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## Conference Paper

# The role of the research and development and the number of patents, in the increase of GDP performance in the European Union for the period 2005-2014

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## THE ROLE OF THE RESEARCH AND DEVELOPMENT AND THE NUMBER OF PATENTS, IN THE INCREASE OF GDP PERFORMANCE IN THE EUROPEAN UNION FOR THE PERIOD 2005-2014

RALUCA NECULA<sup>1</sup>, MIRELA STOIAN<sup>2</sup>, MANEA DRĂGHICI<sup>3</sup>, DIANA NECULA<sup>4</sup>

**Summary.** *Over time, the research has played a key role in the economic development reflected by the GDP growth, the increase of the patents' number, the volume of exports, the economic competitiveness of countries which have invested in research and development.*

*The aim of this paper is to make a study at the level of the European Union's countries of the way that the size of the expenditures with the Research and Development and the number of patents reported at 1 million inhabitants, influences the Gross Domestic Product.*

*In that respect, the research wants to verify the possibility of Romania to achieve the objective written in the Research, Development and Innovation Strategy 2014 to "reaching until year 2020 the critical mass of researchers needed to turn R&D a factor of economic growth through the provision of rapid and sustainable development, numerical and qualitative human resources in research, development and innovation" (R&D Strategy, 2014).*

**Keywords:** *Research & Development, GDP, Patents, European Union, Romania*

**JEL classification** – *O11, O39, Q16*

### INTRODUCTION

The paper is important because it tries to study the factors that contribute to the economic growth, at the macroeconomic level, by the expenditures with research and development, in terms of "among the European objectives for year 2020, is that research, development and innovation- a level of the public and private investments in research and development of 3% from the EU GDP" (Lisbon Strategy 2020).

In the recent economic literature many studies were developed regarding the factors that influence the GDP's growth, at the level of each country, on groups of countries, and at the level of the European Union.

The New Economy's dimension, expressed through the R&D expenditures variable (% from GDP), was used in the Goel & Ram studies (1994) and Pop Silaghi and others (2014).

The investments variable is found in the researches of Barro(2000) and Afonso & Furceri (2008), as share of investment in GDP and in the researches of Croix & Doepke (2003), Voitchovsky (2005) and Kneller (1999) as a rate of investments.

The impact of the expenditures for R&D on the GDP's growth, seem to be positive and high from the numerical point of view and stronger in the least developed countries group (Goel & Ram 1994).

After the study of Pop Silaghi, are the same: a growth of the R&D private expenditures intensity stimulates the economical growth on the short term (Pop Silaghi et al 2014).

According to Eftimoski (2006), "the economic growth depends on the scientific and technological knowledge and on the investments in the human capital" (Eftimoski 2006)

The GDP's evolution analysis, in time, per capita at the European Union's level in time shows that there are variations and very high differences between the countries, but that it exists a convergence tendency according to the rhythm of each country (Necula R. and others, 2016).

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The econometric results show that an increase of 1% of the R&D expenditures increases the GDP/capita with 0.08% (Pescu,2016), which complies with the paper of Pop Silaghi (2014).

## MATERIAL AND METHODS

The paper is structured: in the first part are analyzed the expenditures with the R&D (% from GDP), for the 28 European Union countries, for which are calculated: the average for the period 2005-2014, that is statistically compared with the EU 28's average; the annual growth rhythm of the expenditures and the ranking of countries by the R&D (% from GDP). In the second part the GDP is analyzed (Billion €) through: the average for the period 2005-2014, the annual growth rhythm and the countries ranking by the GDP's value (Billion €). It was analyzed the elasticity between the R&D increase (Billion €) and the GDP increase (Billion €). It was calculated the correlation between the GDP's increase and the R&D increase by: the correlation coefficient  $\rho$  and the elasticity, that were calculated through an exponential equation:  $Y_{GDP}(\text{mild } \text{€}) = X_{R\&D}(\text{mild } \text{€})^{\alpha}$  ( $\alpha$ = coefficient). In was made a countries ranking by the size of the elasticity ( $\delta Y/\delta X$ ). The last part presents the conclusions and some ideas for continuing these researches.

The state authority for the scientific research, technological development and innovation is represented by the National Education Ministry (NEM).

Through the National Strategy for Research, Development and Innovation, 2014-2020, Romania proposes itself that the R&D expenditures, that were in the year 2014 of 0.14% from GDP, to increase at 0.63% from GDP in the year 2017 and at 0.97 in the year 2020 (R&D Strategy,2014).

In the paper the following indicators have been used: arithmetic mean, coefficient of variation, annual growth rate.

