Cluster Analysis of Research and Development Expenditure in EU

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Abstract. *Most authors agree that innovations increase country's competitive advantage. One of the aims of investing in research and development (R&D) is stimulation of increased innovative efficiency of the economy. European Union is encouraging its member states to invest 3% of their GDP into R&D. In this paper cluster analysis has been conducted and the results indicate that, when analysing expenditure for R&D and national competitiveness measures, Croatia is in the same cluster as Bulgaria, Greece, Hungary, Poland and Romania. Further analysis indicates that these countries are investing in research and development less than the European Union average.*

Keywords. Innovation, cluster, cluster analysis, research and development

1 Introduction

Innovation is one of the sources of country's competitive advantage and therefore investment in research and development is one of the basic means to achieve growth and development of a country. National innovation effects are becoming a subject of scientific discussions and measurements and consequently different indices are developed in order to enable comparison between different countries.

The aims of this paper are to present a short overview of innovation and its significance in achievement of national competitiveness. This will be done by using cluster analysis in order to find a latent relationships between European Union member states considering certain variables. Groups of European Union member states will be identified based on expenditure in R&D and based on competitiveness measures related to innovation.

2 Theoretical framework of innovativeness

Depending on the perspective we take, innovation can be defined in different ways. Generally, innovation is a process in which creative ideas are implemented into organization (Amabile et al, 1996.). Atkinson and Ezell (2014) argue that innovation must encompass novelty and a sustainable business concept. The same authors are accenting that innovations are the key to economic growth, employment, income, better life quality and country's competitiveness.

According to Baković and Ledić-Purić (2011) innovation is the source of competitiveness of national economies, but also of organizations. The interconnectedness of innovation, economic growth and employment is also recognized by the European Union and therefore innovation is put in the centre of its strategy for growth and jobs creation. The European Union member states should invest 3% of their gross domestic product into research and development by year 2020 which would enable approximately 3.7 million jobs (European Union, 2017). Currently member states invest from 0.49 (in Romania) to 3.26 (in Sweden) according to the provisional Eurostat data for 2015 (Eurostat, n.d.).

Innovation is leading to economic growth and therefore presents the basis for global competitiveness between countries. Besides the creation of new jobs, the aim of the European Union is to become competitive towards innovative giants such as USA and Japan. The European Union sees innovation as the core of economic growth and competitive strategy.

Small and medium-sized enterprises (SMEs) are the fundament for European Union development. According to Kutnjak (2010) small and medium-sized entrepreneurship is the generator of innovation and country's economy dynamics. The same is also stated by Božić and Radas (2005) who claim that SMEs who conduct innovative activities are becoming the base for national growth. Kuratko, Morris and Covin (2011) state that the basic dimensions of entrepreneurship are seen in innovativeness, proactivity and risk taking.

Since SMEs are making 99% of all enterprises in the European Union (European Parliament, 2016), innovative SMEs are one of the main competitiveness generators in the European Union.

Rammer, Czarnitzki and Spielkamp (2009) state that investment in research and development is one of the possibilities for the creation of innovation in small and medium enterprises. According to Bečić and Dabić (2008) sectoral investment into research and development are not only economic, but also a political priority of the European Union. Having in mind all the stated about innovativeness of SMEs as the generator of competitiveness, one of the variables for measurement of investment into development of innovation is business enterprise expenditure on R&D (BERD). According to Bečić and Dabić (2008) business enterprise expenditure on R&D must result in bringing about the innovations to the market and must be oriented towards their commercialisation in order to contribute to economic growth and national competitiveness.

According to Lane (2012) higher education is also one of the economic generators and universities are critical spots of regional development strategies and innovation systems. Therefore, higher education expenditure on R&D (HERD) is another prerequisite of national competitiveness. Government intramural expenditures on R&D (GovERD) have direct impact on science and knowledge dissemination. The effect is seen in improvement of quality of life, but it is not necessarily reflected in increased productivity. Therefore, measurement of results of GovERD is often neglected (Guellec & Van Pottelsberghe de la Potterie, 2004). Conlé i Shim (2009) state that cooperation between educational and research institutions and companies should result in synergy effects and lead to quicker knowledge dissemination and commercialization of new technologies. The same is also confirmed by Kearney (2009) who sees the exponential growth of collaboration between state, business sector and universities which leads to connecting new knowledge with the development goals of the country.

