CREATIVE POTENTIAL OF RESEARCH AND DEVELOPMENT - A COMPOSITE INDEX OF POTENTIAL SCIENTIFIC CREATIVITY

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Both Lisbon Council in March 2000 and the one in Barcelona in 2002 represent major turning points in science and research activities at European level. At that time there was a formal recognition that science, technology and innovation, coupled with a quality education is the key to development and long-term competitiveness of European space. Moreover, the decade 2000-2010 was declared as a dedicated to the investment in these sectors, and 2009 was named Year of Creativity and Innovation at European level. In a study in the EU States and candidate countries, whose results were published in 2010, it was noted however that, despite the special attention given lately to these issues, index fund allocations for research and development budgets national level of 2007 is 0.67% on average in the EU (27 countries), compared with Japan (0.68%), South Korea (0.80%) and especially the United States (1.03 %).

The purpose of this paper is to identify those factors that influence a nation's potential of scientific creativity and to find a way to compare different countries in terms of such potential. If until now many attempts were made to create an index of national or regional creativity, our goal is to narrow the field of creativity to scientific research and to compare the performance / potential of Romania compared to other European Union countries. Among the basic elements which have a direct impact on the potential for innovative scientific development, one can identify investment, human resources and current performance. Based on the above factors, a composite index of scientific creativity potential was developed, which takes into account the three main elements described above: human capital (human resources in science and technology and researchers), financial capital (investment in research and development) and scientific performance (Hirsch Index). Data for the first two were extracted from the Eurostat database for comparisons to be made between countries, while the third one has been estimated by specialized research teams based on data available on Essential Science Indicators (ESI) of Web of Knowledge. The main limit is the level of accuracy in data provided by each nation, and the extent to which such data were estimated, not final. The main benefit is that of identifying the position one country compared to others, but also to find the main factors that placed that country at one level or another in the overall classifications, thus allowing for the development of action plans particularly focused on those elements.
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JEL Codes: O15, O31, O32

1. Introduction

Although basic research has traditionally registered relatively late economic effects, there are many areas of applied research where they are recorded much faster. This is demonstrated by the growth in importance that research and development departments of several private companies are gaining in several sectors: IT, pharmaceutical, automobile, etc. Many results of these departments are applied in production and the increasing global competition (see the IT sector) makes that the time distance between these results of a research process and their implementation is increasingly lower. Our theory is that research and development is part of the creative economy and represents, perhaps, even though apparently without immediate and direct results, one of the main engines of global growth. The purpose of this paper is to define the main factors that impact on the country's scientific creativity and to compare, using a composite index, the creative potential of countries belonging to the European Union.

2. Consecrated indexes in the estimation of creative potential

One of the most popular theories of economic growth has been developed by Richard Florida (2002), and is based on defining the creative capital as an engine for development. In order to quantify the economic development potential of a city or a region he identified and defined three parameters, which he called the three T: Technology, Talent (skills) and tolerance (Florida, 2002). While his study in 2002 was concentrated on the United States, in the book "The Flight of the Creative Class" (Florida, 2007) he added a part dedicated to an international study. Data used for the study were provided by the WTO, UNESCO, World Bank and Ronald Inglehart's study for the period 1995-1998 in terms of tolerance. Moreover, it also calculates the Global Creativity Index (GCI). Its formula was determined by Tinagli and Florida (Florida and Tinagli, 2004) and was extended from Europe to a global level. GCI is the equally distributed average between Talent (skills), Technology and Tolerance indicators, where national values for each indicator were normalized on a scale from 0 to 1. Romania occupies the last position in the Global Creativity Index ranking with a score of 0.127. The first three positions are occupied by Sweden (0.808), Japan (0.766) and 0.684 Finland. United States occupies the fourth place with a score of 0.666. Romania's low score comes from all three indicators, the lowest compared to the first classified, was that of innovation (which participates in the formation of the technology index), 433 times lower than in Sweden (0.45 to 195 97).

In the last decade another composite indicator of the creative economy has also been estimated (CICE - Creative Economy Composite Index - Bowen, HP et al., 2006). The indicator takes into account three main components: innovation, entrepreneurship and the level of openness. Each of the three components has three sub- components in its structure. Thus, innovation index takes into account the human resources in science and technology, patent applications and Internet access. Entrepreneurship index is composed of indicators that give information about the number of newly established companies, the fear of failure and venture capital. Openess considers the share of urban population, immigrants and foreign students. The authors have developed and used these indicators in particular at regional level, where they had access to comparable data.

