10 COMPETITIVENESS OF EU MEMBER STATES IN ATTRACTING EU FUNDING FOR RESEARCH AND INNOVATION

Simona MOAGĂR-POLADIAN[1]
Victoria FOLEA[2]
Mihai PĂUNICĂ[3]

Abstract

This paper analyses the competitiveness of European Union (EU) Member States (MS) in terms of research and innovation from the perspective of attracting EU funding for research, as well as from the viewpoint of key science and innovation performance indicators over the 2007–2015 period. This period corresponds to the seventh EU framework programme for research and innovation (FP7, 2007–2013) and the beginning of the new EU programme for research and innovation, Horizon 2020 (2014–2020).

The paper also analyses the performance of EU Member States in attracting EU competitive funding for research and innovation and the creation of knowledge (i.e., excellence in S&T; innovation performance), considering these two dimensions essential for the catching up process and a durable competitive economy.

The research methodology developed and calculated performance indicators using data provided by official sources of the European Commission (EC). The analysis considered all EU Member States, with a special focus on four states from Central and Eastern Europe: Bulgaria, Hungary, Poland and Romania, i.e., two MS that joined the EU in 2004 (Hungary and Poland) and two MS that joined the EU in 2007 (Bulgaria and Romania).

Keywords: EU competitive funding for research and innovation; R&D intensity; relative comparative advantage in R&D; innovation

JEL Classification: O32

[1] Institute for World Economy, Romanian Academy. E-mail: smpoladian@gmail.com. Corresponding author.

[2] *Institute for World Economy, Romanian Academy, and the Romanian-American University, Romania. E-mail: victoria@folea.org*

[3] *The Bucharest University of Economic Studies, Department of Accounting and Audit, Romania. E-mail: mihai.paunica@cig.ase.ro*

I. Introduction

Recently, different speeds of progress in the European Union (EU) have called for essentially dissimilar ways for robust progress. The accession of the 11 former communist countries in the last three enlargement processes (2004, 2007 and 2013) shaped the largest European expansion from its entire 60 years of existence, which occurred for the Eastern part of Europe. At the same time, this significant enlargement process induced the largest extent of economic and social disparities in the EU. The persistence of the large gap between the old and the new European Union members can impact the entire EU assembly, with potential effects on the medium- and long-term regional stability.

In this context, the large gap of economic wealth, productivity, GDP structure, rural and urban population, typology of production and services, education degrees, education quality, GERD[4] proportion in business expenditure, GDP per capita, number of patents, , as well as the low levels of science development and innovation in the new MS signify growth paths that were assembled over decades. Additionally, the 2008 international financial crisis has brought austerity in the European countries, and the different economic growth models have put more emphasis on the discrepancy between North and South and between West and East in the EU.

At the time when part of the former communist countries from Central and Eastern Europe (CEE) joined the EU, Radosevic (Radosevic, 2004) considered that these countries have lower productivity levels than might be expected, given their level of research and innovation (R&D). Innovation and production competences create the multi-dimensional innovation capacity at both the national and European levels, with five dimensions: (1) knowledge creation, (2) absorptive capacity, (3) diffusion capacity, (4) demand, and (5) governance capacity (Emmanuel Muller, 2006).

This paper further analyses the competitiveness of the EU MS in terms of research and innovation (R&I), from the perspective of attracting EU funding for research within the Framework Programme 7 (FP7, 2007–2013) and beginning of Framework Programme Horizon 2020 (H2020, 2014–2020), as well as from the viewpoint of key science and innovation performance indicators. The research in this paper focuses on the absorptive capacity of the EU R&I funding and on the creation of knowledge (i.e., excellence in S&T; innovation performance) in the EU MS, because we consider these two dimensions as essential for the catching up process in terms of a durable competitive economy.

In many Eastern countries, the absorptive capacity of EU competitive R&I funding remains much below the budgeted destinations approved by the European Commission (EC) through the multi-annual framework programmes. This low level of competitiveness can be considered as a financial failure for any EU MS that considers the opportunity created by these approved funds financed by the European budget. The statistical data registered at the level of the EC show the huge gap between the older EU countries and the new members in terms of R&D productivity, performance and, ultimately, science and innovation competitiveness.

---

[4] *Gross domestic expenditure on R&D (GERD).*

II. Data and Methodology

The aim of this paper is to analyse the EU competitive funding for R&I attracted by the EU MS, in relation to R&I performance and factors of economic growth, in order to understand the link between the competitiveness of the EU programmes for R&I and the social and economic development.

As inclusion criteria for the analysis, our methodology used the EU MS, with a focus on the Central and Eastern European MS; the EU framework programmes for competitive funding FP7[5] and Horizon 2020; the 2007-2015 period, representing the entire FP7 programme (2007–2013) and the beginning of Horizon 2020 programme (2014–2015). We used the ratio of GERD to GDP, one of five key Europe 2020 Strategy indicators, also known as R&D intensity according to EUROSTAT (R&D Expenditure, 2017)

We collected and analysed scientific, technological and innovation statistical data from open databases and directories from the European Commission (EUROSTAT; CORDIS; Open Science Monitor; DG Research & Innovation).

In order to analyse the level of competitiveness of the EU MS in attracting EU funding for R&I in FP7 and H2020, we developed several indicators related to funding and R&D personnel (Table 1) and used them to calculate the level of performance and dynamics for all the EU MS between 2007 and 2015.