Human resources in science and technology (HRST) also present one of the significant variables for measuring innovativeness. Karaman, Aksentijević, Ježić and Đurić (2008) consider that knowledge based economy efficiently uses human resources in order to encourage economic growth and development. In this case, innovations resulting from human creative intellectual input are becoming the driving force for development and a source of competitiveness. Knowledge based economies are encouraging development of environment conducive to innovation, inter alia by higher number of researchers (Karaman Aksentijević, Ježić i Đurić, 2008). Conlé i Shim (2009) compared indicators of R&D and found evidence that the developed countries not only are investing more in R&D, but they also engage higher number of scientists that work in the R&D sectors or departments.

Research and development expenditure should contribute to innovation increase and consecutively to increased national competitiveness. Measure that is most often used to compare national economies competitiveness is Global Competitiveness Index (GCI) published by World economic forum (WEF, 2017). One of its components is also innovation as a factor that significantly contributes to international competitiveness.

In recent years Global Innovation Index (GII) emerges as a leading innovation measure and a tool that governments use for evidence based decision-making. One of its aims is also to support countries in improvement of their innovation systems. Therefore, GII may be considered a control measure of country's innovation effects and a tool for its improvement. (GII, 2017)

3 Summary Innovation Index

In order to analyse innovation efficiency of the European Union member states, the European Commission is conducting research of the strengths and of the weaknesses of national innovation systems on yearly basis, which should lead to improvement of innovation activities. The result of the analysis is the so called Summary Innovation Index (SII). The framework for its measurement is based on four basic pillars that include ten dimensions and a total of 27 different indicators for measurement of innovativeness. Basic pillars and dimensions according to European Commission (2017) include:

- Framework conditions (Human resources, Attractive research systems, Innovation-friendly environment
- Investments (Finance and support, Firm investments)
- Innovation activities (Innovators, Linkages, Intellectual assets)
- Impacts (Employment impacts, Sales impacts)

This year's SII is calculated on rather changed methodology compared to previous versions (2010-2016) therefore there is no straightforward data comparability in time series.

Figure 1 (European Commission, 2017) shows the results of cluster analysis of the European Union member states according to their average innovation efficiency. The countries are classified into 4 different clusters.

