Abstract
The aim of this paper is to identify clusters of countries, respectively regions from the European Union based on the most relevant indicators of innovation for stimulating competitiveness. The research objectives assumed refer to the determination of the homogenous groups of countries and regions in terms of relevant indicators of innovation, the identification of the indicators of innovation that explain the differences between the clusters generated at the national, respectively regional level, and the formulation of policy recommendations based on the most relevant indicators of innovation with impact on the national and/or regional competitiveness within EU. Methodologically, hierarchical cluster was used. The results of the paper reveal that the countries are less homogenous than the regions, namely the member states of the EU are divided into four or five clusters, while the 126 analysed regions of the EU are split into nine clusters. Practically, the results indicate that there is a higher similarity between the regions, than between the countries of the EU in terms of innovation. The paper ends with several policy recommendations for supporting the most relevant determinants of innovation that leads to the increase of competitiveness.

Keywords: innovation, cluster analysis, regional, European Union

1. Introduction
The connection between innovation and the competitiveness at the national and regional level is largely debated among scientists, policy makers and practitioners. Recent studies (Petrariu et al., 2013) conducted at the national level validate the positive connection between innovation and the competitiveness and economic growth, while other studies highlight the significant impact of innovation on stimulating the regional competitiveness and economic growth (Kroll et al., 2012; Grigore Nae & Sima, 2013). Three of the most relevant instruments that quantify the competitiveness at the macroeconomic level are represented by the World Competitiveness Index (WCI), the Global Competitiveness Index (GCI), and the Country Competitiveness Index (CCI). As regards the quantification of the innovation, indexes as the Global Innovation Index (GGI) and the Innovation Union Index (IUS) prove to be the most representative.

Further on, based on the most recent international reports, the most competitive and innovative EU countries are pointed out. In order to have a picture on the top most competitive EU countries, the recently released international report entitled “The Global Competitiveness Report 2014-2015” ((Schwab, K. & Sala-i-Martin, 2014) was consulted.

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The most recent edition of The Global Competitiveness Report corresponding to 2014-2015 was elaborated for 144 economies from the following five regions: Europe and Eurasia; Asia and Pacific; Latin America and the Caribbean; the Middle East and North Africa, and the sub-Saharan Africa. The leader of the ranking is represented by Switzerland, followed by Singapore as the second-most competitive economy in the world (Schwab, K. & Sala-i-Martin, 2014, p. 12). Particularly, an overview on the top 5 most competitive Member States of the European Union (EU) shows that Finland (4) is placed on the first position, followed on the next four positions by Germany (5), Netherlands (8), United Kingdom (9) and Sweden (10) (Schwab, K. & Sala-i-Martin, 2014).

According to the most recently registered values of the Global Innovation Index (Cornell University et al., 2014), the top 5 most innovative Member States of the EU is led by the United Kingdom (2), followed by Sweden (3), Finland (4), Netherlands (5) and Denmark (8). The number in brackets associated to the name of the Member State refers to the place occupied by that particular country in the world ranking, based on the same reference source. Based on the ranking encountered in the Innovation Union Scoreboard, Sweden is considered to be the leader country in terms of innovation. The following positions are occupied by Denmark, Germany and Finland included in the same category of innovation performance, namely ‘innovation leaders’. The 5th position is represented by Luxembourg that is the first country within the second category of innovation performance, namely ‘innovation followers’.

The current paper is part of a larger study dedicated to analysing the impact of innovation on the national and regional competitiveness within the EU. The purpose of the current paper is to reveal the clusters of countries and regions of the EU in relation to the most relevant indicators of innovation with impact on competitiveness. The current research starts from the results obtained through several econometric analyses that revealed the impact of certain indicators of innovation on the national and regional competitiveness within the European Union. The summary of these results are presented in the following section of the current paper.

The way of accomplishing the purpose of the paper is by conducting a comparative study between the impact of innovation on the national competitiveness and the regional competitiveness. Methodologically, the cluster analysis was used and it allowed grouping the countries and regions of the EU by the most significant indicators of innovation in relation to competitiveness. Consequently, the paper aims to accomplish the following three research objectives: (1) determination of the homogenous groups of countries and regions in terms of relevant indicators of innovation; (2) pointing

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2 The number in brackets associated to the name of the Member State refers to the place occupied by that particular country in the world ranking, based on the same reference source.
out the indicators of innovation that explain the differences between the groups in the three cases dedicated to the national competitiveness and in the case of the regional competitiveness within EU; (3) formulating policy recommendations in relation to the most relevant indicators of innovation with impact on the national and/or regional competitiveness within EU.