The formulas used for to calculate these indicators, are:

For the arithmetic mean  $= \bar{x} = \frac{\sum xi}{n}$ , where  $\bar{x}$  = the arithmetical mean,  $xi$ = the average production values for a number of years (i);  $n$ = number of years taken into account

The annual average growth rhythm  $= r_{1990-1999}$  (and respectively  $r_{2005-2014}$ )  $= \sqrt[n]{\left(\frac{p_1}{p_0}\right) - 1}$ ; .

The means comparison with the research expenditures, was statistically made, in which the average of EU 28 was considered a witness ( $Cv^*$ =Control Value) for the different probability levels ( $P_{0.001}$ ;  $P_{0.01}$ ;  $P_{0.05}$ ).

The calculated equations were exponential ( $Y = A X^{\alpha}$ ) and the significance was made with the correlation coefficient.

## RESULTS AND DISCUSSION

Due to the problems that mankind is confronting: poverty, environment degradation, the job's occupancy uncertainty, the sustainable economic development represents that form of economic development that pursues that the current consumption request satisfaction not to compromise the ones of the future generations (Pânzaru S., 2008).

It were calculated the R&D expenditures means also for some countries like Turkey, Russia, US, China, Japan and South Korea, and were compared with the EU's mean.

From the EU 28's countries, a number of 8 countries have allotted for the R&D less than 1% from GDP (Bulgaria, Greece, Croatia, Cyprus, Malta, Poland, Romania, Slovakia), between 1% and 2% from GDP, a number of 10 countries (Belgium, Czech Republic, Estonia, Ireland, Spain, Italy, Luxemburg, Netherlands, Portugal, England), with a mean different from the EU mean(2\*), very significant negative. Over 2% from GDP are the rest of the countries, where Finland stands out with 3.5% of GDP and Sweden with 3.3% of GDP, of whose mean is very significant positive towards the mean of EU28. At this very high level are also Japan and South Korea.

Table 1. The Research and development expenditure (% of GDP), significance towards the EU 28 mean and the ranking of the expenditures and of the growth rhythm for the period 2005-2014.

Geo\time	Period 2005-2014							Ranking: expenditure RD(% GDP)	Annual growth rhythm (%)	RANKING: RHYTHM
	2005	2010	2013	2014	Mean	T calc.	Significance			
EU (28)	1.8	1.9	2.0	2.0	1.9	Cv*	x	x	x	x
Euro area (19)	1.8	2.0	2.1	2.1	2.0	1.0	N	x	1.60	x
Belgium	1.8	2.1	2.4	2.5	2.1	1.9	N	7	1.96	11
Bulgaria	0.4	0.6	0.6	0.8	0.5	-27.1	OOO	26	3.66	1
Czech Republic	1.2	1.3	1.9	2.0	1.5	-4.1	OOO	13	6.87	3
Denmark	2.4	2.9	3.1	3.1	2.8	9.7	***	3	6.14	16
Germany	2.4	2.7	2.8	2.9	2.7	11.9	***	4	2.70	19
Estonia	0.9	1.6	1.7	1.4	1.5	-2.8	OO	12	1.91	8
Ireland	1.2	1.6	1.5	1.5	1.4	-7.4	OOO	14	5.10	15
Greece	0.6	0.6	0.8	0.8	0.7	-27.3	OOO	22	2.76	10
Spain	1.1	1.4	1.3	1.2	1.3	-15.1	OOO	16	4.20	20
France	2.0	2.2	2.2	2.3	2.1	5.3	***	6	1.25	21
Croatia	0.9	0.7	0.8	0.8	0.8	-29.5	OOO	20	1.14	27
Italy	1.1	1.2	1.3	1.3	1.2	-16.4	OOO	17	-0.94	18
Cyprus	0.4	0.5	0.5	0.5	0.4	-41.3	OOO	28	2.31	14
Latvia	0.5	0.6	0.6	0.7	0.6	-31.0	OOO	25	2.93	13
Lithuania	0.8	0.8	1.0	1.0	0.9	-24.4	OOO	19	2.97	12
Luxembourg	1.6	1.5	1.3	1.3	1.5	-6.2	OOO	11	3.36	28
Hungary	0.9	1.2	1.4	1.4	1.1	-12.0	OOO	18	-2.55	9
Malta	0.5	0.6	0.8	0.8	0.7	-22.5	OOO	23	4.40	7
Netherlands	1.8	1.7	2.0	2.0	1.8	-2.0	N	9	5.11	22
Austria	2.4	2.7	3.0	3.0	2.7	9.4	***	5	1.07	17
Poland	0.6	0.7	0.9	0.9	0.7	-20.9	OOO	21	2.57	6
Portugal	0.8	1.5	1.3	1.3	1.3	-6.9	OOO	15	5.72	4
Romania	0.4	0.5	0.4	0.4	0.5	-37.4	OOO	27	6.05	26
Slovenia	1.4	2.1	2.6	2.4	2.0	0.5	N	8	-0.84	5
Slovakia	0.5	0.6	0.8	0.9	0.6	-20.1	OOO	24	6.04	2
Finland	3.3	3.7	3.3	3.2	3.5	21.7	***	1	6.62	24
Sweden	3.4	3.2	3.3	3.2	3.3	27.9	***	2	-0.55	25
United Kingdom	1.6	1.7	1.7	1.7	1.7	-6.5	OOO	10	-0.78	23
Turkey	0.6	0.8	1.0	1.0	0.8	-20.0	OOO	X	0.47	X
Russia	1.1	1.1	1.1	1.2	1.1	-20.1	OOO	X	5.56	X
United States	2.5	2.7	:	:	2.7	14.6	***	X	1.19	X
China (exp. Hong Kong)	1.3	1.8	2.1	:	1.7	-2.5	O	X	1.63	X
Japan	3.3	3.3	3.5	:	3.4	34.7	***	X	5.85	X
South Korea	2.63	3.47	4.15	:	3.4	8.1	***	X	0.59	X

