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Multivariate data analysis as illustrated by the example of healthcare services in European Union Member States

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Introduction

- Creating health policy that would satisfy aspirations of European societies is an important element of knowledge acquisition.
- Election promises made that are confronted with the reality meet a wide range of difficulties that lead to the situation in which the promises are not kept and decision makers point to circumstances that, in their opinion, are beyond their control, thus making it impossible to provide the healthcare expected by the society (this mainly involves quality, availability and costs).
- Defining which elements actually determine the way the healthcare system functions allow for evaluating if the promises made are realistic. Moreover, this enables us to evaluate reliability of explanations made by decision makers and serves as some foundations to create realistic healthcare related offers:

Firstly, at the stage where state policies are created with reference to healthcare protection, insurance systems, education, private public partnership investments, etc.

Secondly, creating models of healthcare protection in the context of infrastructure, financing, personnel, etc.

Thirdly, decisions related to prioritizing of healthcare protection (division into reference categories, co-financing of prevention, etc.) along with business decisions connected with investment and mobility priorities in the context of personnel and competencies.



Research design

Data

Health graduates per hundred thousand inhabitants

- 1. Medical doctors**
- 2. Nurses**

Health personnel employed in hospital. Head count per hundred thousand inhabitant

- 3. Medical doctors.**
- 4. Hospital employment.**

5. Health care expenditure. Percentage of gross domestic product (GDP)

6. Available beds in hospitals per hundred thousand inhabitant

Self-reported unmet needs for medical examination.

- 7. Too expensive.**
- 8. Too far to travel.**
- 9. No time.**
- 10. Didn't know any good doctor or specialist.**
- 11. Waiting list.**
- 12. Fear of doctor, hospital, examination or treatment.**

Research design

Methods of analysis

This paper presents how taxonomic measure of investment attractiveness (TMAI) was used to shortlist EU countries where healthcare systems are most safe and efficient.

$$TMAI_i = 1 - \frac{d_i}{d_0}$$

where:

$TMAI_i$ - synthetic measure of development for i -th object

d_i - distance of i -th object from model object given by:

$$d_i = \sqrt{\sum_{j=1}^m w_j (z_{ij} - z_{0j})^2} \quad (i = 1, 2, \dots, n)$$

d_0 - standard for $TMAI_i$ to take values between 0 and 1;

$$d_0 = \bar{d} + 2 \cdot S_d$$

Weights w_j were assigned based on coefficient of variation of variable (V_j)

- the higher the coefficient of variation, the higher the weight:

$$w_j = \frac{V_j}{\sum_{j=1}^m V_j}$$



Research design

Methods of analysis

This paper uses Hellwig's method of linear ordering to select EU countries with best efficiency and safety. Hellwig's method allows to create a "ranking" of objects in terms of several variables. Objects are ordered based on their distance between a given object and the reference object.

$$w_{oj} = \max_i \{z_{ij}\}$$

where:

w_{oj} - reference for j-th variable

z_{ij} - variable value for i-th object and j-th variable

Hellwig's method of linear ordering orders objects based on Euclidean distance of i-th object from the reference object.

$$d_{i0} = \sqrt{\sum_j (z_{ij} - w_{oj})^2}$$

This paper uses the hierarchical cluster analysis. Hierarchical cluster analysis enables creating classes of objects similar in terms of several variables, based on the distance matrix. Distances were determined using the Ward's method.

$$d_{AB} = \frac{n_A n_B}{n_A + n_B} d^2(\bar{x}_A, \bar{x}_B)$$



Results approach #1

Health graduates per hundred thousand inhabitants

1. Medical doctors
2. Nurses

Health personnel employed in hospital. Head count per hundred thousand inhabitant

3. Medical doctors.
4. Hospital employment.

5. Health care expenditure. Percentage of gross domestic product (GDP)

6. Available beds in hospitals per hundred thousand inhabitant

Self-reported unmet needs for medical examination.