Table 1

Original Performance Indicators Developed and Calculated in Our Research

Indicator	Definition	Formula
Total funding - T_F (MEuro[6])	The total EU competitive funding attracted by a MS in a given year through all its winning R&I EU projects.	$TF = \sum_{2007}^{2015} F_n$ where: *F* = the amount of EU funding for *R&I* attracted by a MS in a given year n (in MEuro)
Increase in attracting EU funding (Rate of attracting EU funding) - R_F	The competitiveness dynamics of a MS in winning R&I projects and attracting EU R&I funding over the entire duration of the analysed period, *i.e.* 2007–2015	$R_F = \frac{F_e}{F_b}$ where: F_e = the amount of EU funding in the last year of the analysed period, i.e. at the end (in MEuro) F_b = the amount of EU funding in the first year of the analysed period, i.e. at the beginning (in MEuro)

5 The Framework Programmes for Research and Technological Development are the EU's main instruments for supporting collaborative research, development and innovation in science, engineering and technology. Participation is on an internationally collaborative basis and must involve European partners. The First Framework Programme was launched in 1984. The Seventh Framework Programme (FP7) covers the period 2007–2013. The Horizon 2020 programme covers the period 2014–2020.

6 Million Euro.

Indicator	Definition	Formula
		b = first year (beginning) of the programming period, i.e., 2007 and 2014, respectively e = last year (end) of the analysed period, *i.e.*, 2013 and 2015, respectively
Return of EU contribution - RC_{EU} (%)	The level of competitiveness of a MS in attracting EU R&I funding compared to its own contribution to the EU budget over the entire analysed period, *i.e.*, 2007-2013 and 2014-2015.	$RC_{EU} = \frac{F_{Rec}}{F_{Con}} x\ 100$ where: F_{Con} = The funding representing the national contribution to the EU budget of a MS for the analysed period, *i.e.*, 2007-2013, 2014-2015 (MEuro) F_{Rec} = The funding received from EU competitive programmes for R&I by a MS for the analysed period, i.e., 2007-2013, 2014-2015 (MEuro)
Revealed comparative FP7+H2020 funds consumption (%)	An index that measure the share of FP7+H2020 absorption of the total national volume of R&D expenditure divided by the share of total EU-28 FP7+H2020 absorption from the total EU-28 R&D volume on the entire period (2007-2015)	$RCFC\ FP7{+}H2020 = \frac{(FP7 + H2020)_i / R\&D_i}{(FP7 + H2020)_t / R\&D_{EU}}$ $(FP7{+}H2020)_I$ = The amount of funding accessed by country "i" in the FP7+Horizon 2020 programmes $R\&D_i$ = the total amount of $R\&D$ expenditures of country "i" $(FP7{+}H2020)_I$ = The total amount of funding, at EU level, in the FP7+Horizon 2020 programmes $R\&D_{EU}$ = the total amount of R&D expenditures of EU
Relative comparative advantage in R&D - $RCA_{R\&D}$ (%)		$RCA_{R\&D} = \frac{R\&D\ expenditure\_i/GDP\_i}{R\&Dexpedinture_{EU28}/GDP\_EU28}$ where: i = an *EU Member State*

In the paper, we also considered key statistical science and innovation indicators developed by the EC, which we used to determine the evolution of the scientific and technological performance of the EU MS for the period 2007-2015, namely:

Excellence in S&T. This is a composite indicator of four variables:

- The share of highly cited publications in all publications where at least one of the authors has an affiliation in a given country (10% of the most highly cited publications considered, full counting method; calculated by the EC from Source Science Metrix calculations using Scopus data).

- Number of top science universities and public research organisations in a country divided by million population (world top 250 science universities and top 50 public research organisations considered; calculated by the EC from Source Leiden Ranking and SCImago Institutions Ranking).
- Patent applications per million population (PCT patent applications by country of inventor, three year moving average; calculated by the EC from Source OECD, EUROSTAT).
- Total value of ERC grants received divided by public R&D performed by higher education and government sectors (transformed by using the natural logarithm, multi-year projects divided equally over time; calculated by the EC from Source DG-RTD, ERC).

The value of the composite indicator (a country score) is a geometric average of the four variables normalised between 10 and 100 using the minmax method and taking into consideration the two time points simultaneously (IUC, 2014) (Open Science, 2017).

Innovation output indicator. This indicator measures the extent to which ideas from innovative sectors are able reach the market, providing better jobs and making Europe more competitive. It was developed by the EC and adopted in 2013 (IOI, 2017) (DG R&I, 2017).

The Innovation output indicator is based on four components:

- Technological innovation (PCT) as measured by patents.
- Employment in knowledge-intensive activities (KIA) as a percentage of total employment.
- Competitiveness of knowledge-intensive goods and services (SERV). This is based on both the contribution of the trade balance of high-tech and medium-tech products to the total trade balance, and knowledge-intensive services as a share of the total services exports.
- Employment in fast-growing firms of innovative sectors (DYN).

I = $w_1 xPCT + w_2 xKIA + w_3 xCOMP + w_4 xDYN$

where:

PCT = Number of patent applications filed under the Patent Cooperation Treaty per billion GDP[7] (Calculated by the EC from Source EUROSTAT/OECD)

KIA = Employment in knowledge-intensive activities in business industries (including financial services) as % of total employment[8] (Calculated by the EC from Source EUROSTAT).

COMP = 0.5 × GOOD + 0.5 × SERV GOOD = High-tech and medium-high-tech products exports as % of total goods exports (Calculated by the EC from Source EUROSTAT (COMEXP)/ UN (COMTRADE)).

---

[7] *Patent counts are based on the priority date, the inventor's country of residence and fractional counts*

[8] *Knowledge-intensive activities are defined, based on the EU Labour Force Survey data, as all NACE Rev. 2 industries at 2-digit level where at least 33% of employment has a higher education degree (ISCED 5 or ISCED 6)*

SERV = Knowledge-intensive services exports as % of total service exports[9] (Calculated by the EC from Source UN/EUROSTAT).

