Correlations between Expenditure and Employees in R&D Activity by Performance Sectors from Romania

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ABSTRACT

In the context of increased competition in the recent years, the innovation has become a key factor in economic development through better use of opportunities, capturing new markets and creating high quality jobs. A crucial element for achieving innovation is the R & D, due to the stock of knowledge created at the human, cultural and societal level and its use in designing new applications.

In order to manage the funds better in R & D, stimulate competitiveness and attract new funds into R & D, given the target of Europe 2020 Agenda, the paper analyzes the correlation between expenditure and employees in R & D by performance sectors from Romania, and presents a mathematical model which might explain the dynamic of the structure of employees in business sector from R&D. It also considers the impact of the results on the capacity for innovation, economic development and future directions of action to increase investment in R & D, efficient use of intellectual capital and economic specialization.

Keywords*: innovation, R&D, expenditure, employment, investment*
JEL classification: *J21; J24*

CONTEXTUAL ISSUES REGARDING RESEARCH DEVELOPMENT AND INNOVATION

Smart growth, which is one of the three pillars of the Europe 2020 strategy, involves developing an economy based on growth and innovation by improving education, strengthening research performance, promoting innovation and knowledge transfer and full use of information and communication technologies. The role of research and innovation in increasing competitiveness and ensuring high quality jobs through the implementation of innovative ideas into new products and services has been widely developed in the specialty literature (Scherer, F., M., 1986, Grossman, GM and Helpman , E., 1991, et al).

According to the statistics in 2012, Romania ranks last in the European Union in terms of public and private investment in research and development, with a percentage of 0.48% of GDP compared to the EU average of 2.03% and the U.S. 2.75%. Moreover, the European Commission warned the Romanian authorities in the document on the country profile in 2013 that Romania must invest and make reforms in research and innovation, to achieve the target set for 2% of GDP by 2020. For Romania a major challenge is the low level of competitiveness, the Romanian economy is characterized by the predominance of technology-based sectors of medium and low level, with a low demand for knowledge and an underdeveloped innovation culture. The presence of R & D in enterprises is poor, Romania having one of the lowest levels of intensity of activity R & D in business from EU, with a value of 0.17% in 2011 (No. 25 of 27) and an annual average growth rate of -3.4% during 2000-2011. Moreover, no Romanian company is listed in the top 1000 EU companies investing in R&D. Global Competitiveness Report 2011 classifies the country as being focused on efficiency (with Bulgaria), while all other EU economies are either in transition to stage focusing on innovation, either already in this stage.

Given the above context, Romania ranks modest at Chapter innovation too, with the lowest intensity of knowledge in economy in the EU. This indicator measures structural change which focuses on modifications in the sectoral composition of the economy, showing the evolution of the share of sectors, products and services based on knowledge and as a value it reached at 28.35 in 2010, lower than the EU average, ie 48.75 . At European level there have been developed new relevant indicators that highlight important thematic elements in key technology sectors: automotive, ICT, new production technologies, nanotechnologies and safety, and contribution of technology high level (HT) and medium level (MT) on the trade balance. Thus the aggregate contribution of technology (HT + MT) on the trade balance of payments was in Romania to 0.38% in 2011, falling well below the EU average of 4.2%. Moreover,

the indicator on the economic impact of innovation was 0.384 in 2010-2011, which is below the EU average of 0.612.