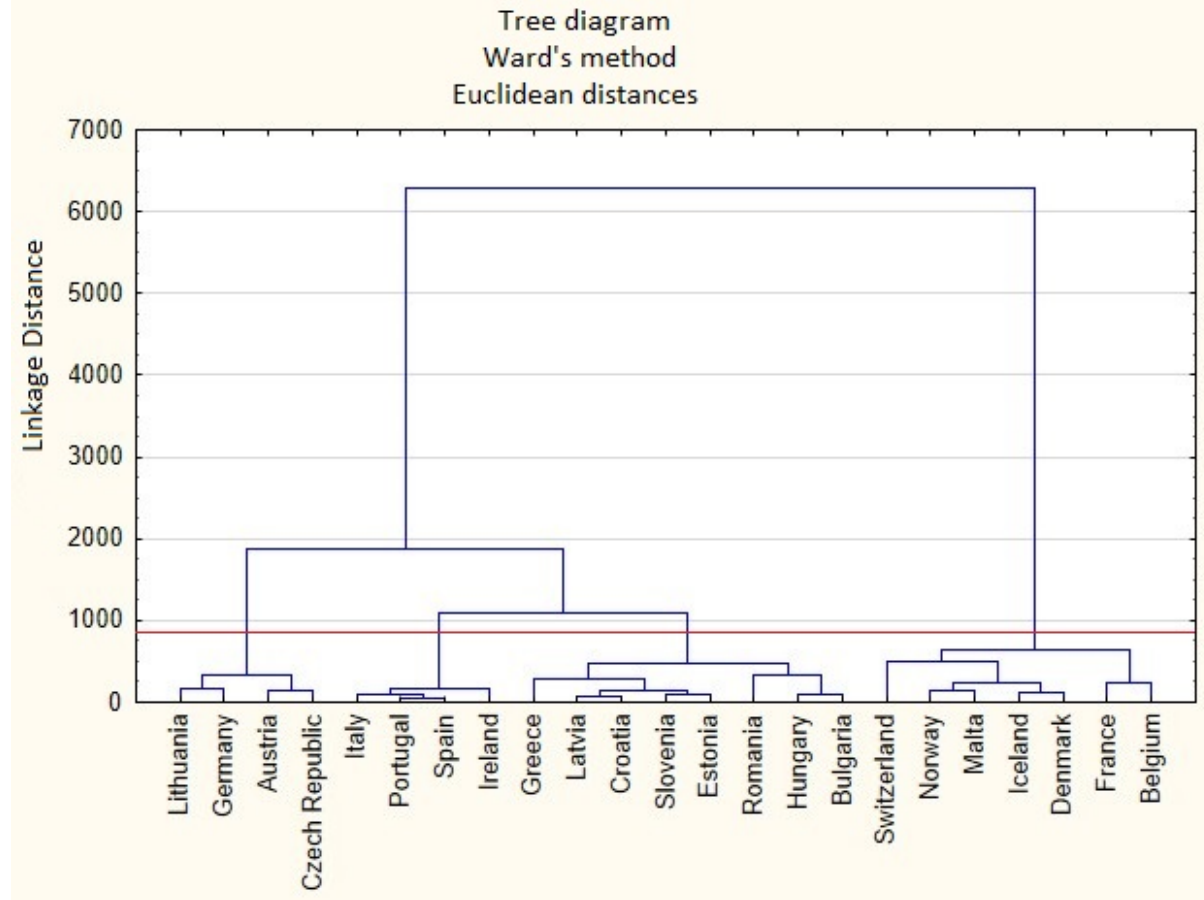
7. Too expensive. Percentage
8. Too far to travel. Percentage
9. No time. Percentage
10. Didn't know any good doctor or specialist. Percentage
11. Waiting list. Percentage
12. Fear of doctor, hospital, examination or treatment. Percentage



Results approach #1

GEO/ISCO08 TMAI

GEO/ISCO08	TMAI
Switzerland	0,68
Austria	0,67
Malta	0,65
Norway	0,62
Slovenia	0,61
Belgium	0,53
Ireland	0,51
Iceland	0,51
Germany	0,50
Denmark	0,49
Czech Republic	0,47
Lithuania	0,46
Portugal	0,42
Italy	0,41
Spain	0,38
France	0,36
Bulgaria	0,36
Hungary	0,35
Romania	0,33
Greece	0,28
Croatia	0,25
Latvia	-0,02
Estonia	-0,24



I group – countries with high values of the Available beds in hospitals variable

II group - countries with low values of the Available beds in hospitals variable and high values of the Self-reported unmet needs for medical examination variable. Too expensive.

