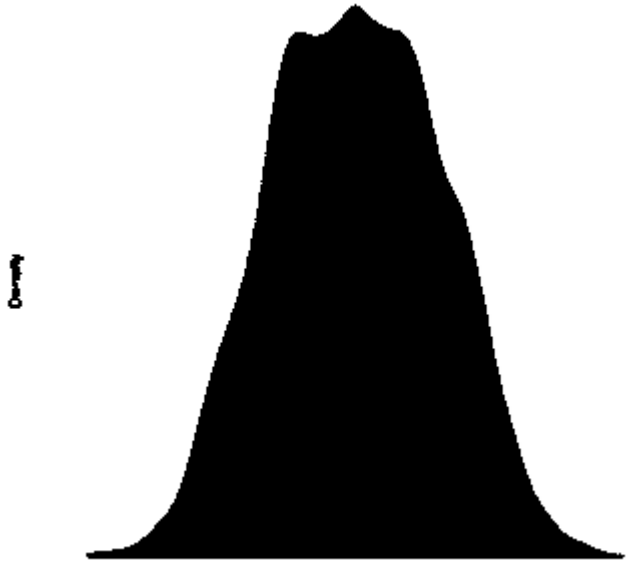
Partitional algorithm

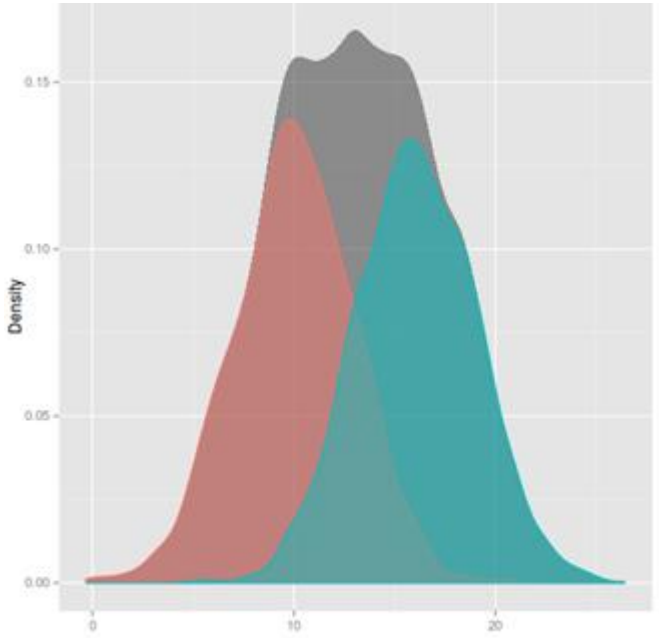
Mixture Models (Model-Based Clustering)

Use of probabilistic models

ASSUMPTION: data are generated by a MIXTURE of probabilistic distributions and each distribution identifies a CLUSTER

TARGET: maximize the fit between data and model



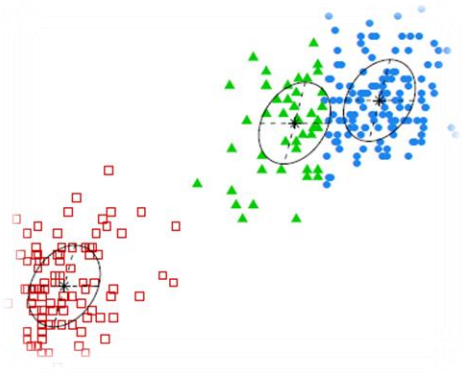


Mixture Models (Model-Based Clustering)

Mixture of distributions

$$\sum_{k=1}^{G} \tau_k \ \phi_k(\mathbf{x}_i \mid \mu_k, \Sigma_k)$$

Model based Clustering



More frequent Tecnique: Gaussian Mixture Models

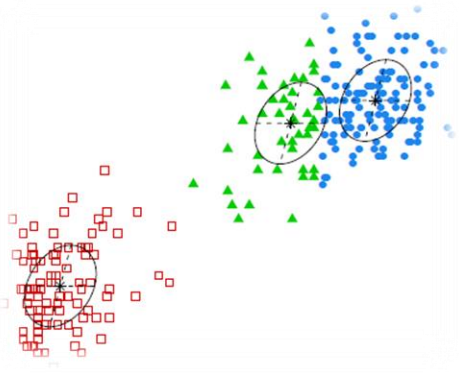
The assumption is that every component of the MIXTURE (cluster) is **Gaussian**

