

## **HOW THE INVESTMENT IN R&D IS RELATED TO THE HUMAN CAPITAL ACCUMULATION? THE CASE OF ROMANIA**

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*ABSTRACT: The paper tries to clarify the link between the investment in R&D and the accumulation of human capital. In the paper is analyzed the investment in R&D at the EU level, underlying the case of Romania and the link between this type of investment and the human capital accumulation. At the EU level, the R&D investment is differently influenced by the human capital accumulation: the educational level of the population and doctorate students in science and technology are influencing the employment in knowledge-intensive sectors and doctorate students in science and technology are influencing the R&D personnel. In Romania, human capital accumulation can stimulate both, inputs and outputs of the R&D investment. The quality of the human capital is important: only the tertiary educated people and graduates in science and technology can influence the R&D investment.*

*Key words: R&D investment, human capital accumulation, knowledge-based society, knowledge workers*

*JEL Codes O30, O33, J24*

### **Introduction**

In the long term, growth depends on building and maintaining an environment that is conducive to innovation and the application of new technologies. This involves ensuring the generation of new knowledge, making public investment in innovation more effective, improving interaction between universities, research institutes and firms, and establishing the right incentives for innovation.(OECD, 2001).

Investing in human capital is good for growth, especially in the context of rapid technological change: for ICT to be used effectively and the benefits of new technology to materialise, the right skills and competencies must be in place. The demand for “knowledge-intensive” employment has risen considerably while skilled-labour shortages have emerged. (OECD, 2001).

The investments in R&D and in human capital are linked and are, both, determinants of the knowledge-based economy.

The paper intends to clarify how the R&D investment can be stimulate by the human capital accumulation and if there are any evidences regarding the possible level of an inverse stimulation.

Romania, as other eastern and central European countries moved from a factor – driven economy to a an efficiency-driven growth. These countries are faced with the task of mobilising and deploying the remaining resources they have. The task is, how to evolve from boasting merely efficiency-driven growth towards being genuinely innovation and knowledge-driven economies (The Lisbon Council, 2008).

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## Literature review

Governments today are faced with a new economic environment. ICT has emerged as a key technology with the potential to transform economic and social activity and has led to more rapid growth in countries where the conditions for macroeconomic stability are in place (OECD, 2001).

The economic growth is not the result of a single policy or institutional arrangement, but a comprehensive and co-ordinated set of actions to create the right conditions for future change and innovation. This depends more than ever on improving the quality of human capital and responding to the changing demands of the workplace (OECD, 2001).

A factor of R&D investment that is widely considered in the literature, both at the macro and at the micro level is human capital. From a theoretical point of view, the argument is that skilled (*i.e.* educated) workers are more capable of learning how to use new technologies and that they are more flexible with respect to their job assignment. Because the adoption of ICT often requires a reorganization of the firm, a firm with a high percentage of skilled workers can implement more easily information technologies ( Guerrieri et al., 2008). In the macro literature, authors who analyzed OECD countries found a significant influence of the level of human capital on ICT adoption (Hargittai 1999; Gust and Marquez 2004). Studies at the micro level, instead, found a positive relationship between the general level of employee qualification and ICT use (Bayo-Moriones and Lera-Lopez 2007; Haller and Traistaru-Siedschlag 2007).

## Research design and methodology

In the paper is analyzed the R&D investments at the EU level in terms of inputs and outputs. The evolution of the following statistical indicators is analyzed: R&D expenditure (% of GDP and in Euro/inhabitant), human resources in science and technology (HRST)(% of the labour force), GDP per capita, number of patents per million inhabitants, employment in knowledge-intensive services sector. In order to investigate the link between these indicators and human capital accumulation, the following indicators were studied: persons aged 20-24 having completed at least upper secondary education, science and technology graduates(per 1000 of population aged 20-29), doctorate students in science and technology (% population aged 20-29).

The source of data is EUROSTAT, 2011.

In the first part of the paper, I investigated the evolution of the inputs and outputs of R&D investment. In the second part, I calculated the correlation coefficients between the statistical indicators of R&D investment and those of the human capital accumulation, at the EU level and for case of Romania.