III group – countries with low values of the Hospital employment variable and low values of the Health care expenditure variable

IV group - countries with high values of the Hospital employment variable and of high values of the Health care expenditure variable

Results approach #2

Health graduates per hundred thousand inhabitants

1. Medical doctors
2. Nurses

Health personnel employed in hospital. Head count per hundred thousand inhabitant

3. Medical doctors.
4. ~~Hospital employment.~~
5. Health care expenditure. Percentage of gross domestic product (GDP)
6. Available beds in hospitals per hundred thousand inhabitant

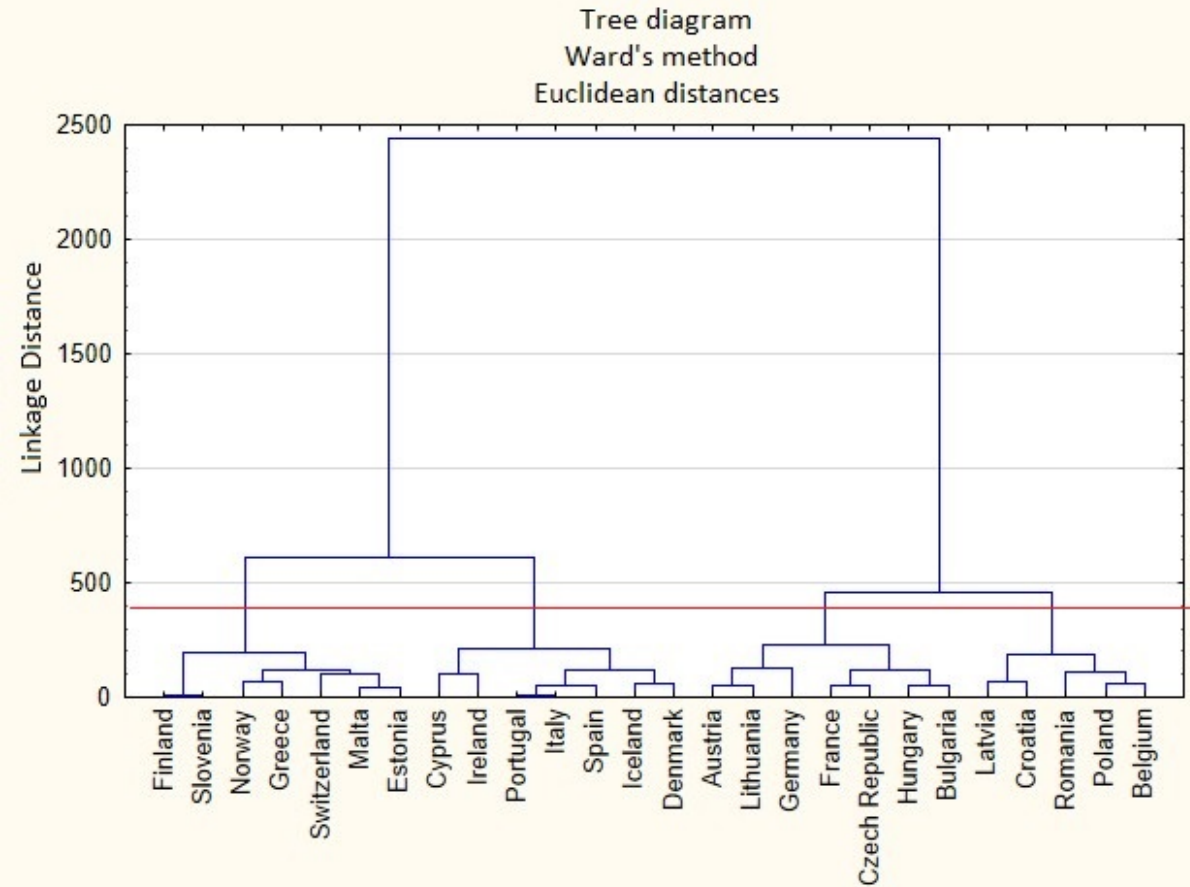
Self-reported unmet needs for medical examination.