Mixture Models (Model-Based Clustering)

Mistura di distribuzioni Gaussiane

Model based Clustering

$$\sum_{k=1}^{G} \tau_k \, \phi_k(\mathbf{x}_i \mid \mu_k, \Sigma_k)$$



dove:

X data matrix

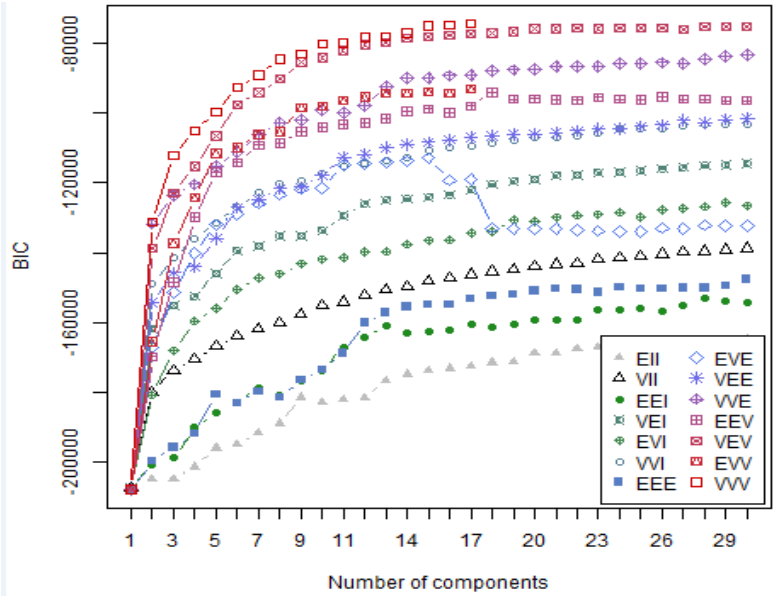
G number of components (**CLUSTER**)

τ_k probability of k-th **CLUSTER** $\quad (\tau_k \geq 0; \quad \sum_{k=1}^{G} \tau_k = 1)$

$\boldsymbol{\Sigma_k}$ covariance matrix **CLUSTER**

$$\phi_k(\mathbf{x} \mid \mu_k, \Sigma_k) = (2\pi)^{-\frac{p}{2}} |\Sigma_k|^{-\frac{1}{2}} \exp\left\{ -\frac{1}{2} (\mathbf{x}_i - \mu_k)^T \Sigma_k^{-1} (\mathbf{x}_i - \mu_k) \right\}$$

Mixture Models (Model-Based Clustering)



Criterion for **identify the optimal** number of CLUSTER

- **BIC** (Bayesian Information Criterion)

Clustering Results

LITHUANIA

60 MUNICIPALITIES

2 stage processing

4 CLUSTERS

Clustering Results

First stage Clustering

Big cities

Resorts

Other Municipalities

Second stage Clustering

2 Clusters

Clustering Results

FIRST STAGE

Big cities

6 Municipalities

Resorts

4 Municipalities

Other Municipalities

50 Municipalities

Clustering Results

BIG CITIES

- VILNIAUS M.
- ALYTAUS M.
- KAUNO M.
- KLAIPĖDOS M.
- PANEVĖŽIO M.
- ŠIAULIŲ M.

Municipalities with a big amount of population and a high population density

Clustering Results

Municipalities strongly oriented to touristic activity

Resorts

RESORTS

BIRŠTONO M.
DRUSKININKŲ M.
NERINGOS M.
PALANGOS M.