WORLD BANK, 25.05.2016, <http://databank.worldbank.org/data/home.aspx>

Cv\*=Control Value; GL=18; P0.001:3.92; P0.01:2.78; P0.05: 2.10; < 2.10:N

Analyzing the growth rhythm of the R&D expenditures from the GDP, it is observed that the countries with very small percentages have a very high rhythm, and the ones with a very high percentage a very small rhythm.

Thus, Bulgaria, that has the smallest percent occupies the first place at the rhythm, meantime Finland, the first place at the rhythm size, occupies place 24.

The exception is Romania, that occupies the place 27 at the size of the percentage of R&D expenditures that justifies the affirmation "the investment in research and development not being considered a priority in Romania" (Delia, Teselios, 2015)

O solution to increase the expenditures with the R&D is "the private-public partnership that can be considered o innovation for the innovation (Stoian M., 2016)



The highest elasticity of R&D expenditures is in Sweden, country in which an increase with 1% of GDP trains an increase of GDP with 1.13%. The UK follows with 1.08%, Luxembourg with 0.98%, Latvia with 0.61%, France with 0.57%. The smallest values are registered in Ireland 0.0%, Portugal with 0.13%, Greece with 0.18%, Hungary with 0.20%. Romania has a high value of 0.59% and occupies the 9<sup>th</sup> place, among EU.

Table 4. The EU countries classification, after the number and the annual growth rhythm of the patents number at 1 million inhabitants, for the period 2003-2014