7. Too expensive. Percentage
8. Too far to travel. Percentage
9. No time. Percentage
10. Didn't know any good doctor or specialist. Percentage
11. Waiting list. Percentage
12. Fear of doctor, hospital, examination or treatment. Percentage



Results approach #2

GEO/ISCO	TMAI
Austria	0,71
Switzerland	0,68
Slovenia	0,67
Malta	0,64
Norway	0,62
Finland	0,56
Belgium	0,54
Ireland	0,53
Germany	0,53
Denmark	0,50
Iceland	0,49
Czech	0,48
Lithuania	0,47
Portugal	0,45
Italy	0,43
Spain	0,41
Hungary	0,40
France	0,38
Bulgaria	0,38
Romania	0,37
Cyprus	0,34
Greece	0,31
Croatia	0,25
Poland	0,10
Latvia	-0,03
Estonia	-0,23



I group – countries with low values of the Health graduates medical doctors variable

II group - countries with low values of the Available beds in hospitals variable

III group - countries with high values of the Available beds in hospitals variable

IV group - countries with low values of the Health personnel employed in hospital. Medical doctors variable and with low values of the Health care expenditure variable.

The exception is Belgium that was placed in this group because of its very low value of the Health personnel employed in hospital. Medical doctors. Variable. The lowest value in the group of all countries.

Results approach #3a

~~Health graduates per hundred thousand inhabitants~~

- ~~1. Medical doctors~~
- ~~2. Nurses~~

Health personnel employed in hospital. Head count per hundred thousand inhabitant

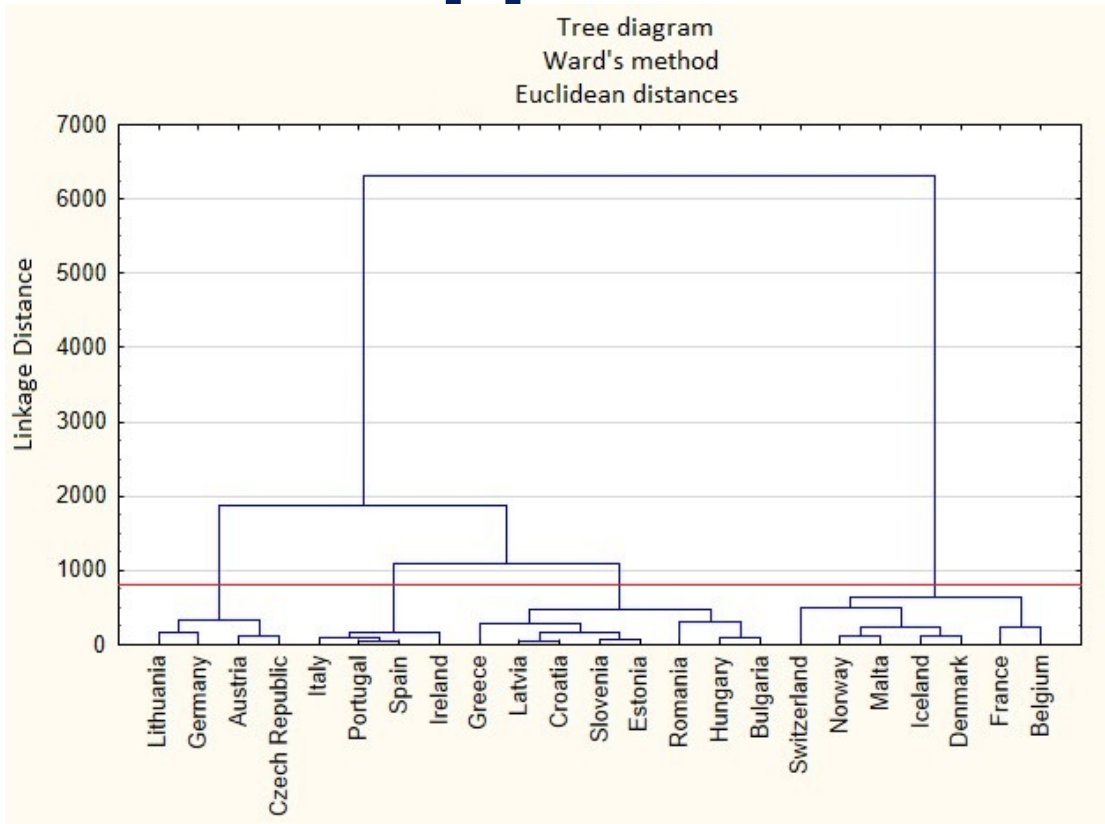
3. Medical doctors.
4. Hospital employment.
5. Health care expenditure. Percentage of gross domestic product (GDP)
6. Available beds in hospitals per hundred thousand inhabitant