2. The connection between innovation and competitiveness

The main indicators used to test the connection between innovation and the national competitiveness within the EU are represented by the World Competitiveness Index, the Global Competitiveness Index, the Country Competitiveness Index, and the Innovation Union Index. At the regional level, competitiveness is represented by the Regional Competitiveness Index, and innovation by the Regional Innovation Index. The connection between the competitiveness and innovation is tested through econometric analyses, where the endogenous variable is represented by the index associated to the competitiveness, and the explanatory variables refer to the indicators that comprise the index corresponding to innovation. The Innovation Union Index is composed of 25 indicators, while the Regional Innovation Index includes only 11 indicators.

The econometric analyses referring to the impact of innovation on the national competitiveness in the EU, respectively on the regional competitiveness in the EU, are using the data corresponding to the indexes of competitiveness and innovation collected from relevant international and European reports prepared by the Institute for Management Development, World Economic Forum and under the supervision of the European Commission (IMD, 2014; Schwab, K. & Sala-i-Martin, 2014; Annoni & Dijkstra, 2013; Hollanders & Es-Sadki, 2014; Hollanders et al., 2014). For testing the impact of innovation on competitiveness, at both the national and regional level within EU, regression equations were formulated. The equations’ results validate the impact of certain indicators of innovation on the national competitiveness, respectively regional competitiveness within the EU.

In the case of the World Competitiveness Index, the indicators of innovation with impact on the national competitiveness within the EU refers to the "new doctoral graduates," "population having completed tertiary education cycle" and "Community designs". In the second case represented by the Global Competitiveness Index, "the population having completed tertiary education cycle", "patent applications" and "trademarks" are validated as indicators with impact on the national competitiveness within EU. In the case of the Country Competitiveness Index, the "R & D expenditure in the public sector", "venture capital investment" and "Community trademarks" are the most representative indicators of innovation to enhance national competitiveness within the EU.

The lack of data corresponding to regional competitiveness led to the elimination of certain countries from the analysis, namely: Belgium, Bulgaria, Germany, Greece, France, Austria and the UK. The
total NUTS 2 regions excluded from the analysis is of 44 and although there are representative countries within the EU, the analysis is not significantly affected as many regions, namely 126, still remain within the analysis. The results of the econometric analysis conducted at the regional level within EU indicate that the "R&D expenses in the public sector", the "R & D expenditure in the private sector", and the "patents applications" are the most relevant indicators of innovation with impact on the regional competitiveness.

Generally, the impact of innovation on competitiveness is confirmed, but as the results show, distinct indicators of innovation with impact on competitiveness are validated at the national compared to the regional level within the EU. The summary of all the validated indicators of innovation with impact on the national competitiveness and/or the regional competitiveness within the EU is reflected in table 1.

Table 1. Summary of the validated indicators of innovation as having impact on the national, respectively regional competitiveness within the EU

<table>
<thead>
<tr>
<th>National</th>
<th>Regional</th>
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<tbody>
<tr>
<td>New doctorate graduates per 1000 population aged 25-34</td>
<td>R&amp;D expenditure in the public sector as % pf GDP</td>
</tr>
<tr>
<td>Percentage population aged 30-34 having completed tertiary education</td>
<td>R&amp;D expenditure in the business sector as % pf GDP</td>
</tr>
<tr>
<td>Community designs per billion GDP</td>
<td>PCT patent applications per billion GDP</td>
</tr>
<tr>
<td>PCT patent applications per billion GDP</td>
<td></td>
</tr>
<tr>
<td>Community trademarks per billion GDP</td>
<td></td>
</tr>
<tr>
<td>R&amp;D expenditure in the public sector as % pf GDP</td>
<td></td>
</tr>
<tr>
<td>Venture capital investment as % of GDP</td>
<td></td>
</tr>
</tbody>
</table>

Source: own representation

The common indicators of innovation with impact on both the national and regional competitiveness within the EU are represented by the ‘R&D expenditure in the public sector as % of GDP’ and the ‘PCT patent applications per billion GDP’. At the national level more indicators of innovation were confirmed due to the variety of indexes used for the determinant variable. ‘R&D expenditure in the
business sector as % pf GDP was validated only in the case of the regional competitiveness, revealing the involvement of the business sector in developing innovative activities at the regional level.