DYN = Employment in fast-growing firms in innovative business industries, including financial services (Calculated by the EC from Source EUROSTAT).

w_1, w_2, w_3, w_4 = the weights of the component indicators, fixed over time, and statistically computed in such a way that the component indicators are equally balanced. Paruolo et al. show that the relative importance of variables is variance based; hence, they are ratios of quadratic forms of nominal weights, while the relative importance is often computed as ratio of nominal weights (Parulo P., Saisana M., Saltelli A., 2013). A correction of the ‘scaling coefficients’ can be made to achieve component indicators with the desired relative target importance (European Commission-JRC, 2016).

Our research methodology developed original indicators for the comparative analysis of the performance of MS in the EU framework programmes for competitive funding of R&I during 2007-2015. The paper also analysed the performance of the EU MS in science and innovation output, based on the statistical data and indicators developed by the EC (*i.e.* “Excellence in S&T” and “Innovation output indicator”).

The analysis developed in our research covered all the EU MS, with a special focus on four MS from Central and Eastern Europe (CEE): Bulgaria, Hungary, Poland and Romania, *i.e.* two MS that joined the EU in 2004 (Hungary and Poland) and two MS that joined the EU in 2007 (Bulgaria and Romania).

III. EU Competitive Funding for R&I and National Investment in R&D over 2007-2015[10]

To attract any EU funding for R&I, organisations across Europe must participate and collaborate in research projects that compete at EU level within open calls for proposals. The competition is fierce, with an average rate of success of 10%. In order to be successful and attract EU funding for R&I (*i.e.* EU grants), a research project must score very high at criteria related to (1) S&T excellence; (2) Impact of research results; and (3) Implementation of the research (Evaluation, 2017). In other words, both the team (consortium) of researchers carrying out the work (R&D personnel, organisations) and the scientific topic developed in the research project (including R&D infrastructure, R&D publications) must be excellent to have a chance at being eventually funded.

The indicators we developed in our study allowed us to analyse the competitiveness of the MS in attracting EU funding for R&I during the FP7 (2007–2013) and beginning of Horizon 2020 (2014–2020) programmes. Beside them, we also analysed the R&D intensity[11] (*i.e*. Gross domestic expenditure on R&D - GERD), in terms of Public

[9] *Exports of knowledge-intensive services are measured by the sum of credits in EBOPS (Extended Balance of Payments Services Classification)*

[10] *The terms R&I and R&D were used in the paper as according to the EC practice, i.e. R&I for EU framework programmes and R&D for EUROSTAT.*

[11] Definition of R&D intensity, as according to the EC: Gross Domestic Expenditure on R&D GERD) as % of Gross Domestic Product (GDP) (IUC, 2014).

expenditure on R&D (GOVERD[12]+HERD[13]), and Business R&D intensity (BERD[14]), as well as the number of researchers per country (full time equivalent - FTE), to better understand the necessary conditions for creating knowledge[15].

Total funding -T_F (MEuro). Total EU competitive funding for R&I attracted by a country is a good indicator for understanding the performance level of the R&I system of a country (Table 2) (European Commission-Budget, 2017).

Table 2

Total EU Competitive Funding Attracted by the EU MS in FP7 (2007–2013) and Beginning of H2020 (2014–2015) (in MEuro)

EU MS[16]	T_F in FP7 (2007–2013)	T_F in H2020 (2014–2015)	EU MS	T_F in FP7 (2007–2013)	T_F in H2020 (2014–2015)
AT	18177.5	5595.9	FR	138892.8	41573.9
BE	33908.4	10703.4	HR	238.2	826.9
BG	2686.4	944.5	HU	6558.1	2069.4
CY	12888.9	390.8	IE	10600	3489.9
CZ	10327.9	3049.1	IT	103708.7	31808.9
DE	166924.9	57268.5	LT	2241.1	774.4
DK	17436.8	5028.8	LU	1994.4	613
EE	1185	410.5	LV	1385.6	505.6
EL	15696.6	3292.6	MT	464.1	180.2
ES	74231.1	21200.4	NL	40423.6	16319.8
FI	12971.7	3758.2			
PL	24774.9	8191	SI	2809.4	788.4
PT	11703.6	3394.3	SK	4708.8	1417
RO	8949.7	2905.3	UK	95385	35481.6
SE	22536	8313.6			

As one may see from calculating the T_F indicator for the FP7 programme, the EU MS that attracted more than 10 billion Euro over 2007–2013 were Germany, France, Italy, the United Kingdom, Spain, the Netherlands, Belgium, Poland, Sweden, Austria, Denmark, Greece, Finland, Cyprus, Portugal, Ireland, and the Czech Republic. For the first two years of the EU Horizon 2020 Programme, the same countries are the best performers in terms of EU attracting funding for research and innovation. The new MS most competitive in the EU framework programmes for research and innovation over 2007–2015 are Poland, Cyprus and the Czech Republic. The top five performers from

[12] *Government expenditure on R&D (GOVERD).*

[13] *Higher education expenditure on R&D (HERD).*

[14] *Business enterprise expenditure on R&D (BERD).*

[15] *The contribution of the research infrastructure and the number of organisations participating in R&I activities are considered in a separate study.*

[16] *Austria (AT); Belgium (BE); Bulgaria (BG); Cyprus (CY); the Czech Republic (CZ); Germany (DE); Denmark (DK); Estonia (EE); Greece (EL); Spain (ES); Finland (FI); France (FR); Croatia (HR); Hungary (HU); Ireland (IE); Italy (IT); Lithuania (LT); Luxembourg (LU); Latvia (LV); Malta (MT); the Netherlands (NL); Poland (PL); Portugal (PT); Romania (RO); Sweden (SE); Slovenia (SI); Slovakia (SK); the United Kingdom (UK).*

the Central and Eastern Europe in both FP7 and Horizon 2020 (over 2007–2015) are the Czech Republic, Romania, Hungary, Slovakia and Slovenia.