~~Self-reported unmet needs for medical examination.~~

- ~~7. Too expensive. Percentage~~
- ~~8. Too far to travel. Percentage~~
- ~~9. No time. Percentage~~
- ~~10. Didn't know any good doctor or specialist. Percentage~~
- ~~11. Waiting list. Percentage~~
- ~~12. Fear of doctor, hospital, examination or treatment. Percentage~~

Results approach #3a

GEO/ISCO08	TMAI
France	0,71
Germany	0,63
Switzerland	0,61
Austria	0,57
Malta	0,55
Norway	0,46
Lithuania	0,44
Czech Republic	0,41
Denmark	0,39
Iceland	0,39
Bulgaria	0,34
Hungary	0,31
Belgium	0,27
Croatia	0,24
Portugal	0,22
Spain	0,21
Slovenia	0,21
Greece	0,21
Estonia	0,21
Italy	0,21
Latvia	0,21
Ireland	0,10
Romania	0,06



I group – countries with high values of the Health personnel employed in hospital. Medical doctors variable and high values of the Hospital employment variable

II group - countries with low values of the Available beds in hospitals variable and low values of the Hospital employment

III group – countries with low values of the Hospital employment variable and low values of the Health care expenditure variable

IV group – countries with low values of the Hospital employment variable and high values of the Health personnel employed in hospital. Medical doctors variable

The exception is Belgium that was placed in this group because of its very low value of the Health personnel employed in hospital. Medical doctors. The lowest value in the group of all countries.

Results approach #3b

~~Health graduates per hundred thousand inhabitants~~

- ~~1. Medical doctors~~
- ~~2. Nurses~~

Health personnel employed in hospital. Head count per hundred thousand inhabitant

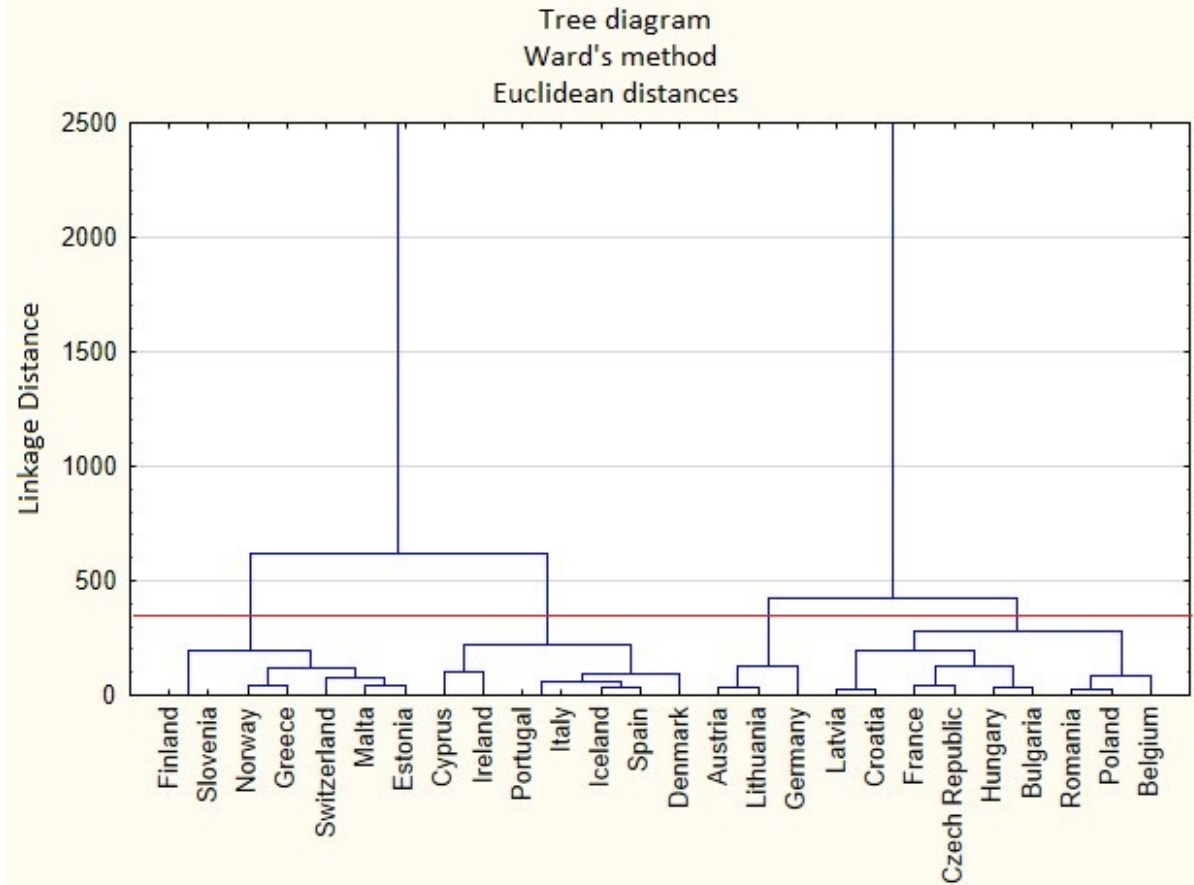
- ~~3. Medical doctors.~~
- ~~4. Hospital employment.~~
5. Health care expenditure. Percentage of gross domestic product (GDP)
6. Available beds in hospitals per hundred thousand inhabitant