## Results and discussion

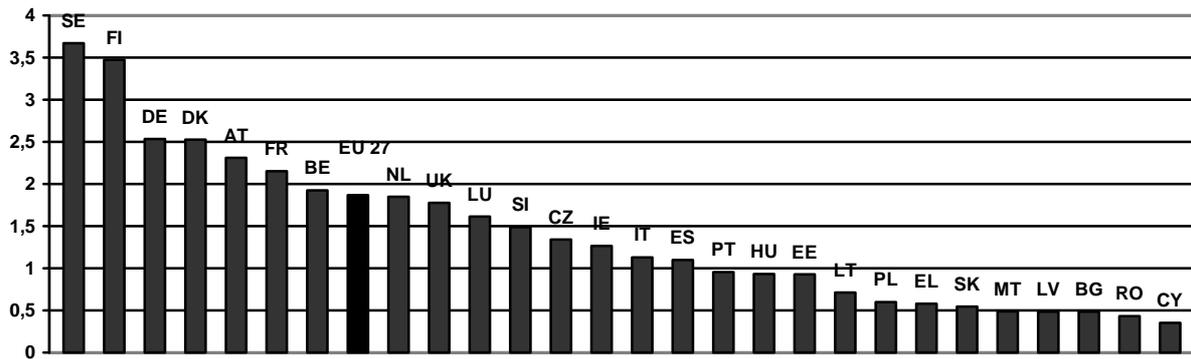
### 1. Inputs of R&D investment

#### *R&D expenditure in the EU Member States*

In 2009, R&D intensity (*i.e.* R&D expenditure as a percentage of GDP) in the EU-27 stood at 2,01 %, from 1.90 % in 2008 and 1.85 % in 2007, but still below the 3 % target set for 2010 by the Lisbon strategy. The 3 % target is for the next ten years as one of the five key targets of the Europe 2020 strategy.

R&D intensity in the EU was well below Japan (2007: 3.44 %), South Korea (2007: 3.21 %) and the United States (2008: 2.76 %), but slightly higher than China (2007: 1.44 %).

R&D expenditure in the EU-27 increased by an average of 3.3 % a year between 2003 and 2008, reaching EUR 237 billion in 2008. Germany, France, Italy and the United Kingdom together accounted for more than half of the EU-27 total.



Source: EUROSTAT (table tsc00001)

**Fig. no. 1.- R&D expenditure in the EU Member States (as a percentage of GDP, average of 1999-2009)**

Only 7 states are above the average of EU R&D expenditure (Belgium, France, Austria, Denmark, Germany, Finland and Sweden, but only 2 of them (Sweden and Finland) are above the EU target of 3%. As average, Romania is under the level of 0,5% of GDP and very far from the average of the EU and of the EU target. During 1999-2009 Romania was maintaining the level of R&D investment in a range from 0,37 % (2000) to 0,58 % (2008). The main explanation consists in the failure of the specific public policy to stimulate the R&D investment.

In Romania, in 2008, were invested only 809 millions Euro in R&D activities, comparatively with Germany (65.622 millions Euro) and UK (34.144 millions Euro). The sources of the R&D funds are: business enterprise sector, government sector, higher education and nonprofit sector.

Table no. 1

**Sources of R&D funds in the European Union and Romania, 2008**

2008	All sectors	Business enterprise sector	Government sector	Higher education	Private non-profit sector
EU-27	100%	63,9	12,66	22,44	1
RO	100%	29,91	41,04	28,92	0,13
gap	%	-33,99	+28,38	+6,48	-0,87

Source: EUROSTAT ( table rd\_e\_gerdtot)

In Romania, the part financed by the government is higher than the average at the EU level and the source of business sector is underestimated. The Romanian universities are contributing to the financial sources of R&D with 41,04 % and the share of the private sector is very small.

As we can see in the Figure 2, the R&D intensity in old Member States as Finland, Denmark, Sweden, Austria and Germany is up to 53 times higher then in Romania and Bulgaria and up to 2 times in countries as France, Netherlands, Belgium and Ireland. On the top is situated Luxembourg with a annual expenditure per inhabitant of 1295 Euro in 2009.