Clustering Results

Residual group of Municipalities

These Municipalities have been furtherly divided into 2 groups according to contextual features (**second stage Clustering**)

Other Municipalities

Clustering Results

Residual group of Municipalities

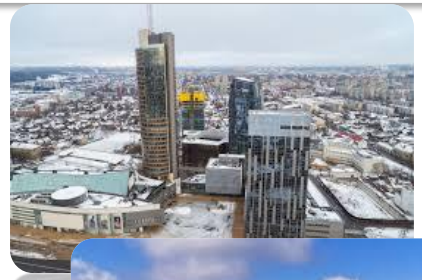
Other predominantly urban

Other predominantly rural

Other Municipalities

Clustering Results

FIRST and SECOND STAGE



Big cities

6 Municipalities

Other predominantly urban

12 Municipalities

Other predominantly rural

38 Municipalities

Resorts

4 Municipalities

Clustering Results

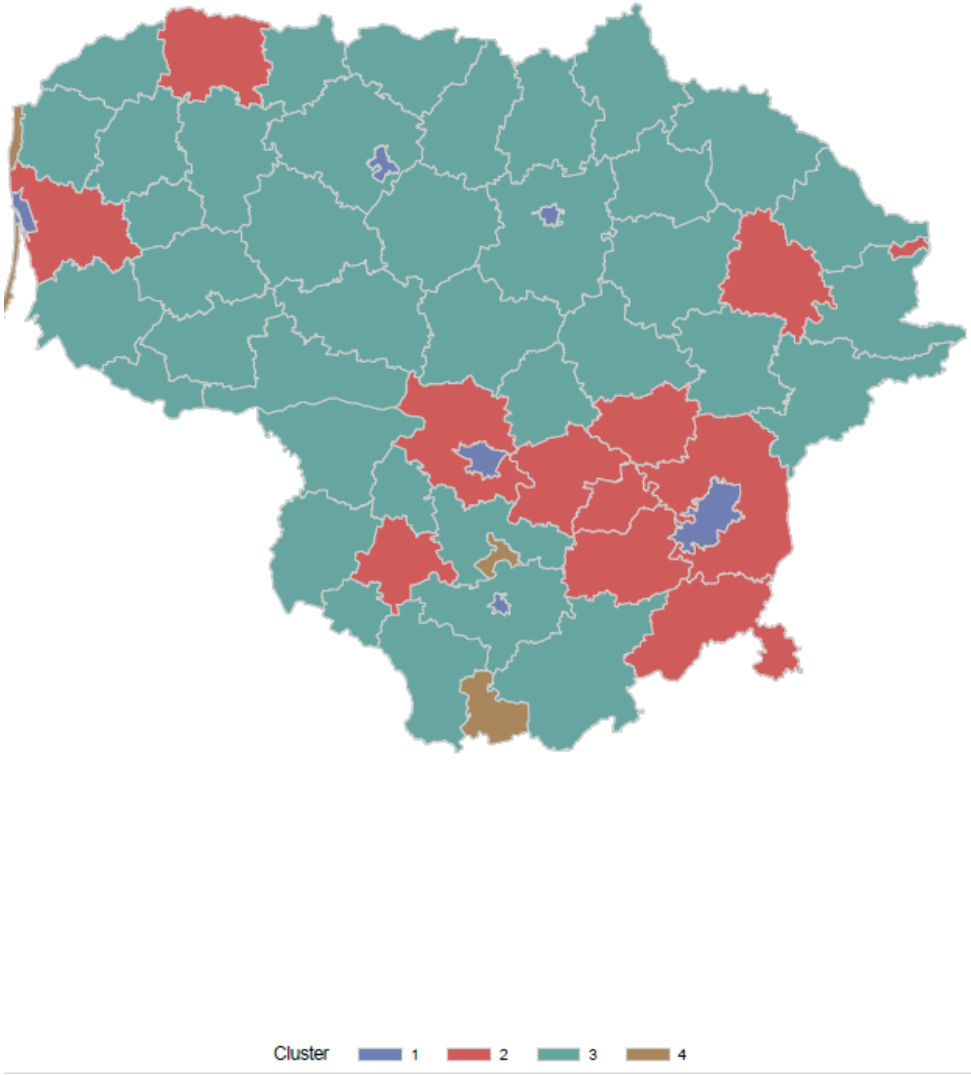
- Population
- Density of population
- Population 0-19
- Population over 65
- Working age population

DISCRIMINANT VARIABLES

- Area (squared km of land)
- Agricultural land
- Forest land
- Built-up area
- Waters

- Number of tourists accommodated in accommodation establishments
- Number of overnight stays in accommodation establishments

Clustering Results



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