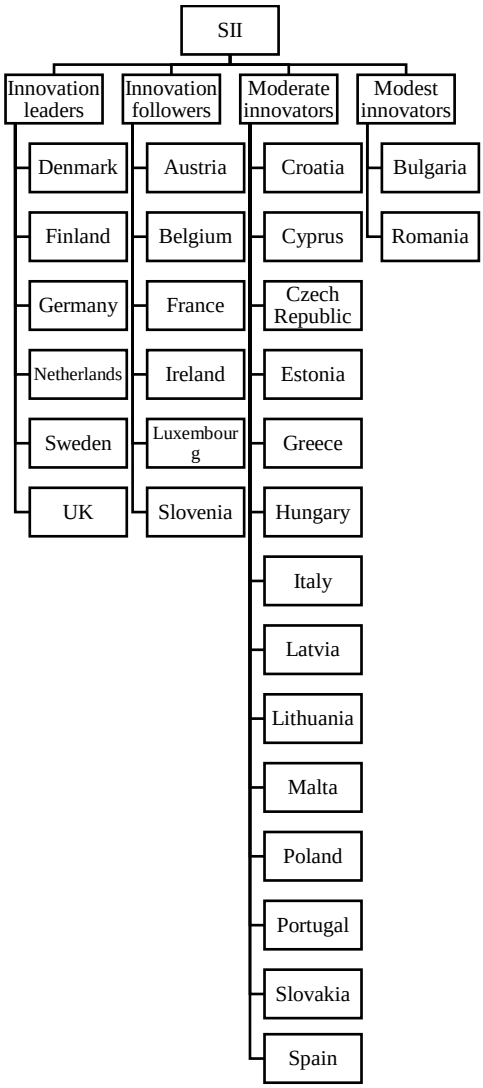

Figure 1. Classification of the EU member states according to SII

The data for calculation of SII indicators is out of date. The indicator has been used for clustering in 2016 and the time horizon of data set included in calculation ranges from 2005 to 2014. Innovation should contribute to national competitiveness improvement and it is therefore necessary to use competitiveness dimension of a certain country as a control measure and in this particular case of SII this component is missing.

4 The cluster analysis methodology

The taxonomy analysis enables clustering certain system based on multidimensionality, i.e. by using more variables for clustering. The use of taxonomy analysis is appropriate for modelling entities based on their common features (Halmi, 2016). It is used in the case when sample needs to be modelled in groups with homogenous features (Halmi, 2016).

The aim of the conducted cluster analysis is to determine groups of the European Union member states based on the homogeneity of investment in research and development, innovation and competitiveness. Other specific aims of the paper include:

a) finding a latent relationship between the European Union member states having in mind the mentioned variables,

b) determining cluster in which Croatia is included and

c) conduct a comparative analysis of countries belonging to the same cluster as Croatia.

The sample consists of 27 European Union member states. Due to the lack of data Ireland was not included in the sample. Clustering has been conducted based on the data for 2015 according to variables whose significance for this topic has been discussed in previous section of the paper:

- Business enterprise expenditure on R&D as a percentage of GDP (BERD),
- Higher education expenditure on R&D as a percentage of GDP (HERD),
- Government intramural expenditure on R&D as a percentage of GDP (GOVERD),
- Human resources in science and technology (HRST) as a percentage of active population,
- Global Innovation Index and
- Global Competitiveness Index.

Since all variables are numerical, Euclidian distance has been used as appropriate measure for similarity, i.e. for measuring distance between analysed entities. This implicates that variables are more similar when distance between them is smaller. Having in mind that similarity measures are sensitive to different measurement units, the analysis has been conducted based on standardised data. The method used is hierarchical method. In order to measure distance between certain clusters the method of maximum (method of complete linkage) has been used with the aim of ensuring highest distance between all couples in particular clusters. The results of the conducted analysis are presented in following section.

5 The cluster analysis results

Hierarchical analysis does not define exact clusters but they are assessed by the researcher. Figure 2 shows the results of the hierarchical analysis.

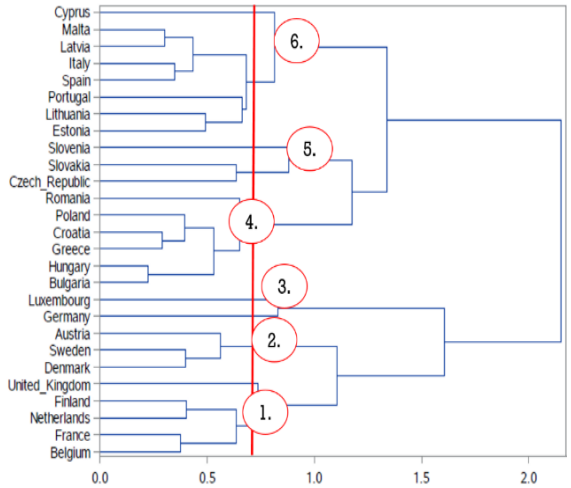

Figure 2. Hierarchical cluster analysis

The results indicate existence of 6 clusters:

- Cluster: Belgium, France, Netherlands, Finland and United Kingdom;
- Cluster: Denmark, Sweden and Austria;
- Cluster: Germany and Luxembourg;
- Cluster: Bulgaria, Hungary, Greece, Croatia, Poland and Romania;
- Cluster: Czech Republic, Slovakia and Slovenia;
- Cluster: Estonia, Latvia, Portugal, Spain, Italy, Lithuania, Malta and Cyprus.