Increase in attracting EU funding (Rate of attracting EU funding) - R_F. This indicator, developed in this research, shows the dynamics of attracting EU competitive funding for R&I, thus helping to better understand the degree of competitiveness of EU MS in R&I (Table 3) (European Commission-Budget, 2017).

Table 3

Increase in Attracting EU Funding for Research and Innovation (RF) during the FP7 (2007–2013) and Beginning of Horizon 2020 (2014–2015)

EU MS	R_F for FP7 (2013–2007)	R_F for H2020 (2015–2014)	EU MS	R_F for FP7 (2013–2007)	R_F for H2020 (2015–2014)
AT	92.2	97.6	IE	76.3	63.7
BE	336.9	79.7	IT	143.7	149.2
BG	6.1	1.5	LT	6.3	1.4
CY	11.5	12.3	LU	0.3	-1.4
CZ	29.5	4.1	LV	7.4	3.6
DE	581.8	347.4	MT	3.6	-0.1
DK	107.7	59.1	NL	343.5	470.1
EE	11.5	12.5	PL	38.3	24.2
EL	87.7	94.3	PT	59.1	43.2
ES	636.6	309.5	RO	11	0.6
FI	60.6	75.5	SE	122.8	78.7
FR	429.5	221.6	SI	12.2	16.7
HR	12.6	4.1	SK	5.8	0.5
HU	23.5	-148.8	UK	691.6	461.3

The dynamics of absorption of EU research funding for the 2007–2015 period revealed an increase by 2.31 percent for EU-28. At country level, we notice the maintaining of the top positions for the best performers in terms of attracted R&I funds for both FP7 and Horizon 2020 (*i.e.* the United Kingdom, Spain, Germany, France, the Netherlands, Belgium, Italy, Sweden, Denmark) The new MS registered on the entire period 2007–2015 a constant growth rate between 1 and 4 percent, but the volume gap between the new MS and the old MS has remained constantly significant, starting from a very low base. The important difference in terms of initial absolute volume in attracting R&I funds is practically the most important unsolved problem of catching up. For example, the R&I funds increased by 3 times in the UK, from almost 422 MEuro to 1210 MEuro, in Germany by 2 times, from 561 to 1160 MEuro, and in France by almost 2 times, from 481 to 792 MEuro during 2007–2015. In the case of the most dynamic countries from the new EU MS, we saw Hungary in the first place (54 MEuro), Poland (52 MEuro) in the second place, and the Czech Republic (33 MEuro) in the third place, in terms of R&I average volume in the 2007–2015 period. As compared to the EU-28, the share of all R&I funds attracted by the old MS represented 95.8 percent of all such funds. On average, *the new EU MS attracted only 4.2 percent of all the EU-28 R&I funds during 2007–-2015.*

Return of EU contribution - RC_{EU} (%). Another indicator developed by the authors to calculate the measure of EU MS competitiveness in attracting EU funding for R&I between 2007–2015 reflected how much was attracted by a MS from the EU competitive programmes for R&I against its own national contribution to the EU budget (Source EUROSTAT).

Considering the RC_{EU} indicator, one may see that during the EU FP7 (2007–2013) the MS that were most successful in attracting competitive EU funding for R&I against their national contribution to the EU budget were Belgium (11.6%), Luxembourg (9.9%) and the Netherlands (6.9%). The MS that were less performing in terms of attracting competitive EU funding for R&I during FP7 (2007–2013) were the Czech Republic and Lithuania (with RC_{EU}=2% each), Poland (1.5%), Romania (1.3%) and Slovakia (1.1%). (*Note*: for this programming period, Croatia was excluded from the analysed group of countries, since it joined the EU only at the end of the period, in 2013).

For the beginning of Horizon 2020 (*i.e.* 2014-2015), the most successful MS in attracting EU competitive funding for R&I against their national contribution to the EU budget were Belgium (13.2%), Hungary (11.4%), Cyprus (9.2%) and Greece (9.0%). At the other end of the scale, the less competitive countries in attracting EU funding for R&I as compared to their own contribution to the EU budget are the same like in FP7, i.*e.* Romania (1.2%), Poland (1.1%) and Slovakia (1.1%).

The RC_{EU} indicator also allowed for the comparative analysis of the EU MS competitiveness in the two programming periods considered (2007–2013, and 2014–2015). In general, the competitiveness level remained approximately the same for the two programming periods. However, significant increase in attracting more EU competitive funding for R&I in Horizon 2020 vs. FP7 was noted in the case of Hungary (RC_{EU}=3.8% in FP7 and 11.4% in Horizon 2020); Cyprus (RC_{EU}=5.7% in FP7 and 9.2% in Horizon 2020); Greece (RC_{EU}=5.9% in FP7 and 9.0% in Horizon 2020) and Estonia (RC_{EU}=5.4% in FP7 and 7.8% in Horizon 2020).

R&D intensity. This indicator was calculated using the data for gross domestic expenditure on R&D - GERD, as percentage of the GDP (EUROSTAT, 2017). For the public R&D expenditure, the government expenditure on R&D (GOVERD) and the higher education expenditure on R&D (HERD) as percentage of total GERD[17] were considered.

Calculating as an average over the period 2007–2015, the EU MS with the highest gross domestic expenditure on R&D (GERD, as percentage of the GDP) were Finland and Sweden. Close by, with over 2% of the GDP investment in R&D, were Denmark, Austria, Germany, Belgium, France and Slovenia. With low and very low GERD during 2007–2015 (calculated as average over the nine years considered) were Lithuania, Croatia, Poland, Greece, Slovakia, Malta, Latvia, Bulgaria, and Romania.