In the context of the Europe 2020 strategy, in particular the initiative "Innovation Union" and the main implementation instrument - Horizon 2020 was developed National RDI Strategy 2014-2020 in Romania and the two instruments for its implementation, the National Plan for RDI 2014-2020 and the National Strategy for Competitiveness (CNS), which marks the beginning of a new cycle and that has set the following general objectives: increasing the competitiveness of the Romanian economy through innovation, growth Romanian contribution to the advancement of knowledge frontier and increasing the role of science in society. One of the cross objectives envisaged "*achieve by 2020 a critical mass of researchers needed a RDI conversion factor of economic growth".* Strategy targets were set in the spirit of the convergence of Romania to the EU average, based on the premise that by 2020, public spending on research will gradually increase to 1% of GDP, plus fiscal incentives for private firms. Thus, the number of researchers in the private sector full-time equivalent provides a significant increase from 3518 existing in 2011, at 7000 in 2017 and respectively 14500 in 2020, supported by an equally dramatic increase in R & D expenditures of Business sector from 0.17% of GDP in 2011 to 0.6% of GDP in 2017 and 1% of GDP in 2020. For the public sector is expected that the number of researchers (equivalent full time) increase slightly smoother compared to the private sector, from 1.409 in 2011, to 15000 in 2017 and respectively 17000 in 2020, supported by increased public spending on R&D (% of GDP) from 0.31 to 0.63 in 2017 and 1.0 in 2020. We mention that in the period 2005-2011 the total number of researchers in the R & D activity decreased with 30%, and the biggest drop on the sectors of performance was recorded in the business sector (66 %). In the National Reform Plan, is referred in the country-specific recommendation (RST 7) to *ensure the implementation of a closer association between research, innovation and enterprise, in particular by granting priority status of research and development that are likely to attract private investment.*

Given these goals we continue to highlight structural weaknesses in the allocation of labor performance R&D sectors, with special regard to the dynamics of private sector staff involved in R&D.

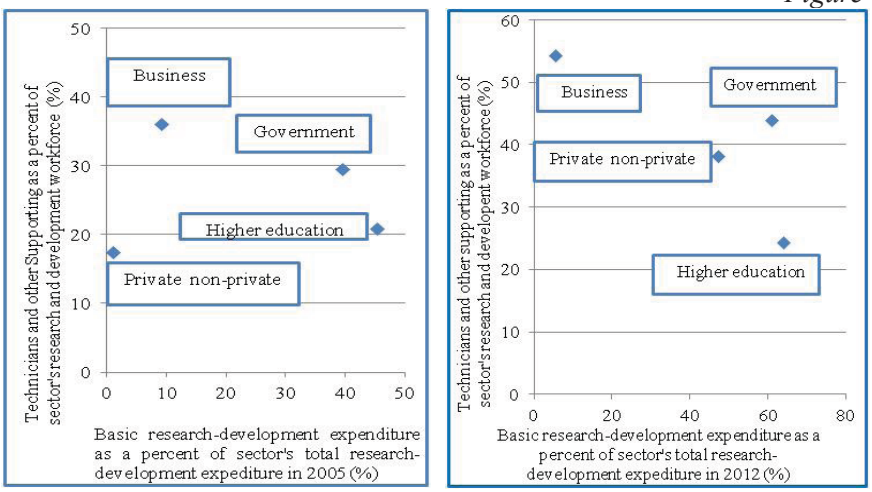
CORRELATIONS BETWEEN EXPENDITURES AND EMPLOYEES IN R & D ACTIVITY BY PERFORMANCE SECTORS

It will be noted that there is an inverse relationship between the research expenditure in research-development activity and the share of technicians and other similar categories of staff within this activity. In 2005,

the share of technicians, similar categories and other categories of employees in the EU, were approximately 44% in total employees of research and development activity and in Romania 30.9% being on a inferior level in EU. This allocation was based on operational needs of the productive units. These assumptions reflect, also, the economic specialization and the rationality of economic development. The business sector develops a more applied and experimental activity, meanwhile the public institutions and higher education sector develop more fundamental research activities. What is irrational in this context is the high level of technicians and other supporting allocated to the government sector, meanwhile this sector develop mainly the basic research where the need for administrative and technical support is not relevant. After 7 years, between 2005 and 2012, these correlations have changed: only 5.4% of expenditures were dedicated for basic research in business sector (an efficient process), a significant decrease comparative to 2005, but a rationale measure and appropriate one for this sector (fig.1).