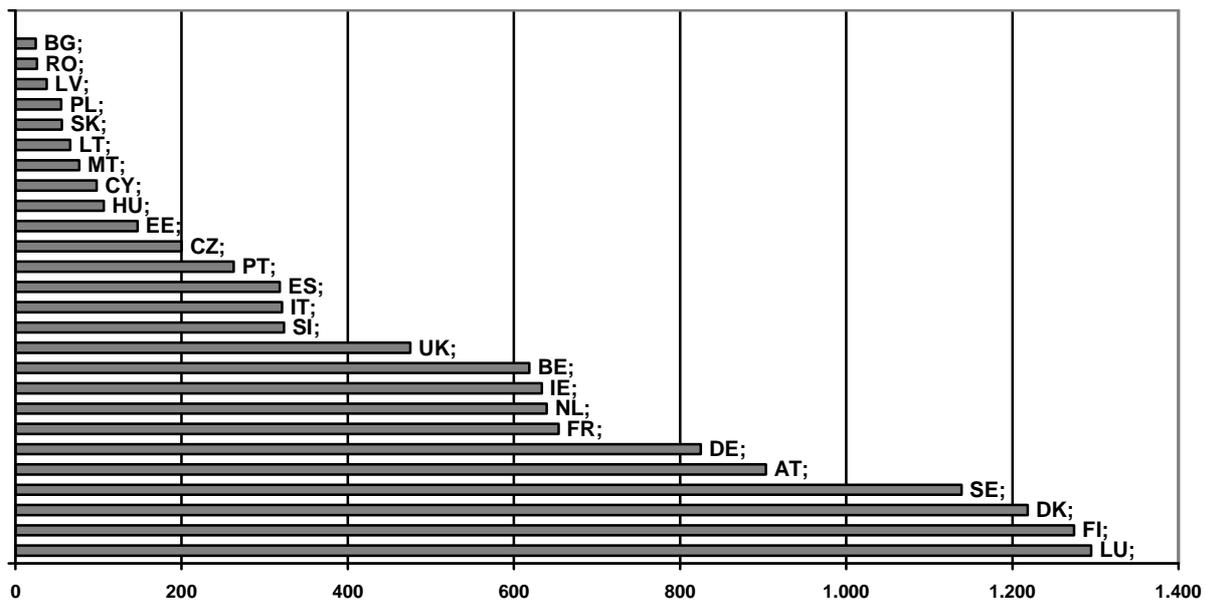


Fig. no. 2 - R&D intensity in Member States, 2009(R&D expenditure in Euro/inhabitant)

Source: EUROSTAT (table rd\_e\_gerdtot)

#### *Human resources in science and technology*

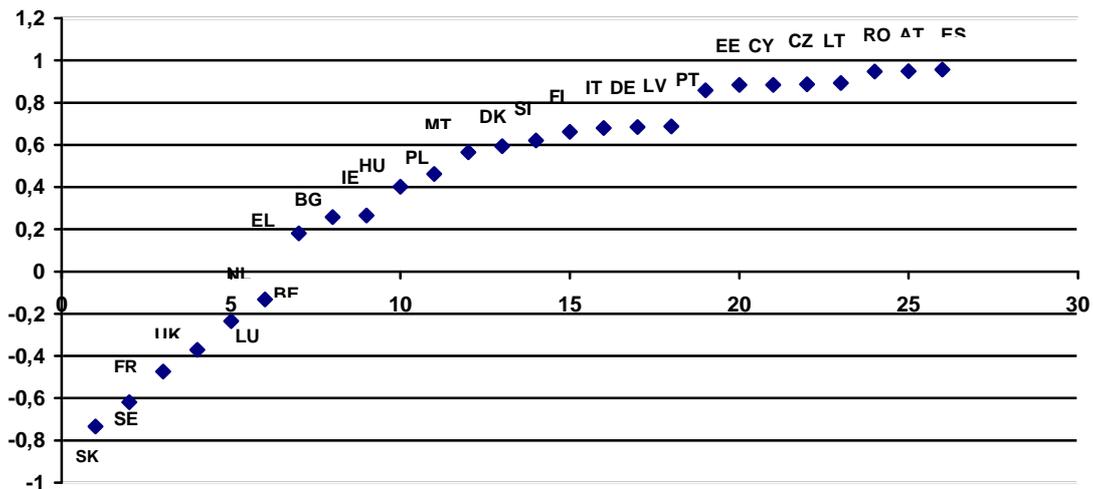
Another input of the R&D investment is represented by human resources in science and technology HRST). According to EUROSTAT, in 2010, Denmark and Netherlands had the largest proportion of the population aged 24-65( 51,9%) devoted to science and technology activities. In the EU, the HRST population increased by at an average rate of 2,8% per year between 2004 and 2008. The most accelerated growth during 2000-2010 was registered in Luxembourg(1:1,48),Poland (1:1,44), Ireland(1:1,41) and a low dynamic was registered in Finland(1:1,054), Bulgaria(1:1,06).