Geo(time)	MU	2003	2007	2010	2014	Mean	St. dev.	Coefficient of variation	Ranking : Patent applications	Annual growth rhythm	
						No. / 1 mil pers.	No. / 1 mil pers.			%	Ranking
EU (28 countries)	No. / 1 mil pers.	107.95	117.39	112.49	111.57	112.4	3.89	3.46	x	0.60	x
Belgium	No. / 1 mil pers.	131.7	147.74	139.21	137.30	139.0	6.65	4.78	8	1.10	22
Bulgaria	No. / 1 mil pers.	2.73	1.61	2.29	6.55	3.3	2.22	67.30	27	7.56	6
Czech Republic	No. / 1 mil pers.	10.88	18.39	18.41	25.30	18.2	5.89	32.29	16	8.28	5
Denmark	No. / 1 mil pers.	207.14	239.45	231.38	244.45	230.6	16.54	7.17	4	1.93	19
Germany	No. / 1 mil pers.	269.12	296.1	285.88	255.95	276.8	17.78	6.42	2	-0.65	26
Estonia	No. / 1 mil pers.	8.29	21.01	29.2	10.31	17.2	9.75	56.71	17	1.59	20
Ireland	No. / 1 mil pers.	57.41	75.66	69.49	64.61	66.8	7.72	11.55	12	2.47	17
Greece	No. / 1 mil pers.	7.79	9.4	5.89	10.62	8.4	2.05	24.31	21	2.87	15
Spain	No. / 1 mil pers.	23.02	30.95	32.44	32.51	29.7	4.53	15.24	14	4.19	11
France	No. / 1 mil pers.	128.64	135.79	131.03	138.37	133.5	4.42	3.31	9	1.24	21
Croatia	No. / 1 mil pers.	9.41	7.12	7.05	3.43	6.8	2.47	36.61	25	-8.89	28
Italy	No. / 1 mil pers.	76.95	84.54	75.92	69.54	76.7	6.15	8.01	11	-0.36	24
Cyprus	No. / 1 mil pers.	7.05	13.63	9.36	7.81	9.5	2.94	31.07	20	2.64	16
Latvia	No. / 1 mil pers.	3.09	7.09	7.44		5.9	2.42	41.15	26	24.61	1
Lithuania	No. / 1 mil pers.	4.91	3.02	5.06	16.61	7.4	6.21	83.91	23	10.17	4
Luxembourg	No. / 1 mil pers.	194.45	154.94	151.97	109.32	152.7	34.79	22.79	7	-3.33	27
Hungary	No. / 1 mil pers.	13.14	18.99	19.49	22.52	18.5	3.92	21.15	15	4.77	9
Malta	No. / 1 mil pers.	8.18	16.84	8.45		11.2	4.92	44.13	18	2.28	18
Netherlands	No. / 1 mil pers.	216.22	204.13	183.95	205.23	202.4	13.45	6.64	6	-0.12	23
Austria	No. / 1 mil pers.	171.77	207.34	211.25	230.18	205.1	24.38	11.88	5	3.16	14
Poland	No. / 1 mil pers.	2.87	5.3	9.48	15.99	8.4	5.74	68.28	22	16.85	3
Portugal	No. / 1 mil pers.	6.39	11.66	8.99	12.16	9.8	2.66	27.19	19	6.01	7
Romania	No. / 1 mil pers.	0.75	1.54	1.69	5.11	2.3	1.94	85.24	28	18.16	2
Slovenia	No. / 1 mil pers.	36.81	59.75	51.75	65.85	53.5	12.56	23.46	13	5.74	8
Slovakia	No. / 1 mil pers.	5.84	7.17	8.63		7.2	1.40	19.35	24	4.14	12
Finland	No. / 1 mil pers.	248.77	241.51	259.86	339.91	272.5	45.56	16.72	3	3.31	13
Sweden	No. / 1 mil pers.	230.01	311.54	300.59	349.36	297.9	49.83	16.73	1	4.59	10
United Kingdom	No. / 1 mil pers.	95.33	91.96	85.16	83.12	88.9	5.72	6.43	10	-0.53	25
United States	No. / 1 mil pers.	118.03	107.77	97.73	83.12	101.7	14.88	14.64	x	0.65	x
South Korea	No. / 1 mil pers.	70.07	96.65	108.21	83.12	89.5	16.53	18.46	x	17.18	x
Australia	No. / 1 mil pers.	54.86	45.04	37.09	83.12	55.0	20.09	36.50	x	5.25	x
New Zealand	No. / 1 mil pers.	54.51	40.44	36.56	83.12	53.7	21.10	39.32	x	-1.12	x

WORLDBANK, 25.05.2016, <http://databank.worldbank.org/data/home.aspx>

In the conditions when the current development forms, the workforce and nature, cannot create new development possibilities, without a reduction of cumulation, some assumptions include the ability of the capitalist economy to initiate a new golden age, based on technological innovations. In this respect the number of patents per 1 million / inhabitants is a primary indicator.

Ray Kurzweil, states that current technological achievements are part of a larger phenomenon, which occurs at an accelerated pace: integrate human intelligence with artificial (Ray Kurzweil, 2016).

In our country Alexandru Trifu believes that classical production factors can be replaced by ideas and knowledge, resulting in increased productivity ((Trifu, 2005).

Romania aims that revenues from licenses and patents from abroad that were 0,135 of GDP in 2011, to increase at 0.15% of GDP in 2017 and at 0.17% in 2020 (Strategy R&D, 2014).