Correlations between basic R&D expenditures ratio and technicians and others ratio in 2005 comparative to 2012

Figure 1



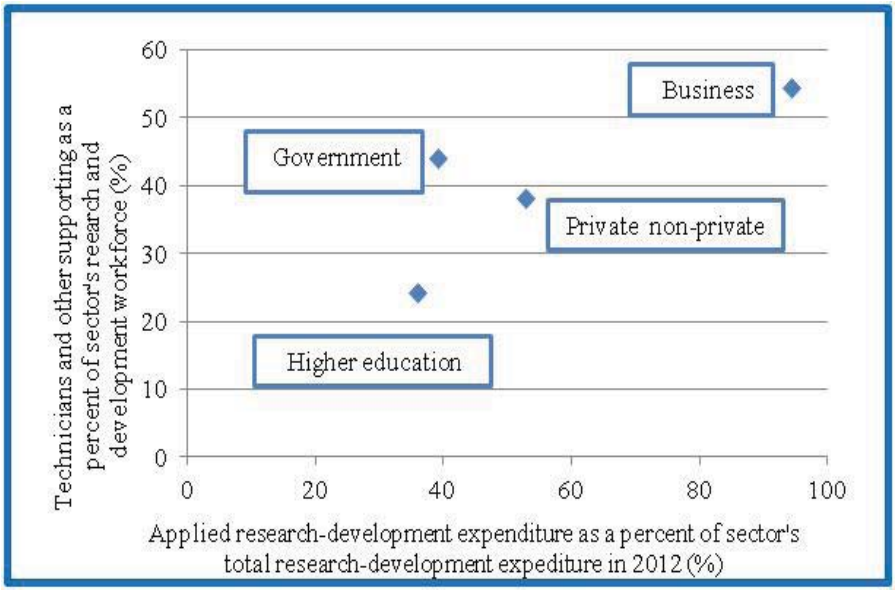
Source: NIS data processed by authors, National Institute of Statistics, Romanian Statistical Yearbook, 2006 and 2013

Within the higher education sector, basic research expenditure reached 64% of total research expenditures and technicians who are working in this sector reached a proportion of 24.3% from the total employees in research and development activity.

Within government sector, the number of technicians and other supporting staff increased from 29.6% (of total employees in this sector) in 2005 to 44% in 2012 and the basic research-development expenditure increased from 39.5% in 2005 to 61% in 2012. In private non-profit sector, the number of technicians and other supporting staff increased from 17.4% in 2005 to 38.2% in 2012 and the basic research-development expenditure increased, also, strongly from 1.1% in 2005 to 47.3% in 2012. If we analyse the correlations between applied research-development expenditures and the number of technicians and other supporting staff, we will highlight the rational way of development of business sector, demanding more technicians and other supporting (54.4%), spending more for applied research (94.4%) then other sectors. Higher education sector is spending less for applied research and is using fewer technicians, meanwhile an irrational way of development is showed by government sector who is spending for applied research less than half of total (39%) and is using a ratio of 44% technicians of total employees (fig. 2).

Correlations between applied R&D expenditures ratio and technicians and others ratio in 2012

Figure 2



Source: NIS data processed by authors, National Institute of Statistics, Romanian Statistical Yearbook 2006 and 2013; applied research expenditures refer to experimental and applicative research-development expenditures

We should, also, note as a deficiency the allocation of a high percentage of other supporting labor force (other than technicians) in sectors, such as government (26.6%), private non-profit (24.8%) and even business (32.9%).

A MATHEMATICAL MODEL THAT MIGHT EXPLAIN THE CHANGE IN STRUCTURE WITHIN THE R&D SECTORS

In order to try to explain the logic behind the employment structure within the R&D sectors, we will need to work in an environment where all factors are constant except for the labor; we are including here factors such as technological capital. Our primary task is to identify the skills required in order to be successful within such a department.

First of all, R&D is a very heterogeneous field and thus before starting any sort of analysis we have to confine the area of study. Moreover, it is natural to assume that researchers are the ones who have the abilities to be successful in R&D and thus we will focus our paper on them. Following up, whenever we will compare two researchers we will assume that they are pursuing the same idea, obviously in the same department.