~~Self-reported unmet needs for medical examination.~~

- ~~7. Too expensive. Percentage~~
- ~~8. Too far to travel. Percentage~~
- ~~9. No time. Percentage~~
- ~~10. Didn't know any good doctor or specialist. Percentage~~
- ~~11. Waiting list. Percentage~~
- ~~12. Fear of doctor, hospital, examination or treatment. Percentage~~

Results approach #3b

GEO/ISCO08	TMAI
Austria	0,87
Germany	0,77
France	0,73
Bulgaria	0,58
Switzerland	0,55
Czech Republic	0,52
Malta	0,50
Lithuania	0,50
Hungary	0,47
Greece	0,39
Norway	0,38
Croatia	0,37
Finland	0,33
Slovenia	0,33
Estonia	0,31
Iceland	0,31
Italy	0,30
Denmark	0,30
Latvia	0,30
Portugal	0,30
Spain	0,27
Belgium	0,22
Poland	0,21
Romania	0,19
Ireland	0,10
Cyprus	0,02



I group is made of countries that have a similar level of values of the Available beds in hospitals variable.

About 400 Available beds in hospitals per hundred thousand inhabitant.

This group is very diversified with reference to other variables.

II group is made of countries with low values of the Available beds in hospitals variable.

III group is made of countries with high values of the Available beds in hospitals variable.

IV group is made of countries with low values of the Health care expenditure variable.

Belgium and France are exceptions in this group.

Discussion

- Analysis of many factors makes it impossible to identify relationships between them (makes it very difficult to identify them).
- Analysis of factors in groups confirms logical assumptions that a human being can make in the area of the factors identified.
- Decreasing a number of factors to the most important ones allows for identifying logical relationships. Creating policies of healthcare protection must involve interdependencies between availability of beds, personnel and issues related to financial burden.



Limitations

- High risk of reasoning resulting from obtaining large amounts of data from largely diversified communities (in the context of culture, finance, health, life levels or organization).
- In the groups distinguished there are frequently countries that do not fit the group description, which makes it difficult to analyze dependencies logically.
- Data taken into consideration refers to annual data characteristic for a particular country – this does not include spatial differences and changes in time. The evaluation is realized locally and in particular time.



Future research

- **Other set of data:** collected in a different manner, refers not only to healthcare protection but also to medial specializations
- **Quality and availability of data** limit reliability of conclusions formulated.

Thank you

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