## **2. Outputs of the R&D investment**

### *GDP per capita*

In the period of 1995-2010, the average growth rate at the EU level was 1,53%. Beyond this level, in countries as Estonia (5,51%), Latvia (5,04%) and Poland (4,42%) the rate of GDP per capita was almost 4 times higher. The growth rate was higher also in Bulgaria, Romania, Ireland, Hungary and Finland, Belgium and Luxembourg. In 2009, the growth rate was negative in all countries due to the impact of the global crisis on the European economies.

Investigating the statistical data for the Member States in the period of 2000 to 2009, I found a strong correlation of 0,69 between GDP per capita and R&D investment across the European countries.



Source: EUROSTAT (table nama\_aux\_gph, tsc 00001)

**Fig.no. 3 - Correlation coefficient between R&D expenditure and GDP per capita, 2000-2009**

In the Annex 1 is calculated the correlation coefficient between R&D expenditure and GDP per capita across the European countries. As is shown in the figure 3 we can identify four groups of countries: group 1 with a negative correlation, group 2 with a coefficient between 0 and 0,5, group 3 with a coefficient between 0,51 and 0,8 and group 4 with the coefficient between 0,81 and 0,95. The countries in the first group are old Members States with high levels of R&D investment and of GDP per capita. An explanation of the inverse correlation could be the fact that other factors are contributing to the economic output. The second group includes 3 eastern European countries (Bulgaria, Hungary and Poland), Ireland and Greece where R&D investment is positive correlated to the economic output. With an output of 17.910 Euro per inhabitant ( as average in 2001-2010) and with an investment of only 0,57% of GDP in R&D, in Greece, for example, only 3,25% of the GDP per capita variation can be explained by R&D investment. For Hungary and Poland the correlation is positive and very close to 0,5. In the third group, in countries as Malta, Finland, Denmark and Germany the variation of GDP per capita is explained in proportion of 31-47% by the R&D investment. The fourth group is the largest, consisting, in a half, in eastern European countries and new Member States as Estonia, Lithuania Romania and Czech Republic. Portugal, Cyprus, Austria and Spain are in the same group. The evolution of GDP per capita is strongly related to the R&D investment.

#### Patents

Regarding the number of European patents applications, according to EUROSTAT, during 1997-2008, in Germany, the level of this indicator was of 3645 times higher than in Malta and of 2,8 times higher than in France. In terms of patent applications per million inhabitant, in 2008, Sweden was in the lead (319), closely followed by Germany (299) and Finland (250). At EU level, the number of patent applications to the European Patents Office (EPO) increased by an average of 2.7 % a year between 1997 and 2008. Over the same period, patenting activity rose in every EU Member State except in the United Kingdom.(EUROSTAT 2011: table pat\_ep\_ntot). In 2010, according to EPO statistics, the number of patents applications submitted to EPO from Germany was 33139 and from France, 11692.