Considering the source of funds (public, *i.e.* government and higher education, and private, *i.e.* business enterprise) as a percentage of the total GERD, calculated as average over 2007–2015 (where data were available), one may notice that the EU MS with the highest private contribution to the R&D expenditure are Germany, Finland, Slovenia, Belgium, France, Denmark and Ireland. Hungary had an average BERD of

[17] *Note: EUROSTAT does not have full statistical data for 2014 and 2015. We present our calculations for 2007-2013 only.*

47.24%, while lower values of BERD were registered for Romania, Poland, Latvia, Lithuania, Greece, Bulgaria and Cyprus. These countries compensate their R&D expenditures from public (mainly government) funding (GOVERD as percentage of total GERD, calculated as average over the 9 years, 2007–2015).

In comparison to an EU-28 average, there are different proportions of R&D spending between the EU MS according to the size of economy, to high-tech manufacturing and knowledge-intensive service firms and to universities' openness toward scientific progress (EUROSTAT, 2017). There are similar proportions in the case of R&D expenditures intensity in the EU-15, while over 2007–2015 we notice a gradual increase in R&D intensity at EU-28 level, up to 2% of the GDP (2.03% in 2015), and to 3% of GDP or higher (Finland and Sweden). In turn, the catching up process for the new MS was directly related to their economy size and structure.

Correlating the national investment in R&D (GERD as % of the GDP) with the capacity of being competitive in the EU competitions for R&I projects, one may see that, in general, countries with low GERD are also poor performers in attracting EU competitive funding for R&I.

A snapshot from the EUROSTAT data for the 2007–2015 period revealed that all the new EU MS had low national investment in R&D, which may be one of the factors determining a reduced capacity to win in EU competitions for R&I projects and funding. Luxembourg, Portugal, Ireland, and Greece, which recorded, an average, a low GERD over 2007–2013, were more competitive in attracting EU funding for R&I than the new EU MS, the possible reasons being their better R&D capacities and infrastructure, higher level of recognition for their science outputs (higher citation indexes) and stronger research networks. At similar levels of EU R&I funding attracted are Finland, Sweden, Denmark and Austria. However, their high national investment in R&D helped these MS to develop better innovation structures (as we discuss in Chapter 4).

Analysing the indicators calculated in our study, it may be noticed that, in general, the EU MS from the Central and Eastern Europe (new MS) are not yet capable of attracting similar EU competitive funding for R&I as compared to the old MS (EU-15). This lagging behind may be caused by different factors, such as: R&I national policies not as efficient and performance-inducing as those enforced by the old EU MS; R&I infrastructure generally at a lower level and capability; less R&D personnel, lower wages for R&D; R&I networks smaller and weaker in terms of scientific and technological strengths; lower impact and visibility of the national R&I; and low level of national support (National Contact Points, experts in Programme Committees).

In the FP7 framework programme (2007–2013), the EU competitive funding for R&I increased over the programming period year after year for almost every EU MS. However, this is not the case in Horizon 2020. For the first two years of the EU programme, there are EU MS that attracted less EU funding in the second year (2015) than at the start of the programme (2014); for example Malta (R_F=-0.1), Luxembourg (R_F=-0.7), Hungary (R_F=-74.4). A possible explanation is the nature of Horizon 2020, which brings a special focus on innovation. Horizon 2020 is more innovation/solution oriented, and the organisations that usually participate in such EU programmes are research/academic.

Revealed comparative FP7+H2020 funds consumption - RCFC FP7+H2020 (%) This is an index created by the authors as a share of FP7+H2020 absorption of the total national volume of R&D expenditure, divided by the share of total EU-28 FP7+H2020 absorption from the total EU-28 R&D volume on the entire period (2007–-2015). This new index may be a tool in analysing the relative advantage or disadvantage of a specific EU-28 country in FP7+H2020 consuming relative to R&D expenditure allocated at the national level as a sum for the 2007–2015 period. The concept of Revealed comparative FP7+H2020 funds consumption (RCFC) is like that of Economic Base Theory first developed by Robert Murray Haig in 1927, but considering employment rather than funds for research and development (Haig, 1927).

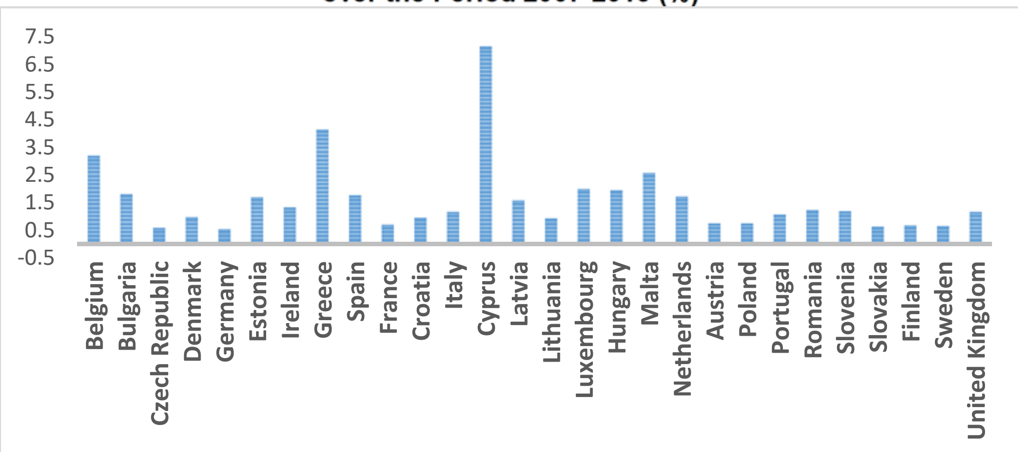
If RCFC ≥ 1 for a certain country, then that country achieved from the European funds additional incentives than the European allocation of the corresponding funds relative to the total EU-28 R&D expenditures. This position could be described in the following possible cases:

- either the specific country has allocated an internal small amount of R&D expenditure (see the case of Romania, Bulgaria) or
- the amount of EU funding for a certain country is great enough to surpass the average R&D funds of EU-28 (see the case of Cyprus, Greece and Belgium).