3. Clusters of countries and regions of the EU in relation to the most relevant indicators of innovation with impact on competitiveness

The methodology used was cluster analysis, namely hierarchical clustering, that “is based on the core idea of objects being more related to nearby objects than to objects farther away” (Anon., n.d.).

The purpose of the cluster analysis is to group the EU countries, respectively regions of the EU according to those validated indicators of innovation that influence the national, respectively regional competitiveness. The cluster analyses are corresponding to the three cases corresponding to the national level, through the World Competitiveness Index, the Global Competitiveness Index, and the Country Competitiveness Index, and to the regional case, through the Regional Competitiveness Index.

The main indicators of innovation previously validated through the econometric analyses represent the multiple objects used for developing the corresponding clusters for each case.

The cluster analysis is conducted by using the SPSS programme, where the data corresponding to the confirmed indicators of innovation were inserted for each particular case. Within the programme, the command analyse-classify-hierarchical cluster is applied. Measuring the distance is made by the Squared Euclidean Distance, the methods of connection refer to Ward's Linkage, and the interpretation of results is based on the Vertical Icicle Plot and the associated dendograms. Further on, the results of each dendogram will be briefly captured in figure 1.

The snapshot on the profiles of each generated cluster is based on the calculation of the corresponding mean values and by comparing them with the EU average.

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3 The cluster analyses take into account all the 28 EU member states, in the following order: Belgium (1), Bulgaria (2) Czech Republic (3), Denmark (4), Germany (5), Estonia (6), Ireland (7), Greece (8) Spain (9), France (10), Croatia (11), Italy (12), Cyprus (13), Latvia (14), Lithuania (15), Luxembourg (16), Hungary (17), Malta (18), the Netherlands (19), Austria (20), Poland (21), Portugal (22), Romania (23), Slovenia (24), Slovakia (25), Finland (26) Sweden (27) and the UK (28). In the case of the Country Competitiveness Index, the cluster analysis included only 20 EU member states due to the deficiency of data for certain indicators of innovation that were confirmed through the econometric analysis.
In the first case dedicated to the national competitiveness in the EU four cluster levels were obtained: four clusters are corresponding to the first level, and one cluster for each of the following three levels. The EU countries belonging to the first level are distributed as follows: the first cluster contains nine countries, namely: Belgium, France, the Netherlands, Denmark, Estonia, Poland, Spain, Slovenia and Latvia; the second cluster consists of seven countries, as follows: Ireland, Lithuania, Sweden, UK, Finland, Cyprus and Luxembourg; the third cluster is including only three countries Greece, Hungary and Germany; and the last cluster is composed of nine countries, namely: Croatia, Slovakia, Malta, Romania, Bulgaria, Czech Republic, Portugal, Italy and Austria. The other cluster levels are captured in the dendogram corresponding to WCI in figure 1a).

Consequently, according to the main indicators of innovation with impact on the national competitiveness in the case of WCI, namely the "new doctoral graduates," "population having completed tertiary education cycle" and "Community designs", the four resulting clusters are characterized as follows:

Cluster 1 includes countries with the highest potential in terms of community designs compared to the other clusters, but it does not overcome the EU average of 4.75. Additionally, the “population completed tertiary education” (%) registers a value above the EU average, 40.81 compared to 35.8;
Cluster 2 is composed of countries that have the highest “population completed tertiary education” (%) compared to the other clusters and more above the EU average. Moreover, the value associated to “new doctorate graduates” is the same as in the case of EU average.

Cluster 3 comprises countries with the values of all the three indicators of innovation below the values associated to the EU average.

Cluster 4 resembles cluster 3 regarding the low values associated to the three indicators of innovation compared to the EU average.

