The Regional R&D Activity in Romania –
A Perspective Post-EU Accession

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Abstract

The study consists of analyzing the evolution of the research and development (R & D) sector in Romania, from the point of view of the structural changes registered at the level of the eighth development regions. The period considered in analysis consists in the years after the accession of Romania to the European Union, with the aim of identifying the territorial disparities as well as the generating factors associated with the general dysfunctions of the economic and social system. The data used in the study refers to the 2007-2014 period, 2014 being the last year with data available on Eurostat database for all the indicators considered.

Key words: research and development, regions, disparities, Romania
J.E.L. classification: C19, O39, R12.

1. Introduction

In the last ten years, on the efforts to build up the European System of Innovation at the level of the EU member states has been a progressive and systematic process of convergence in terms of national R&D strategies and policies, as well as in terms of R&D expenditures (Goschin, Sandu, and Goschin, 2016, p.1). However, Romania had an insufficient and inadequate investment in this important sector. Nowadays, our country is still an insignificant force through the EU member states, with only 0,5% of its GDP dedicate to these important activities, even if a number of facilities have been thought, of lately to stimulate the sector, like labor incentives, fiscal incentives, reinvested profit, and state aid for R & D or intellectual property (Buciuman, Tapai, and Grigore, 2017, p.2). More than that, the territorial component of the national innovation system is still underdeveloped. The existence of major technological disparities among Romanian regions and counties has been recognized as a constraint in building an efficient national innovation system, but it is still lacking a strong regional R&D policy to address such disparities (Goschin, Sandu, and Goschin, 2016, p.2). To growing the R&D sector, is needed a continuous attention from the Romania's government, with higher targets, capable to create a functional and sustainable context to developing public and private research and development facilities.

2. Datasets and methodology

We considered two important classes of relevant indicators to defining the regional profile from this perspective: a) R & D expenditure (GERD), which includes spending on research and development by business enterprises, higher education institutions, as well as government and private non-profit organizations, and b) the number of researchers involved in R&D activities. Taking into account regional specific issues, to have a complete picture of the size of the R & D sector we consider the main indicators that can synthesize both the dimension of this sector and correlation with the regional employment profile, too:
• **Group 1** – "Expenditures", including 3 indicators: IND_1 - total R&D, which indicates the level of investment in R&D activities, IND_2 - total R&D expenditure in inhabitant, (measured in Euro), indicator describing the investment in R&D relative to the size of the region, respectively the number of inhabitants, and IND_3 - Total R&D expenditure as a percentage of GDP of the region, named "R&D intensity" because it is used to measure the relative degree of an economy to invest in new knowledge and innovation (See Table no. 1), and

• **Group 2** – "Researchers", including 4 indicators: IND_4 - R&D Researchers measured in FTE, IND_5 - R&D Researchers measured in HC, IND_6 - R&D Researchers, as % of total employment - numerator in FTE, and IND_7 - R&D Researchers, as % of total employment - numerator in (HC) (See Table no. 2).

### Table no. 1. R&D expenditure (GERD) by NUTS 2 regions

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Source: Based on Eurostat.

The data in the table shows a lent tendency to decrease R & D expenditure nationwide for all three indicators considered, while the only region that in the year 2014 has an 11-15% increase from 2007 is the Centru Region. On the opposite side, we find the South East region where the relative decrease reaches 10,73% for IND_1, 8,98% for IND_2 and more than 14% for IND_3. Even with a relative decrease above than the national level for the period 2007-2014, București - Ilfov remains the region with the highest level of R&D spending, indicating the concentration of the sector, especially in the capital of the country, București. As can be seen in the table below, between the year 2007 and 2014, the changes in the volume and structure of the researchers involved in the sector are much more obvious. While for most regions, including at national level, the trend was generally in decline, there are two regions where the trend is increase and a significant one: Vest and Centru Regions.
Data analysis consists of two successive stages in which two of the most usual methods in territorial studies, which allow comparability of the territorial units with the average level, or the "best performance", as the case may be, as well as the measurement of the gaps between its, were applied.

Table no. 2. R&D Researchers of all sectors of performance by NUTS 2 regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Indicator</th>
<th>Year</th>
<th>Changes 2014/2007</th>
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<td>2.823</td>
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<td>IND 10</td>
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</table>

Source: Based on Eurostat.