#### Employment in knowledge-intensive services sectors

During 1999-2009 the employment in knowledge-intensive services sector, as share of the total employment, in the Member States raised in all countries, the EU average level of this statistical indicator, in 2007, being of 32,96%. Beyond this level, countries as Denmark,

Luxembourg, Netherlands, Sweden and United Kingdom registered values higher with 10 percentage points. Sweden is the best situated with 47,83% employment in intensive sectors. Under the average level are all central and eastern European countries. Romania is on the last place, with a share of employment in knowledge-intensive sector of 14,4% from the total employment. The EU countries are split into 3 groups: western countries above the EU average, countries with a share of 0,99-0,85 in the EU average and countries with a share of 0,85-0,5 in the EU average (Annex 2). The countries from the third group didn't have design or implemented the appropriate public policies to develop the sector of knowledge-intensive services and to stimulate the employment in this field.

### 3.The link between human capital and R&D investment

In the tables below are calculated the correlation between statistical indicators of inputs and outputs of the R&D investment on one side and the indicators of human capital accumulation at the EU level (all Member States) and in Romania.

Table no. 2

#### Correlation coefficients between R&D investment and human capital at the EU level, 1998-2008 (averages)

Indicator	Type of indicator (input/output for R&D investment)	Employment in knowledge-intensive services sector	Number of patents per million inhabitants	R&D personnel	Human resources in Science and Technology	Persons aged 20-24 having completed at least upper secondary education	Science and technology graduates	Doctorate students in science and technology
		R&D investment			Human capital investment			
Employment in knowledge-intensive services sector	Output	-	0,30	0,18	0,35	0,79	0,46	0,49
Number of patents per million inhabitants	Output		-	0,86	0,73	0,03	0,2	0,41
R&D personnel	Input			-	0,71	0,03	0,27	0,45
Human resources in science and technology	Input				-	0,25	0,26	0,23

At the EU level, between 1998-2008, the employment in knowledge-intensive services is strongly correlated with the educational level of the population (0,79) and at an average level correlated with the doctorate students in science and technology(0,49).

The number of patents per millions is positively and strongly related with the human resources in science and technology (0,86) and a correlation of 0,41 is found with the doctorate students in science and technology.

A similar situation is registered regarding the R&D personnel that is strongly correlated with human resources in science and technology (0,71) and balanced correlation with the doctorate student in science and technology.

Very weak correlations are identified between human resources in science and technology, as input of the R&D investment, and the educational level of the population, the science and technology graduates and doctorate students in science and technology.

The explanation of a low level of correlation between R&D investment and doctorate students in science and technology is the poor data (only for the last 4-5 years EUROSTAT data are available).

As a conclusion, at EU level, as average, the R&D investment is differently influenced by the human capital accumulation: the educational level of the population and doctorate students in science and technology are influencing the employment in knowledge-intensive sectors (an output of the R&D investment); doctorate students in science and technology are influencing the R&D personnel (an input of the R&D investment).

Table no. 3

**Correlation coefficients between R&D investment and human capital in Romania, 1998-2008**

Indicator	Type of indicator (input/output for R&D investment)	Employment in knowledge-intensive services sector	Number of patents per million inhabitants	R&D personnel	Human resources in Science and Technology	Persons aged 20-24 having completed at least upper secondary education	Science and technology graduates	Doctorate students in science and technology
		R&D investment				Human capital investment		
Employment in knowledge-intensive services sector	Output	-	0,89	-0,2	0,88	0,02	0,90	-0,80
Number of patents per million inhabitants	Output		-	-0,34	0,90	0,07	0,93	0,35
R&D personnel	Input			-	-0,5	-0,25	-0,35	-0,16
Human resources in science and technology	Input				-	-0,14	0,9	0,21

Source: own calculation based on EUROSTAT, 2011 (tables: tsc 00012, tsc 00002, tsc 00015, tsc 00028, pat\_ep.ntot, tsiir 110, tsiir 050)

In Romania, the employment in knowledge-intensive sector is strongly related to human science and technology graduates (0,90) and is evolving in the same direction with human resources in science and technology and with the number of patents per million inhabitants.

The number of patents per million inhabitants is positively and strongly correlated to the human resources in science and technology and to the science and technology graduates.