In the second case dedicated to the national competitiveness in the EU there are also four levels of clusters, with five clusters corresponding to the first level, and with one cluster for each of the following levels. The following five clusters are encountered at the first level: the first cluster contains six EU countries, namely: Bulgaria, Portugal, Czech Republic, Greece, Hungary and Germany; the second cluster includes four countries, namely: Romania, Slovakia, Croatia and Italy; the third cluster is represented by two countries Malta and Austria; the fourth cluster consists of nine countries, as follows: Poland, Slovenia, Latvia, Estonia, Spain, Denmark, the Netherlands, Belgium and France; and the fifth cluster includes seven countries, namely: Cyprus, Luxembourg, Finland, United Kingdom, Sweden, Ireland and Lithuania. The other cluster levels are captured in the dendogram corresponding to GCI in figure 1b).

Consequently, according to the main indicators of innovation with impact on the national competitiveness in the case of GCI, namely the "the population having completed tertiary education cycle", "patent applications" and "trademarks", the five resulting clusters have the following characteristics:

Cluster 1 is including countries that register values lower than the EU average for all the three validated indicators of innovation.

Cluster 2 is similar to cluster 1, but with the lowest values for all the three indicators of innovation compared to all the other clusters.

Cluster 3 is composed of countries that are the most attractive in terms of community trademarks, with a value of 11.61 compared to the EU average of 5.91.

Cluster 4 is formed of countries that are register a high value of the population completed tertiary education (%) and are close to the EU average in terms of PCT patent applications and community trademarks.

Cluster 5 includes countries that are the most competitive in terms of population completed tertiary education (%) and community trademarks, obtaining values much above the EU average.

Due to the missing data for the "venture capital investment" indicator in the case of eight member states, the third case focused on the national competitiveness in the EU is including only 20 countries.
In this case five levels of clusters were obtained: the first level has four clusters, the second level includes two clusters, and each of the other levels contains one cluster. The first level contains the following clusters: the first cluster consists of six countries, namely Denmark, Sweden, Germany, Spain, the Netherlands and Finland; the second cluster is also composed of six countries, as follows: Ireland, Italy, Belgium, the UK, Bulgaria and Portugal; the third cluster includes three countries represented by Hungary, Romania and Greece; the fourth cluster contains three countries, namely: Czech Republic, France and Poland; and the fifth cluster is composed of Austria and Luxembourg. Into the second level of clusters two clusters are encountered, the first results from the union of the third and fourth clusters corresponding to the first level, and the second cluster is composed of two countries, represented by Luxembourg and Austria. The other cluster levels are captured in the dendogram corresponding to CCI in figure 1c).

Consequently, according to the main indicators of innovation with impact on the national competitiveness in the case of CCI, namely the "R & D expenditure in the public sector", "venture capital investment" and "Community trademarks", the five resulting clusters are characterized as follows:

Cluster 1 is referring to countries that have the highest potential in terms of R&D expenditure. Moreover, the “community trademarks” registers a mean value above the EU average. Regarding the venture capital investments, its mean value is very close to the EU average of 0.28.

Cluster 2 is composed of countries that have mean values for all the three indicators of innovation below the EU average.

Cluster 3 is composed of countries with the lowest values for all the three indicators of innovation.

Cluster 4 is including countries that show a high interest for R&D expenditure in the public sector, with a value very close to the EU average of 0.75.

Cluster 5 resembles to cluster 1, registering mean high values above the EU average for venture capital investments and, mainly, for community trademarks. In terms of community trademarks, this cluster is the most competitive compared to the other clusters.

The cluster analysis conducted at the regional level is complex, containing seven levels where the 126 regions of the European Union included within the study are grouped. At the first level nine clusters are formed, as follows: the first cluster includes 28 regions, the second cluster is composed of 24 regions, the following has 26 regions, the forth is formed of 19 regions, the next cluster includes 5 regions, the sixth cluster has 12 regions, the following two clusters are composed of two regions each, and the last cluster corresponds 8 regions. Consequently, the clusters were formed based on the main indicators of innovation with impact on the regional competitiveness, namely the "R& D expenses in the public sector", the "R & D expenditure in the private sector", and the "patents applications".
Grouping countries or regions leads to an overall picture that represents the basis for a series of proposals that could stimulate the most representative innovation indicators to increase the national and/or regional competitiveness within EU.