We will now take a closer look at an actual process of R&D. Everything starts with an idea proposed by a researcher, a goal that is to be pursued. The second part consists of implementing the idea and pushing it as far as possible. In order to do that, the researcher acts as a manager and guides all three types of labor in the R&D, researchers, technicians and support personnel, towards the final product. For simplicity let's denote them respectively by A, B and C. By taking a similar approach as in the *The Lucas "Span of Control" Model* (Lucas, R., 1978), we will have:

$$E_i = p_i\left[R_i(A_i^{\alpha} + B_i^{\beta} + C_i^{\gamma})\right]^{\theta} \qquad (1)$$

Where E_i is the expected revenue, in terms of knowledge created, coming from researcher *i* by letting him guide A_i workers of type *A*, B_i workers of type *B* and C_i workers of type *C*. p_i represents the probability with which *i* will make the breakthrough while R_i is his *"ability"* to implement it. The other parameters, $\gamma < \beta < \alpha < 1$, suggest that as employment in the department gets larger, the marginal product of labor diminishes, as more workers are increasingly unwieldy to oversee. Moreover, the level of education of an employee is direct proportional with its returns and thus, being that A > B > C, education wise, we have the inequality $\gamma < \beta < \alpha$. Last, but not least, θ is a simple coefficient representing the technological capital already available for research.

Moving a step further, profit is the most powerful, and arguably, the only important galvanizing factor on the labor market. Thus we must take it as the prime characteristic. For that we are going to define $f(x) : (0, \infty) \rightarrow (0, \infty)$ as being the correspondence between the levels of knowledge and the actual revenue/benefits that can be obtained by the firm by exploiting it in the present conditions. *f* depends on the technological capital and other factors currently available to the company. Taking a mathematical look at the function, we can see that it is continuous but not necessarily differentiable, due to small discoveries that can end up with big profits. Moreover, it is obvious that it is increasing in x, x being the amount of knowledge. Therefore, the profits function for *i* can be written as:

$$\pi_i = \int_0^{E_i} f(x)dx - (w_A(A_i + 1) + w_B B_i + w_C C_i) \quad (2)$$

The parenthesis represents the labor costs of production, where w_A is the wage for labor of type *A*, w_B of type *B* and respectively w_C of type *C*.

Having established these notations and formulas, we are ready to tackle the evolution of the structure of labor within the R&D departments. There has been reported a decrease in the number of researchers in 2011 compared to 2005. The most abrupt change was recorded in the business sector and now, using our simple yet comprehensive model we will try to give an explanation to this phenomenon.

When talking about actors in the business sector, we are talking about firms whose only goal is to maximize profit. Thus, when comparing two researchers, the only thing they will take into account is *(2)*, the expected profit that they could bring to the company. Moreover, it is safe to assume that when hiring researcher *i,* or promoting him to the rank of project manager, he is given A_i, B_i and C_i people under his guidance in order to maximize profit. Thus, due to the unbalanced labor structure, it is highly likely that after employing *n* researchers and setting up their teams, we would end up with only workers of type *A*. In this case, setting up an extra team would imply the following profit:

$$\pi_{n+1} = \int_0^{E_{n+1}} f(x)dx - (w_A(A_{n+1} + 1)) \quad (3)$$

$$E_{n+1} = p_{n+1}[R_{n+1}(A_{n+1}^{\alpha})]^{\theta} \quad (4)$$

Having in mind the diminishing returns and the fact that *A* are the researchers who could be guiding their own teams instead of working in teams where they are not necessarily working at their full potential, we can conclude that this is not the optimal case. As a result, the employer might want to hire

more workers of type *B* and *C* and less of type *A* in order to maximize profit, in the short run due to present limitations of the technological capital.

Coming back to the statistics in the private sector, the fall in the number of researchers should not be seen as an act of neglecting the R&D departments, but more of a step towards efficiency in the short term, towards maximizing the profit. Being that there are a lot of abstract parameters characteristic to every firm, we cannot affirm whether this is the ideal structure, but just try to provide a justification for the change. Moreover, by analyzing the statistics, we can see the same tendency in the governmental sector, but not as steep. The reason for this is that the governmental faces little to no competition and thus profit is not a factor as powerful as it is in the private sector. The non-profit sector if pretty much inexistent in Romania having a total of 192 employees of all kinds so we cannot talk of any structure.

Society-wise, it would be beneficial if the employers would look at the total knowledge that can be created by two researchers *(1)* with the available resources and not the profit they can bring since not every profitable idea requires vast amounts of knowledge. This paradox is easily solved by looking at the *f* function that differs from firm to firm. Although vaguely defined, it has certain characteristics, as stated before. The crucial argument is that *f* is increasing in the amount of knowledge but it is not directly proportional to it. Thus, *f* aims to emphasize the heterogeneity of technological capital, and other factors, available throughout the R&D departments. In other words, although some discoveries might be made, due to the lack of conditions, they cannot be applied and thus are not bringing profit to the employer in the near future, which in the business sector, is all that matters.