3. Defining the composite index of scientific creativity potential (CISCP)

Creativity is in part the ability to find innovative solutions to problems, create new products or processes, either from existing ones or from nothing. Thus, it appears to be closely linked to innovation and has become evident that promoting and encouraging the innovative character of a nation are essential to future economic development. Among the basic elements, which have a direct impact on the potential for innovative development, one can identify: investment in research and development (financial capital), human resources in science and technology and researchers supply (human capital). Of high importance is also the current scientific performance, that makes a country competitive in the field of science. Based on the above factors, a composite index of the potential of scientific creativity was developed that takes into account and is equally divided among three main elements: human capital (human resources, science and technology and research), financial capital (investment in research and development) and current scientific performance.

Human capital (H). Human capital (skills and knowledge) is regarded as having a crucial contribution in developing the scientific creativity and is a key element of a country's competitiveness. Meeting the demand for highly skilled human resources requires constant investment in education. Human capital has a 1/3 share in CISCP composition, equally divided between human resources in science and technology and the supply of researchers.

Human resources in science and technology (HRST). A common indicator of the level of human capital in a country or region is the total amount of human resources employed/ educated in science and technology . In the index calculation in particular, we took into account those resources holding the proper education, even if they are not working in a field of reference. They are, however, potential resources, benefiting of the necessary foundations. This index includes thus people who have obtained a tertiary degree in a field of science and technology (eg, science, engineering, medicine).

Researchers. Human capital fully devoted to research activity is a direct indicator of the extent to which this area is of interest to a nation. The share of researchers in total employment was taken into account in the analysis.

Financial capital (F) The index takes into account the share in total GDP dedicated to research and development. Research, especially the fundamental one, is most often not self-funding. Government participation is crucial in this respect, most leaders from developed countries, having understood it and pursue it thus with utmost care. This element was given a weight of 1/3 in the composite index calculation.

Scientific performance (S). In order to measure scientific performance, the element taken into consideration is Hirsch national index for each analyzed country. Jorge E. Hirsch (2005) introduced the h-index to quantify the scientific publication output and the impact of the work of researchers. It is a composite measure based on the combination of the number of papers published and the number of citations these papers have received according to records created for and reported by Web of Science (WoS) and Scopus.H-index reflects both the number of publications and the number of citations per publication, making it possible to have a ranking among countries in terms of scientific competitivness.

For comparability reasons, for each element of the indexes above, data was normalized (to the maximum value obtained), and the normalized values are taken into account in estimating the composite indicator.
Thus, for a country x, the CISCP is calculated as follows:

$$\mathbf{CISCP_x = 1/3*H_x + 1/3*F_x + 1/3*S_x}$$

4. Estimation of the index at Romanian level and comparison wth the other European Union states.

In order to understand Romania's position in terms of innovative/scientific potential, we calculated the indicators developed above for all 27 countries belonging to the European Union. Thus, for each of them H, F,I and S were calculated. Data was extracted from Eurostat website for the first two indicators and while Hirsch indicator was calculated by specialists based on ESI database (Csajbok &all, 2007). Each set of data was normalized from 0 to 1, with reference to the highest vale (assigned as upper limit 1). Starting from here values were then assigned to each country (between 0 and 1).
Thus, for HRST index, the highest value was found and calculated for Finland, where people with tertiary education in science and technology accounted for 41% of the total population. Romania here registered the last position, with a 16%, representing a HRST index of 0.4, almost half the EU average of 0.71. Data were available for 2009, excluding Luxembourg, for which the most recent data available are from 2008. A similar situation was noted for researchers, where Romania's position is also at the lower limit, accounting for 0.33% of total employment, compared to 2.14% in the case of Finland. The index has the value 0.15, while the European average reaches about 0.45. Data were extracted from the Eurostat website, mostly available for 2007, except for the Czech Republic, Estonia and Slovakia (2008), Italy (2006), Greece (2005) and Netherlands (2003). Given that there is a field of reduced fluctuation, which requires a relatively high degree of specialization, we took into account those older data, as well, where recent data was not available.
The financial capital invested (total spending for research and development as a percentage of GDP) is one area where our country is still at the bottom of the range, surpassing, this time with by very little (1%), Cyprus and Latvia. It registered a score of 0.12 compared to Finland, which leads the classification in this case, as well. European Union recorded an average index of 0.4. In this case, the most recent information has been provided by Austria and Finland (2010), and the oldest by Greece (2007), while the remaining information was available for 2009.
As far as the scientific performance is concerned, the highest h-index in EU countries was registered by the United Kingdom, helding a value of 426 and is followed by Germany and France (392 and 362). Romania's h-index amounts to 44, reaching the 20th position out of 27 countries. In terms of normalized values, 9 countries out of 27 register a higher value than 0.5 (with Romania's value reaching 0.1).
Taking into account all the elements we discussed above, a weight was assigned to each calculated index and thus estimated the composite index of scientific creativity potential for each country.Results can be observed in the following graph:

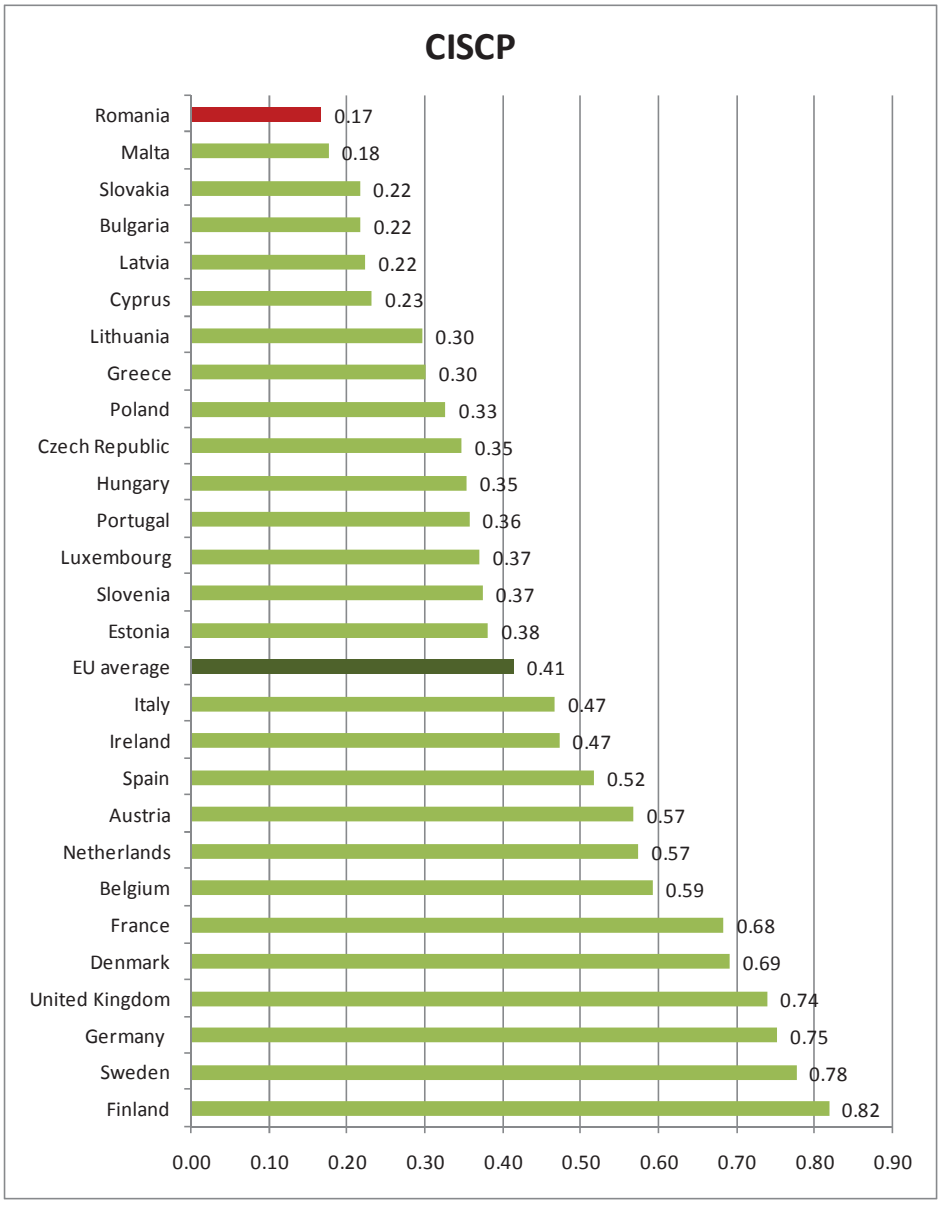

Fig.1. CISCP for EU countries

Source: Obtained by the authors

As a result of the above analysis we observed the fact that Romania occupies, in this case, the last place in the European countries with a score of 0.17. The maximum score, as expected, given the individual values obtained, is registered by Finland and has a value of 0.82. The European average is at the level of 0.41, more than twice the index of Romania.

Conclusions. Romania's scientific potential of is far below the EU average, in some cases even hovering in last place. Given that these resources should underpin a country's competitiveness, it is clear that measures will be needed in order to encourage the development of this potential. Along with greater emphasis on the financial terms for thise segment, the orientation towards research should be encouraged as well. At this time there is a vicious circle out of which exist is expected to be relatively difficult. Thus, the attractiveness of potential human resources field is reduced, particularly due to lack of funding and a certain level of performance. Romania is currently facing a potential crisis in research. One reason is the lack of attractiveness for younger generations, both because they no longer see a clear future in this direction, and the lack of a sufficiently advanced level of education. Another reason is the current conditions of the Romanian research, the criteria for measuring performance and remuneration are still ambiguous and poorly applied. This has encouraged and will continue to encourage the exodus of human resources to other countries. At the same time, a high performance level and funding attraction can be achieved only if there is human capital that can support development.

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