Firstly, the NUTS2 regions were clustered based on the multicriteria similarities of the seven indicators considered. The number of clusters was determinate by using the Hierarchical Cluster Analysis with Ward’s method, and then for regions classification, the K - means Cluster algorithm. Ward’s method is „similar to other linkage methods in that it begins with N clusters, each containing one object, it differs in that it does not use cluster distances to group objects. Instead, the total within-cluster sum of squares (SSE) is computed to determine the next two groups merged at each step of the algorithm. The error sum of squares (SSE) is defined (for multivariate data) as:

\[
SSE = \sum_{i=1}^{n} \sum_{j=1}^{k} (y_{ij} - \bar{y}_i)^2
\]

where \( y_{ij} \) is the jth object in the ith cluster, and \( n_i \) is the number of objects in the ith cluster” (Ferreira and Hitchcock, 2009, p4) For both procedures, the data were processed with SPSS v.20.0.
The NUTS2 regions were hierarchized in the second stage. From a large class of hierarchy techniques were used, the real rank method, which is based on the gapes to the best performance as the referential value, relative to the amplitude variation. This technique assumes that, depending on the nature of the indicator, the calculation of the real rank for each indicator is performed with a specific formula. (Nelea, 2006) We used for the seven indicators analyzed, the formula:

\[ R_j^i = n - \frac{a_j^{\text{max}} - a_j^i}{\max_j(a_j^i) - \min_j(a_j^i)} (n - 1), i = 1, 2, ..., n; j = 1, 2, ..., m \]  

(2)

where: \( a_j^i \) - the value of the \( j \) indicator for the territorial unit \( i \), \( n \) - the number of territorial units, \( m \) - the number of indicators considered, \( a_j^{\text{max}} \) - the maximum value of indicator \( j \), the "best" depending on the nature of the indicator. Final real ranks are calculated as average values. The method allows the calculation using the weighted arithmetic average model, the weights being determined according to the importance of each indicator considered in the study. In this case, the weights were considered equal. The hierarchy has been ranked according to the rank level, allowing for the identification of changes between and within regions. To highlight the evolution and structural changes of the R & D sector at the territorial level, from the perspective of the considered indicators, the results for the years 2007 and 2014 were compared.

3. Results and discussion

For both the 2007 and the 2014 situation, the clustering result revealed the major gap between the București-Ilfov Region and the other Romanian 7 NUTS2 regions, which remain grouped as similar.

Figure no. 1. Dendrograms

Note only two clusters formatted both in the year 2007 and 2014, too. Cluster 1: București - Ilfov Region, and Cluster 2: all the rest seven regions. The results of the clustering in 2 clusters using SPSS K - means Cluster procedure highlights the large distances between the two cluster centers and the role of the chosen variables in classifying. By using Ward’s method, the two clusters have been formatted to maximize the differences among the eight regions, so the F tests from ANOVA table are used only for descriptive purposes. In this case, the observed significance levels indicate that there are not indicators, among the 7 indicators considered in the multicriteria analysis, with large F values which can provide a greater separation between the two clusters. However, note a smaller distance between cluster centers, only 12915.826, in 2014, versus 14739.567 in 2007. That can explain a reduction in disparities. Because of all of that, it was necessary to hierarchize the eight development regions using real ranks method to put in evidence the real distances between them.

Finally, was analyzed the cumulative influence of the seven indicators in re-ranking regions in the national hierarchy.
Regarding the hierarchy based on the indicators of Group 1 - "Expenditures" note the advance of the București-Ilfov Region compared to all the others. București - Ilfov placed in the first position, with "best performance" since 2007. The other regions are positioned especially on the final positions, 7-8 in terms of real ranks, both for each indicator, as well as multicriterial. Only Sud-Muntenia Region seems to be placed closest from București-Ilfov, but only on the 6,85 position (See Table no. 3.). Remark Centru Region placed in the last position for all indicators, and Vest Region on the 7,53 position in terms of real ranks, but the position 5 in the final ranking.

For the year 2014, București - Ilfov remains in the first position, while four of the other regions are advancing in the hierarchy, although insignificant, grouping on positions 6-7, and only three places in positions corresponding to 7-8. Looking at the hierarchy changes for each region, in 2014 compared with 2007, in terms of real rank, can note that, excepting București -Ilfov Region, which remained in the first place, and Sud-Est Region, which had an insignificant decrease but remained in the last place, the other six regions recorded easy improvements in positions, climbing in the hierarchy. In terms of final hierarchy, București-Ilfov maintained the first position; Sud-Muntenia maintained the second place, too.