4. Policy recommendations

Based on the indicators of innovation validated as having impact on the national and/or regional competitiveness within the EU and on the results obtained through the cluster analyses, several policy recommendations are formulated. As each country and/or region has its particularities, the policy recommendations have to be adapted to the regional specificities and capabilities to manage knowledge, and to positively speculate them in favour of innovation and competitiveness.

Stimulating innovation in order to enhance regional and national competitiveness is a challenge of the governments that have to overcome various and different barriers as exposed in table 2.

Table 2. Policy recommendations for increasing the regional and national competitiveness within the EU by stimulating innovation

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Solution</th>
<th>Recommendation</th>
</tr>
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<tbody>
<tr>
<td>The high level of administrative burden on enterprises</td>
<td>Implementing measures for improving the general business and innovation environment (UNECE, 2012)</td>
<td>“Harmonizing the relevant laws and regulations with international norms; Reducing costs and simplifying the procedures governing their establishment and operation; Preventing violations of property rights and fostering transparency of regulations and their application, in particular, with respect to intellectual property protection” (UNECE, 2012, p.59). “Transparency by clear justification of the spatial allocation of funds; Continuity over time in public support decisions” (ESPON &amp; BEST - Politecnico di Milano, 2012). “Facilitating and fostering the financing of innovation based start-up companies using, among other instruments, merit-based awards and feasibility grants, facilitate the development of national business angel networks and their links with research institutions and universities, and promote partnerships between industry and government” (UNECE, 2012, p. 60).</td>
</tr>
<tr>
<td>High disconnection between industry-science-policy</td>
<td>Building national and local linkages between industry, science, and policy, and regionally connecting them to Developing public-private co-operations for building a stable national innovation system; Increasing the capacity of the national administration;</td>
<td>Developing public-private co-operations for building a stable regional innovation system; Increasing the capacity of the regional administration; Increasing the professional</td>
</tr>
<tr>
<td>Insufficient communication and collaboration between the scientific community and industry (UNECE, 2012)</td>
<td>Involving private actor in funding R&amp;D / in the process of applied research and its continuous support for generating and promoting innovation</td>
<td>Establishing public-private and public-public partnerships with the Member States focused on research and innovation within the programme Horizon 2020 (EC, 2013); Supporting regional public-private partnerships to co-operate with associated international partners in order to exchange practices;</td>
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<tr>
<td>Low level of practical implications of the research</td>
<td>Creating financial and non-financial incentives for successful</td>
<td>“Encourage universities to develop coherent policies regarding the ownership of intellectual property; Establish technology transfer offices in universities;”</td>
</tr>
</tbody>
</table>
Conclusions
The purpose of the current paper was achieved by grouping the countries and regions of the EU in clusters. The objects used in the cluster analysis were represented by the most relevant indicators of innovation with impact on national, respectively regional competitiveness. These indicators were obtained through econometric analyses that were explained within a previous paper (Iosif, 2014).
Methodologically, the cluster analysis was used for grouping the countries and regions of the EU by the most significant indicators of innovation in relation to competitiveness. The purpose of the hierarchical clustering was that of highlighting commonalities and differences across countries and regions of the EU that were presented in the third part of the paper.
Detecting and supporting the national and regional skills, traditions, social values, positive attitudes towards the environment and local culture, solidarity and cultural diversity, creating an innovation-friendly business environment, reducing barriers, enhancing receptivity to external stimuli and opportunities, discovering new local potentials are some of the main recommendations formulated by the KIT project team in order to stimulate innovation (ESPON & BEST - Politecnico di Milano, 2012) and also apply in relation to the results of the current paper. The same researchers (ESPON & BEST - Politecnico di Milano, 2012) enforce that the approach of the innovation policy has to be thematically/regionally focused, rather than neutral. This issue is also sustained through the results of the cluster analysis conducted at the regional level, where the 126 regions were split into a high number of groups. Each group has its characteristics and particular policy recommendations have to be applied.
A limitation of the current research is the limited number of regions that were included within the cluster analysis.
Future research direction may consist of developing a deeper profiling of the clusters, by revealing the arguments that stand behind the indicators of innovation that divided countries and regions into that particular groups.

Acknowledgment
This work was cofinanced from the European Social Fund through Sectoral Operational Programme Human Resources Development 2013-2020, project number POSDRU 159/1.5/S/134197 “Performance and excellence in doctoral and postdoctoral research in Romanian economics science domain”.

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