Unfortunately, due to the insufficient data regarding doctorate students in science and technology of EUROSTAT, the influence of this human capital indicator in the R&D investment could not be estimated.

Between R&D personnel and human capital indicators no correlation is found.

Human resources in science and technology are strongly correlated (0,9) with science and technology graduates.

In conclusion, in Romania, the human capital accumulation, reflected in the number of science and technology graduates has a strong influence on the outputs of the R&D investment

(employment in knowledge-intensive sectors and the number of patents per million inhabitants) and on the input of this investment (human resources in science and technology).

### **Conclusions**

According to the main findings above, Romania has to design a R&D policy focused on raising the share of the business sector, higher education and the private sector as financing sources of R&D activities by incentive policy measures tailored to the needs for development of these sectors.

Human capital accumulation can stimulate both, inputs and outputs of the R&D investment. In detail, the quality of the human capital is important, because only the tertiary educated people and graduates in science and technology can influence the R&D investment. The number of graduates in science and technology influence one of the inputs of R&D investment and the outputs of this investment (employment in R&D and number of patents per million inhabitants).

If the human capital accumulation stimulates the R&D investment, a question is raised: the latter will increase the demand for new skills and capabilities of the workforce? The answer is yes, due to the statistical evidences related to the increasing number of knowledge workers (R&D personnel and Human resources in science and technology) and their concentration in knowledge-intensive service sectors (high technology services) in all European countries. In this view, R&D investment is leading to an accumulation of high quality human capital. Further directions of research are needed in order to investigate this stimulation of human capital by the R&D investment.

Romania, as other eastern European countries, is faced with the hard task of mobilising its human capital and resources to evolve towards to the knowledge-based economy. Furthermore, Romania has to use all resources to exit from the economic recession.

According to these requirements, appropriate R&D policy measures have to be taken for a notable contribution of R&D activities to the Europe 2020 targets, as well.

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12. [www.epo.org](http://www.epo.org)

### Annex 1 Correlation coefficients between R&D expenditures and GDP per capita

Country	Correlation coefficient between R&D expenditure and GDP per capita 2000-2009	Determination coefficient	Group
SK	-0,867673604		I
SE	-0,733965576		
FR	-0,618416455		
UK	-0,474075487		
LU	-0,370929929		
BE	-0,234969145		
NL	-0,132110144		
EL	0,180341085	0,032522907	II
BG	0,258725308	0,066938785	
IE	0,265944953	0,070726718	
HU	0,402395268	0,161921952	
PL	0,462095435	0,213532191	
MT	0,565644879	0,319954129	
DK	0,594120637	0,352979331	III
SI	0,621271626	0,385978434	
FI	0,661777259	0,437949141	
IT	0,679491667	0,461708926	
DE	0,684713705	0,468832858	
LV	0,68724843	0,472310405	
PT	0,857917598	0,736022605	IV
EE	0,883647826	0,780833481	
CY	0,884716477	0,782723245	
CZ	0,886284463	0,785500149	
LT	0,892696947	0,796907839	
RO	0,947525293	0,89780412	
AT	0,948728715	0,90086174	
ES	0,957232473	0,916294008	
General	0,691924		

**Annex 2 EU countries ranked by employment in intensive-knowledge service sectors, 2007**

Country	Employment in intensive-knowledge service sectors(% of total employment), 2007	Group (by the range of the share in the EU average)
Sweden	47,83	
Denmark	43,51	
Luxembourg	43,02	
United Kingdom	42,85	
Netherlands	42,71	I
Finland	40,73	Above the EU average
Belgium	38,24	
France	36,89	
Ireland	35,48	
Germany	34,79	
<b>EU-27 average</b>	<b>32,96</b>	
Malta	32,82	
Italy	30,67	
Austria	30,0	II
Cyprus	29,2	0,99-0,85
Hungary	28,2	
Spain	28,19	
Estonia	27,84	
Slovenia	26,27	
Lithuania	25,97	
Czech Republic	25,66	
Greece	25,07	III
Poland	24,81	0,85-0,5
Slovakia	24,74	
Latvia	24,72	
Portugal	23,51	
Bulgaria	21,66	
Romania	14,4	