When all the other regions have advanced one place in 2014 compared with 2007, only the Centru Region climbed 5 positions, from the last one, the 8th, in the hierarchy in 2007, to the position 3 in the hierarchy in 2014, indicating the efforts of the region to alleviate the major gap in 2007 faced by the region with respect to the others in terms of Total R&D expenditure.

Table no. 3. The algorithm of hierarchizing concerning the group -1 of indicators, for the years 2007 and 2014

<table>
<thead>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N-V</td>
<td>58.00</td>
<td>21.3</td>
<td>0.38</td>
<td>45.92</td>
</tr>
<tr>
<td>C</td>
<td>22.26</td>
<td>8.8</td>
<td>0.15</td>
<td>52.82</td>
</tr>
<tr>
<td>N-E</td>
<td>49.03</td>
<td>13.2</td>
<td>0.36</td>
<td>43.08</td>
</tr>
<tr>
<td>S-E</td>
<td>24.17</td>
<td>8.5</td>
<td>0.18</td>
<td>10.91</td>
</tr>
<tr>
<td>S</td>
<td>69.49</td>
<td>21</td>
<td>0.45</td>
<td>66.73</td>
</tr>
<tr>
<td>B-I</td>
<td>376.60</td>
<td>168.5</td>
<td>1.24</td>
<td>313.8</td>
</tr>
<tr>
<td>S-V</td>
<td>20.32</td>
<td>8.9</td>
<td>0.2</td>
<td>16.47</td>
</tr>
<tr>
<td>V</td>
<td>33.45</td>
<td>17.4</td>
<td>0.27</td>
<td>25.28</td>
</tr>
</tbody>
</table>

**Source:** Calculated by the authors using MS Excel, based on data from Eurostat database http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_e_gerdreg&lang=en

Regarding the Group 2 - "Researchers" included four indicators, in 2007, București - Ilfov Region placed in the first position, with "best performance". All the other regions are positioned especially on the final positions, from 7,467 to 7,959 in terms of real ranks as a multicriterial view. Almost half of the Romanian researchers are concentrated in București - Ilfov Region in 2007. In the year 2014, we found a slight movement of real positions, from 7,467 to 7,959, to 6.82- 7.63. The Vest Region occupied the second position, after București - Ilfov Region - "the best performance", and Sud-Est Region, the last one.

Table no. 4. The algorithm of hierarchizing concerning the group -2 of indicators, for the years 2007 and 2014

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>N-V</td>
<td>232.92</td>
<td>125.04</td>
<td>0.2023</td>
<td>0.1093</td>
</tr>
<tr>
<td>C</td>
<td>2257</td>
<td>837</td>
<td>0.2242</td>
<td>0.0832</td>
</tr>
<tr>
<td>N-E</td>
<td>3269</td>
<td>1632</td>
<td>0.1928</td>
<td>0.0962</td>
</tr>
<tr>
<td>S-E</td>
<td>1776</td>
<td>1006</td>
<td>0.1538</td>
<td>0.0871</td>
</tr>
<tr>
<td>S</td>
<td>2724</td>
<td>2074</td>
<td>0.1855</td>
<td>0.1413</td>
</tr>
<tr>
<td>B-I</td>
<td>14361</td>
<td>9807</td>
<td>1.4103</td>
<td>0.9631</td>
</tr>
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</table>
In terms of changes in real ranks generated by the Group 2 of indicators – “Researchers”, excepting Sud - Est Region, which fell a position from the 7,96 in 2007 to 8 position in 2014, the authors advance their real position. However, in terms of changes in the national hierarchy, four regions maintained in 2014 their places from 2007 (București - Ilfov – in the first place, Sud - Est – in last place, Nord - Est in the 3rd place, and Nord – Vest in the 4th place). Other two regions have descended into the hierarchy (Sud-Muntenia from the second position in 6th place, Sud - Vest Oltenia Region from the 6th place in 7th place) and only the Vest Region registered the performance to climb from position 5 to position 2 (See Table no. 4.). Regarding the changes in hierarchy generated by all seven main indicators, the algorithm of real ranks reveals that București - Ilfov Region maintained as the best region in 2014 as in 2007. Only two regions, Sud - Muntenia and Sud - Est, worsed their positions in the hierarchy, and the other four regions, Nord - Vest, Centru, Nord - Est, Sud - Vest Oltenia, and Vest Region registered better positions in 2014 as in 2007. (See Table no. 5)