In the case of net contributors, we notice a revealed comparative FP7+H2020 consumption < 1 due to much larger internal funding received by the central government, private R&D, universities (see the case of Germany, Austria, Finland, France, Sweden) (Figure 1).

Figure 1

Revealed Comparative FP7+H2020 Funds Consumption (RCFC) for the EU MS over the Period 2007-2015 (%)



Source: Original representation of the authors based on data provided by EUROSTAT.

IV. EU MS Key Science and Innovation Performance Indicators for 2007–2015

The R&D funding from national sources (GERD) and EU framework programmes (EU competitive funding) is generally spent by an EU MS on the following main types of costs: labour (salaries and wages of R&D personnel); R&D equipment and infrastructure; dissemination of knowledge and networking, and one may analyse the efficiency of investment in knowledge (R&D expenditure) for a MS by simply measuring these outputs.

The use of R&D funding (EU competitive and national) is analysed in this paper by considering the EU MS science and innovation performance indicators as compared to the indicators developed by the European Commission (see Data and Methodology): Excellence in S&T, Innovation output indicator and Contribution of high-tech and medium high-tech manufacturing to trade balance. The Innovation output indicator was analysed for 2012, while the other two indicators were analysed considering their growth rates calculated by the EC for 2007–2012 or latest data available. We also used the indicators developed in our research, namely the High-tech exports as a percentage of total exports (HT, %) and the Relative comparative advantage in R&D ($RCA_{R\&D}$, %) (see Table 1), which we calculated for the EU MS during 2007–2015.

Excellence in S&T. The indicator on excellence in science and technology takes into consideration the quality of scientific production, as well as the technological development. According to the data provided by the EC (IUC, 2014), the highest growth rate in Excellence in S&T over 2007–2012 is shown by Ireland (14.6%) and Estonia (13.4%). High values of growth are registered also by Slovenia, Poland, Croatia and Slovakia. Bulgaria, Spain, and Cyprus showed less than 1% growth rate for this indicator, while Italy and Greece performed worse in 2012 than in 2007 (negative values for the growth rate of -0.5% for Italy and -1.9% for Greece) (IUC, 2014).

Innovation output indicator. As previously mentioned, this indicator describes the technological innovation, skills in knowledge-intensive activities, competitiveness of knowledge-intensive goods and services, and innovativeness of fast-growing enterprises, focusing on innovation output (IOI, 2017).

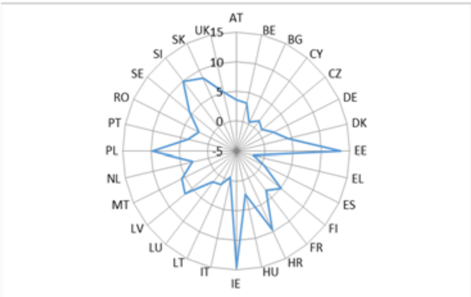
According to the data provided by the EC, the most innovative MS in 2012 were Germany, Sweden, Ireland, Luxembourg, Finland, Denmark, the United Kingdom, France and Austria (with values over 100 for the innovation output indicator). At the other end of the scale, with values below 70, are Croatia, Bulgaria, Latvia and Lithuania.

When analysing the correlation between the funding used for R&D and the science and innovation performance, one may see that, in general, the countries with the highest GERD (as % of the GDP) are also the best performers in terms of innovation output: Germany, the United Kingdom, France, Sweden, Finland, Ireland, and Austria. The old EU MS (EU-15) are also excellent competitors in attracting EU funding for R&I from the EU framework programmes. The new MS are able to attract less EU-competitive funding for R&I (with top performers Hungary and Poland); however, it seems that these MS are mostly concentrated on improving their scientific and technological output (Excellence in S&T) rather than on the innovation base. For instance, Estonia, Slovenia, Poland, Croatia, Slovakia, and Latvia are all top performers in terms of growth rate in

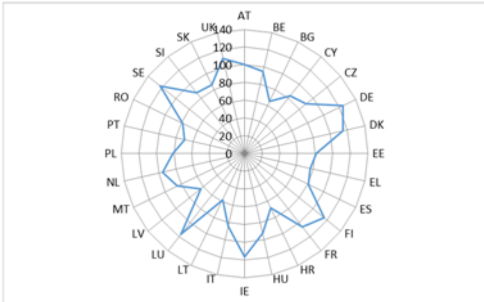
Excellence in S&T over 2007-2012, surpassing Sweden, the United Kingdom, Finland and Denmark (Figure 2).

Figure 2

Science and Innovation Performance Indicators for 2007-2012 (Excellence in S&T) and for 2012 (Innovation Output Indicator)



(a) Growth rate in Excellence in Science and Technology (S&T) 2007-2012 (%).
EU Growth Rate in 2012: +2.9%