Taking a closer look at θ, which is the technological capital already available for research, we can observe striking differences between countries. Let's denote by θ_R the level of technological capital in Romania and by at θ_G the respective level in a technological edge country such as Germany. It is safe to assume that $\theta_R \leq \theta_G$, not strict being that some sectors might have certain connections that permit them to freely share knowledge and technology. *(1)* clearly suggests that a higher at θ enhances the creation of knowledge, but what is still to be analyzed is *(2)* and more exactly the f function. Our claim is that $f_R(x) \leq f_G(x),\ \forall\, x \in (0,\infty)$. In other words, given the same amount of knowledge to Germany and Romania, Germany will exploit the information at least as much as Romania, being that is has superior technology.

One further claim is that $f(x) \leq f(M) + \varepsilon, \varepsilon > 0,\ \varepsilon \ll 1, \forall x \in (0,\infty),\ x \geq M$ where *M* is fixed constant depending on θ and other factors such as total capital. The idea behind this relation is that given a fixed amount of capital, regardless how much knowledge you have, you cannot exploit the knowledge entirely,

or the returns are extremely small. A simple example could be the discovery of gold on the bottom of the ocean after years of research and analysis. On the other hand, researchers have yet to discover ways to extract the gold. An analogy can be drawn between this case and Romania's R&D sectors. Therefore it is obvious, that an employer is not interested in the amount of knowledge created but more in the amount of knowledge that he can exploit to its full potential (in the near future), maximizing his profit.

Pushing it even further, by denoting M_G and M_R the limits for Germany and Romania, respectively, we can write that $M_G \geq M_R$. This implies that an extra piece of knowledge $\delta > 0$ such that $M_G > M_R + \delta > M_R$, may have little to no returns for Romania due to technological (and other) limitations but have great returns for Germany who are capable of fully exploiting the knowledge.

One small, yet significant change might be establishing a rigorous management of the pool of knowledge and property rights in the innovation sector. Thus by giving the creator or the company itself property rights we would *"artificially"* inflate the values of *f*, $f(x) \leq f'(x)\ \forall\, x \in (0, \infty)$ where *f'* is the newly *f* function which takes into consideration the returns in the long run of the newly created knowledge. This would not only stimulate the firms to produce more pure knowledge but also encourage the labor to push itself, knowing that their results will be patented. Although encouraging, (Stiglitz, J., 2014) such a system is very fragile and needs to be tackled in a critical yet mindful way, being that it may discourage companies in the private sector to invest in innovation.

CONCLUSIONS

The role of research and innovation in increasing the competitiveness is considered essential to ensure a smart specialization of the economy and represents a strategic objective for 2020. Due to a poor level of intensity of the R&D activity in business (one of the lowest from EU) and of the reduced technology transfer, the Romanian economy has a low competitiveness based on efficiency and not on innovativeness as in the other EU countries.

The R&D sector is characterized by structural weaknesses which reduce the efficiency and capacity for innovation in the economy. Thus, by examining correlations between R&D expenditures and number of employees in the R&D sector by performance sectors, between 2005 and 2012, we can conclude: the number of employees, technicians and other support staff in public sector grew (knowing that the sector develops fundamental R&D activities where there is no need for a large number of technicians and

administrative staff); basic research has increased the volume of expenditure; basic research expenditure in the private sector has been reduced; applied research and development costs have increased together with the number of technicians and administrative staff in R&D activities of the business sector.

We are dealing with a sector which develops in divergent directions, with rational and irrational evolutions from an economic point of view, which means that the R&D is restructuring and is in a continuous redefinition. Significant efforts are necessary to achieve a critical mass of researchers by 2020, required for converting the R&D in a factor of economic growth.

To conclude, these differences and limitations are challenges that the R&D sectors in Romania must face, especially the private sectors whose only concerns are surviving and increasing their profit on the labor market. Although changes and discoveries are being made, due to the unbalance between capital, knowledge and labor structure, Romania is having trouble in keeping up with the more advanced countries, slowly but surely falling behind its partners.

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