Table no. 5. NUTS 2 Changes in hierarchy

<table>
<thead>
<tr>
<th>NUTS2 Regions</th>
<th>Real Ranks</th>
<th>Changes in Ranks</th>
<th>Final Ranks</th>
<th>Changes in Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
<td>2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IN_1-3</td>
<td>IN_1-3</td>
<td>IN_1-3</td>
<td>IN_1-3</td>
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<tr>
<td></td>
<td>IN_4-7</td>
<td>IN_4-7</td>
<td>IN_4-7</td>
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<td>IN_1-7</td>
<td>IN_1-7</td>
<td>IN_1-7</td>
</tr>
<tr>
<td>Nord-Vest</td>
<td>7,07</td>
<td>6,82</td>
<td>↑</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>7,72</td>
<td>7,35</td>
<td>↑</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>7,395</td>
<td>7,085</td>
<td>↑</td>
<td>4</td>
</tr>
<tr>
<td>Centru</td>
<td>7,98</td>
<td>6,52</td>
<td>↑</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>7,83</td>
<td>7,39</td>
<td>↑</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>7,905</td>
<td>6,955</td>
<td>↑</td>
<td>5</td>
</tr>
<tr>
<td>Nord-Est</td>
<td>7,29</td>
<td>6,88</td>
<td>↑</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>7,55</td>
<td>7,12</td>
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<td>3</td>
</tr>
<tr>
<td></td>
<td>7,42</td>
<td>7</td>
<td>↑</td>
<td>3</td>
</tr>
<tr>
<td>Sud-Est</td>
<td>7,91</td>
<td>8</td>
<td>↓</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>7,96</td>
<td>8,00</td>
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<td></td>
<td>7,935</td>
<td>6,83</td>
<td>↓</td>
<td>8</td>
</tr>
<tr>
<td>Sud–Muntenia</td>
<td>6,85</td>
<td>6,26</td>
<td>↓</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>7,46</td>
<td>7,40</td>
<td>↓</td>
<td>6</td>
</tr>
<tr>
<td>București – Ilfov</td>
<td>1</td>
<td>1</td>
<td>→</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>→</td>
<td>1</td>
</tr>
<tr>
<td>Sud–Vest Oltenia</td>
<td>7,89</td>
<td>7,62</td>
<td>↑</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>7,76</td>
<td>7,63</td>
<td>↑</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>7,825</td>
<td>7,615</td>
<td>↑</td>
<td>7</td>
</tr>
<tr>
<td>Vest</td>
<td>7,53</td>
<td>7,33</td>
<td>↑</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>7,75</td>
<td>6,82</td>
<td>↑</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>7,64</td>
<td>7,075</td>
<td>↑</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: Calculated by the authors

However, in the national hierarchy by final ranks, remark two regions that registered the performance to climb in the hierarchy, Centru Region from position 7 to position 5, and Vest Region from position 5 to position 2. Sud - Muntenia Region descended into the hierarchy from the second position in 6th place. Only regions Centru and Sud - Muntenia manage to get closer to București - Ilfov in 2014 as in 2007, placing themselves in the positions 6,955 and 6,83. The Sud - Vest Oltenia Region descended into the hierarchy from the 6th place in 7th place, even if in real ranking had a better performance in 2014 as in 2007. Nord - Vest and Nord - Est Regions, with better performances in 2014 as in 2007, remained in the same places in the national hierarchy. (See table no. 5.)

5. Conclusions

The identification and measuring the regional gaps, tendency to sustain or increase regional disparities with territorial concentration effects, can be a useful tool in the development policy of a state by forecasting, preventing, and correction the socio-economic disparities. It is well-known that supporting research leads to increased attractiveness of a region for investments, given that there is an availability of knowledge and professional human resources there. București - Ilfov is such an example in Romania, București, the capital of the Romania, being included in the region.

The clustering could only highlight the great gap between the București - Ilfov Region and the rest of the NUTS2 regions, which was maintained throughout the analyzed period. That can be explained by included Romania’s capital in this region, the largest city with the highest standard of living. Eurostat statistics placed only București - Ilfov Region, as NUTS 2 region in Romania, above the European average in terms of GDP per capita, in 2014, (129%), while among the other 7
only two others were slightly above half of the European average: the Vest region - by 58%, and the Centru - by 52%. Development of Research and Development sector can be one explanation.

6. References