(b) Innovation Output Indicator - Values for 2012.
EU Value for 2012: 100.6

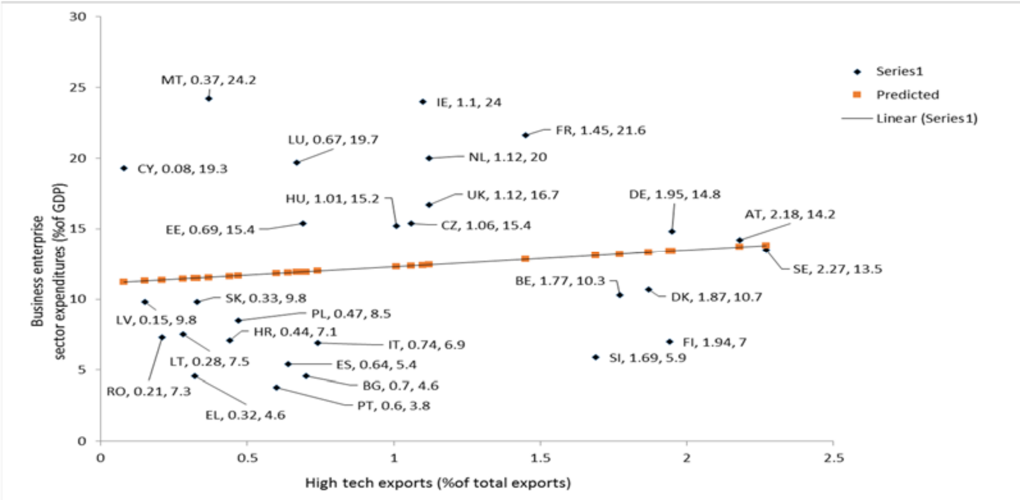
Source: Original representation of the authors based on data provided by reports of the European Commission (IUC, 2014).

Comparing four new MS (Hungary, Poland, Bulgaria, and Romania), *i.e.* two MS that joined the EU in 2004 and the other two MS that joined the EU in 2007, one may see that Hungary and Poland are much better performing than Romania and Bulgaria. Hungary and Poland were better competitors in attracting EU funding for R&I from the framework programmes FP7 and the beginning of Horizon 2020 than Romania and Bulgaria. Moreover, Hungary and Poland have both higher values for the science and innovation indicators over 2007–2012 than Romania and Bulgaria. The low rate of absorption of European competitive funds for research and innovation in the Eastern Europe countries reveals a narrow capacity of innovation.

High-tech exports as percentage of total exports correlated with BERD. The total research and development (R&D) expenditures (GERD) is the sum of government, private, universities and non-profit organisations payments focused on growing the stock of knowledge in different forms, reflecting the national potential for growth. From all components of national R&D expenditures, the business enterprise expenditures (BERD) should have a direct effectiveness in high-tech products where a large amount of money was needed to maintain position on the international markets. As Figure 3 shows, where the linear regression for all EU MS using the high-tech exports and business enterprise expenditure on R&D (BERD) data was calculated, we may notice that the new EU MS are almost all clustered in the bottom left corner. This was explainable because both the BERD and the high-tech exports as % of total exports registered some of the lowest EU levels. In the case of Romania and Bulgaria, the share of R&D expenditures in total GDP continued to be the lowest in the EU-28. We also noticed a lower contribution of business enterprise sector to the national R&D

expenditures (0.2% for Romania and 0.7% for Bulgaria), as compared to the Czech Republic (1.1%) and Hungary (1.0%).

Figure 3
Correlation between High-tech Exports and Business Enterprise Expenditure on R&D by using Linear Regression, 2015



Source: Original representation of the authors based on data provided by EUROSTAT.

These two countries joined the EU at the same time (2004), reflecting a more advanced convergence process than in the case of Romania and Bulgaria (which joined the EU in 2007). Hungary and the Czech Republic ranked quite closely to the positions of the most advanced EU MS (see Figure 3). Other countries from the South of Europe revealed low levels on both mentioned indicators, due to the international financial crisis that hit in 2009 (Spain, Greece, Italy and Portugal) and due to the predominantly non-high-tech exports specialisation (*e.g.,* food products, beverage, tourism, textiles and cosmetics). In the right corner above the regression line we find the most efficient countries, where the business companies invested a large share on R&D expenditures and, consequently, the effects were reflected in EU-28 top positions regarding the high-tech exports (Germany, France, the United Kingdom, Sweden, the Netherlands, Ireland, Austria, Belgium, the Czech Republic and Hungary).

Relative comparative advantage in R&D - $RCA_{R\&D}$ (%). After Romania joined the EU, the development of capital formation was significantly diminished, especially when the international financial crisis erupted and the government was forced to cut the investment expenditure after 2012. The domino effect in this area has contributed not only to drastically diminishing the potential for growth, but also to deteriorating the ability to attract EU-competitive funding for R&I, also affecting the infrastructure and public services capacity for modernisation. Among the GDP components, the GFCF is one of the most important indicators of a firm and durable economic development. The relationship between the GFCF and R&D intensity is better observed when considering the infrastructure development.

Per the official data released by the Romanian National Institute for Statistics, the GFCF represented approximately one-fifth of total GDP in the years that followed the accession to the EU. The annual decrease by 3.6% in the GFCF reflected a fall by 0.8% in the global result of GDP, diminishing in this way the rise in the rest of income categories forming the GDP total. The steady shrinkage of GFCF since 2007 constantly remains the key unresolved issue of the Romanian economy since its EU accession. In the first eight years after joining the EU, Romania still did not reach the 2007 GFCF level.

Bulgaria had one of the most dynamic R&D expenditure and increase in the R&D personnel in the business enterprise sector since it joined the EU in 2007 (EUROSTAT). Among the four institutional sectors that invested in R&D in Bulgaria, the contribution of the enterprise sector registered a significant growth (73.3% of total GERD), one of the highest shares in the EU-28. The catching up process was below EU standards; however, the investment made in R&D by the large number of new R&D performing companies was quite remarkable.

Analysing the R&D intensity, the stable positive position of Germany and France over the entire 2007–2015 period should be noticed. In the catching up process of the new MS, we noticed important gains in comparative advantages for the Czech Republic and Poland, especially for the government sector. Romania is the only new MS that did not achieve an improvement in terms of increasing R&D expenditure over the same period (constantly well below 0.5% of GDP during 2004–2015).

The R&D intensity for business enterprises (BERD) showed the relevance of the private sector in the achievement of GDP, and the need for a knowledge-intensive economy. Among the EU-15 MS, Germany, Austria and Sweden are the top three EU-28 countries that performed according to this indicator in 2015. Among the new EU MS, Slovenia, the Czech Republic and Hungary registered the highest BERD intensity. Romania ranked the last (0.20% of the GDP) over the whole analysed period. A fast catching up was recorded by Bulgaria, from the 0.1% in 2004 to 0.7% in 2015.