Table 5. The correlation between the R&D expenditures and the number of patents, for the period 2005-2014

Countries	MU	Period 2005-2014			Y pat* = A X(CD) <sup>a</sup>					Elasticity( $\delta Y/\delta X$ )	
		2005	2010	2014	A	$\alpha$	R2	r	significance	%Pat/1% DC	Ranking
EU (28)	Billion € RD	216.85	246.94	283.38	106,246	-0.112	0.554	0.74	*	-0.112	x
Belgium	Billion € RD	5.91	7.48	9.86	1,483.10	0.009	0.003	0.06	N	0.009	18
Bulgaria	Billion € RD	0.12	0.22	0.34	112.05	0.963	0.476	0.69	*	0.954	3
Czech Republic	Billion € RD	1.52	2.10	3.09	0.28	1.985	0.657	0.81	**	1.955	17
Denmark	Billion € RD	5.41	7.10	7.95	641.51	0.365	0.423	0.65	*	0.362	7
Germany	Billion € RD	58.87	69.92	83.68	140,913	-0.428	0.876	0.94	***	-0.427	24
Estonia	Billion € RD	0.15	0.23	0.29	16.67	-0.333	0.093	0.30	N	-0.332	25
Ireland	Billion € RD	2.22	2.68	2.87	278.20	0.146	0.023	0.15	N	0.145	13
Greece	Billion € RD	1.22	1.36	1.49	4.92	89.320	0.001	0.04	N	0.092	19
Spain	Billion € RD	11.79	14.59	12.81	698.60	0.285	0.233	0.48	N	0.283	11
France	Billion € RD	37.99	43.57	48.19	3,581.30	0.237	0.640	0.80	**	0.236	12
Croatia	Billion € RD	0.30	0.33	0.34	19.09	-0.179	0.003	0.06	N	-0.178	23
Italy	Billion € RD	16.89	19.59	20.82	59,940	-0.870	0.906	0.95	***	-0.869	26
Cyprus	Billion € RD	0.06	0.09	0.08	0.65	-0.952	0.044	0.21	N	-0.952	27
Latvia	Billion € RD	0.11	0.11	...	211.62	1.081	0.188	0.43	N	1.070	6
Lithuania	Billion € RD	0.19	0.22	0.37	768.50	2.783	0.849	0.92	***	2.731	1
Luxembourg	Billion € RD	0.56	0.60	0.62	37.63	-1.359	0.095	0.31	N	-1.361	28
Hungary	Billion € RD	0.90	1.13	1.43	181.80	0.586	0.798	0.89	***	0.581	5
Malta	Billion € RD	0.03	0.04	0.07	0.01	-1.928	0.215	0.46	N	-1.937	20
Netherlands	Billion € RD	10.19	10.86	13.06	3,975.0	-0.064	0.016	0.12	N	-0.064	21
Austria	Billion € RD	6.32	8.07	9.85	939.30	0.308	0.622	0.79	**	0.306	8
Poland	Billion € RD	1.50	2.60	3.86	82.59	1.488	0.970	0.99	***	1.470	2
Portugal	Billion € RD	1.58	2.75	2.24	133.02	-0.212	0.118	0.34	N	-0.211	22
Romania	Billion € RD	0.44	0.57	0.57	64.43	0.666	0.040	0.20	N	0.660	9
Slovenia	Billion € RD	0.48	0.75	0.89	126.90	0.159	0.136	0.37	N	0.158	14
Slovakia	Billion € RD	0.22	0.42	0.67	54.72	0.284	0.330	0.57	N	0.282	10
Finland	Billion € RD	5.77	6.98	6.51	1,255.30	0.076	0.001	0.03	N	0.075	16
Sweden	Billion € RD	11.72	11.88	13.61	428.80	0.756	0.724	0.85	**	0.749	4
United Kingdom	Billion € RD	34.04	30.65	38.32	4141.00	0.078	0.054	0.23	N	0.078	15

Y = A X $\alpha$ ; GL=8; (0.001, 0.87, \*\*\*; 0.01, 0.76, \*\*; 0.05, 0.63\*; <0.63, N)

## CONCLUSIONS

In this paper it is highlighted the importance of the factors that contribute to the economic growth, among them being the results of the research and development, in special the increase of the expenditures allotted for research, development and innovation.

It is demonstrated that the higher the share of expenditures is from the GDP, the country is more developed.

It is also demonstrated that small countries are making big efforts, the correlation between the growth rhythm of expenditures and the growth rhythm of GDP standing up for this theory. The developed countries have instead at a small rhythm of the expenditures increase, maintaining the share from the GDP.

Romania is unfortunately an exception, occupying a 27 place and confirming that there are small investments in the research and development, also signaling an alarm, to increase the interest for investments in this field if a higher GDP is desired and a real economy development.

Regarding the revenues from licenses and patents in Romania, are at a small percentage, only of 0,135% of GDP in year 2011, with a target to increase at 0.15% of GDP in 2017 and at 0.17% in 2020 if we consult the National Strategy for Research, Development and Innovation.

As a final conclusion, it can be observed in the whole paper that the investments in Research and Development have a high importance in the economy growth, its share in GDP being high in the countries that are part from the developed countries.

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