Table 1 (Eurostat, 2017) presents an overview of data on research and development expenditure as a percentage of GDP for business and government sector and higher education sector for countries classified into the Cluster 4.

Business enterprise expenditure on R&D (% of GDP) for analysed countries is smaller than the EU average. The average of the cluster in BERD amounts to 0.53%, which is 0.77% less than the European Union average. Expenditures for analysed sector in Croatia are even smaller than the cluster average and amount to 0.44% of GDP. Lower business enterprise expenditure on R&D is present only in Greece and Romania.

Average of Cluster 4 in Government intramural expenditure on R&D (% of GDP) is also lower than the European Union average, but only by 0.02%. Greece invests 0.02%, and Poland 0.01% more than the European Union average (0.24%).

The average of analysed countries for Higher education expenditure on R&D is 0.47% of GDP. Average of cluster 4 is 0.20% which makes it less than the EU average by 0.27%. Croatia is investing even less, i.e. only 0.21% of its GDP. When compared to other countries belonging to the same cluster, Croatia is investing more than Bulgaria, Hungary and Romania.

Table 1. Expenditure on R&D % GDP

	2015.		
Country	(BERD % GDP)	GOVERD % GDP	HERD % GDP
Bulgaria	0.7	0.2	0.05
Greece	0.32	0.26	0.37
Croatia	0.44	0.21	0.21
Hungary	1.01	0.18	0.17
Poland	0.47	0.25	0.29
Romania	0.21	0.19	0.09
EU -28	1.3	0.24	0.47
Cluster average	0.53	0.22	0.20

Figure 3 shows BERD, GOVERD and HERD variables of the cluster 4 countries in relation to the European Union average and it is evident that the countries belonging to cluster 4 are investing less than the European Union average. This also results in weaker competitiveness of their economies.

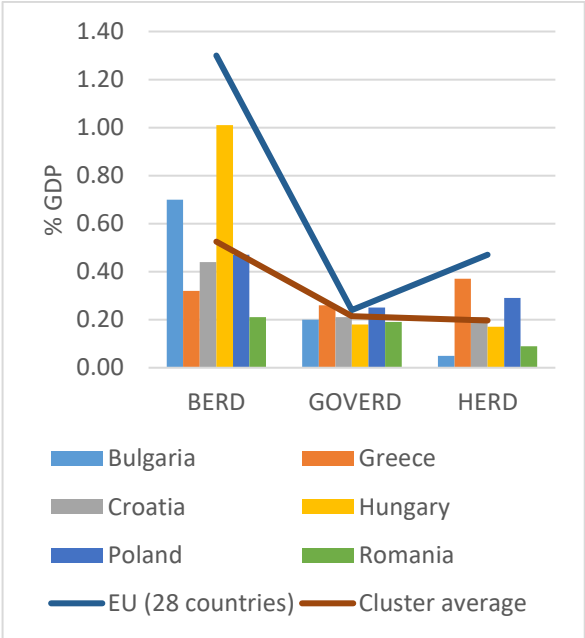

Figure 3. BERD, GOVERD and HERD for Cluster 4

7 Conclusion

Most authors agree that investment in research and development has positive impact on innovation efficiency and national competitive advantage where more emphasis is put on the investment of the business sector. The same is recognized by the European Union, who wants to improve its innovation efficiency to become more competitive compared to USA and Japan by increasing investment in research and development.

The results of the hierarchical cluster analysis on the level of the European Union indicates existence of 6 clusters based on investment in research and

development and measures of national competitiveness. The results indicate that Croatia is the most similar to Bulgaria, Greece, Hungary, Poland and Romania. The average of this cluster indicates that the named countries are investing in R&D far less than the European Union average. If these countries want to catch up more developed countries in the EU and improve their competitiveness, they should improve their innovation systems and form the environment more conducive to innovation by raising the gross expenditure on R&D. Learning by example from their more advanced co-members shouldn't be as hard considering the free movement of people, knowledge and capital within the EU.

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