All differences between the EU MS reflected different national R&D capacities and infrastructures. We correlated the data calculated for the R&D intensity (presented above, source EUROSTAT) with the information provided by CORDIS for the EU research projects that received funding during 2007–2015 within the FP7 and Horizon 2020 programmes for research and innovation. We noticed that the most developed (in terms of R&D) and the most competitive MS in attracting EU funding for R&I tend to collaborate, forming groups of organisations (consortia) with similarly advanced levels of R&D (Figure 4) (Folea, 2016). In general, the EU CEE MS are less visible in the winning consortia, which is well in accordance with the lower level of EU funding for R&I attracted by these countries over 2007–2015.

Figure 4

Participation and Collaboration of MS in EU Funded Research Projects (Examples of Consortia)

(a). Project Reference 649342 (Horizon 2020)

(b). Project Reference 649342 (Horizon 2020)

(c). Project Reference 649717 (Horizon 2020)

(d). Project Reference 645425 (Horizon 2020)

The geographical balance of consortia in the European research projects is not anymore a specific request in Horizon 2020, the European Commission considering that a project's impact can reach a pan-European dimension and the project research results can be disseminated and implemented in other countries as well.

V. Conclusion

The paper analysed the EU-competitive funding for R&I attracted by the EU MS regarding R&I performance and factors of economic growth.

The EU MS from the Central and Eastern Europe are not yet capable of attracting similar EU-competitive funding for R&I as the EU-15 MS. Several factors may contribute to this lower level of performance, such as: national policies for R&I; the R&I infrastructure; researchers' numbers and wages; international research; visibility of research; and national support. We also highlight the role of national strategies for increasing knowledge-based economic development in general and high-tech sector development, in particular, in the analysed countries (Moagar Poladian S., Dumitrescu G., & Dragoi A., 2015).

During the FP7 framework programme (2007-2013), the EU-competitive funding for R&I increased over the programming period year after year for almost every EU MS. However, this is not the case in Horizon 2020. For the first two years of the EU programme, there are EU MS that attracted less EU funding in the second year (2015) rather than at the start of the programme (2014); for example, Malta (RF=-0.1), Luxembourg (RF=-0.7), and Hungary (RF=-74.4). A possible explanation is the nature of Horizon 2020, which brings a special focus on innovation. Horizon 2020 is more innovation/solution oriented, and the organisations that usually participate in such EU programmes are research/academic.

The highest growth rate in Excellence in S&T over 2007–2012 is revealed by Ireland and Estonia. High values of growth are also registered for Slovenia, Poland, Croatia and Slovakia. Bulgaria, Spain, and Cyprus showed less than 1% growth rate for this indicator, while Italy and Greece performed worse in 2012 than in 2007. The most innovative MS in 2012 were Germany, Sweden, Ireland, Luxembourg, Finland, Denmark, the United Kingdom, France and Austria (with values over 100 for the Innovation output indicator). At the other end of the scale, with values below 70, are Croatia, Bulgaria, Latvia and Lithuania.

Comparing four new MS (Hungary, Poland, Bulgaria, and Romania), i.e. two MS that joined the EU in 2004 and the other two MS that joined the EU in 2007, one may see that Hungary and Poland are much better performing than Romania and Bulgaria. Hungary and Poland were better competitors in attracting EU funding for R&I from the framework programmes FP7 and the beginning of Horizon 2020 than Romania and Bulgaria. Moreover, Hungary and Poland have both higher values for the science and innovation indicators over the 2007–2012 period than Romania and Bulgaria. The low rate of absorption of European competitive funds for R&I in the Eastern Europe countries reveals a narrow capacity of innovation.

VI. References

CORDIS, 2017. [Online] Available at: http://cordis.europa.eu/home_en.html.

DG R&I, 2017. [Online] Available at: <http://ec.europa.eu/research/index.cfm?pg=dg>.

Muller, E. Jappe-Heinze, A. Héraud, J.A. and Zenker, A., 2006. A regional typology of innovation capacities in New Member States & Candidate Countries. *Arbeitspapiere Unternehmen und Region*, No. R1/2006, pp.1-32.

European Commission-Budget, 2017. *Budget.* [Online] Available at: <http://ec.europa.eu/budget/figures/interactive/index_en.cfm>.

European Commission-FP7, 2016. *FP7. l*[Online] Available at: https://ec.europa.eu/research/fp7/index_en.cfm.

European Commission-H2020, 2017. *Horizon 2020.* [Online] Available at: <https://ec.europa.eu/programmes/horizon2020/>.

European Commission-JRC, 2016. *The Innovation Output Indicator 2016, Methodology Update,* s.l.: 2016.

EUROSTAT, 2017. *European Commission.l* [Online] Available at: <http://ec.europa.eu/eurostat>.

Evaluation, 2017. *Evaluation criteria in Horizon 2020.* [Online] Available at: <http://ec.europa.eu/research/participants/data/ref/h2020/call_ptef/ef/2016-2017/h2020-call-ef-ria-ia-csa-2016-17_en.pdf>.

Folea, V., 2016. Imbalanced participation of European organizations in research and innovation actions in economy and finance in the EU framework programme Horizon 2020. *The Impact of socio-economic and technological transformations at national, European and international level*, 11(1), pp.30-46.

Haig, R.M., 1927. Major economic factors in metropolitan growth and arrangement; a study of trends and tendencies in the economic activities within the region of New York and its environs. N.Y. *Regional survey of New York and its environs.*

IOI, 2017. Innovation Output Indicator. [Online] Available at: <http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=output>.