INDUSTRIAL R&D INVESTMENT IN EU: RECENT TRENDS AND LESSONS FOR ROMANIA

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***A**bstract.* *R&D and innovation are broadly acknowledged as the main drivers of an economy's competitiveness and growth and the measures to encourage investment in research are a central part of economic policies. This paper addresses the question of R&D investment by the private sector and aims at investigating its economic effects in terms of profit and net sales increase for the top 1000 R&D industrial investors based in the EU.*

***Key words**: R&D investment, industry, EU*

JEL Classification: O32, L19

1. INTRODUCTION

The EU's ambitious objective of progressively moving towards a more knowledge-based economy calls for radical improvements to the European system of research and development (R&D), to narrow the R&D gap with US and Japan. As such a gap entails negative consequences for the long-term potential of innovation, economic growth and employment creation in Europe, all EU Member States agreed on the importance of increasing investment in research and a Research Investment Action Plan (European Commission, 2003) intending to foster private R&D investment was built.

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As a part of this plan, monitoring of research activity was established and the resulting EU Industrial R&D Investment Scoreboard was published annually. The Scoreboard monitors the top 1000 R&D investors based in the EU drawing on companies' annual reports and accounts. It includes all R&D financed by companies' own funds, regardless of the place where the R&D is actually performed.

The recent economic crisis and the current slow recovery limited the finance resources for R&D activities. Nevertheless, the recent Scoreboards indicated that worldwide corporate R&D investment continued to grow in 2008-2010. Large, powerful European companies managed to maintain a significant degree of investment in research, while smaller companies found it very difficult to invest in research and innovation due to their already restricted own financial capacity and persistently low availability of external funds. Such economic conditions make now even more important the goal to ensure sustained and coherent progress through improving effectiveness of policy support for research and innovation.

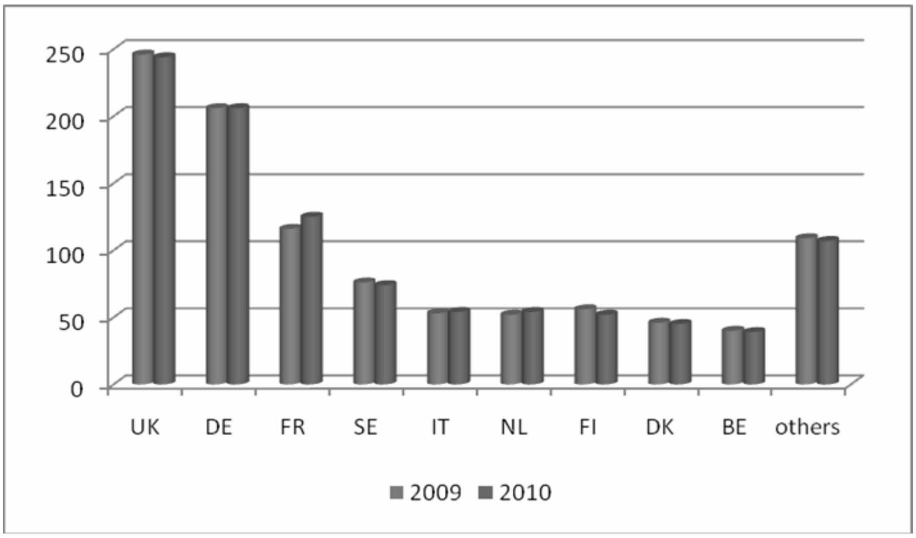
In this context, the paper seeks to address two interrelated issues. Firstly, we conduct a statistical investigation of the most recent trends in R&D investment of the private sector in the EU. Secondly, we examine, by means of an econometric model, the extent to which R&D investment by the top industrial companies impacts upon their economic performance in this post-crisis environment. To achieve these goals we exploit the most recent EU Industrial R&D Investment Scoreboards data.

2. MAIN TRENDS IN INDUSTRIAL COMPANIES' R&D INVESTMENTS IN THE EU

Concentration of R&D investments. A major characteristic of R&D investments is their strong concentration in a small number of large companies, in a relatively few sectors and countries (Ciupagea and Moncada-Paternò-Castello, 2006). This pattern is also visible within the group of top 1000 industrial companies based in the EU: companies in the top 10 Member States account for about 97% of the total R&D investment in the EU and over two thirds of the R&D investment comes from the three largest Member States: Germany, France and the UK. At country level a few large firms account for sizeable shares in the R&D investment, as well; for instance, only two companies contributed more than 95% of Denmark's R&D growth: Novo Nordisk (27.3%) and Vestas (49.8%) jointly accounted for 40% of the country's R&D investments in 2010.

The Industrial R&D Investment Scoreboard that monitors the top 1000 R&D companies based in the EU indicates the United Kingdom, Germany and France as the top three investors (Figure 1), concentrating the largest part of the total R&D investment in the EU. Almost no change has occurred in 2010, as compared to 2009, in the distribution by country of the top 1000 industrial companies, indicating stability in R&D rankings. These data prove the importance of the investment behaviour of a few large players for the country and sector R&D mix.

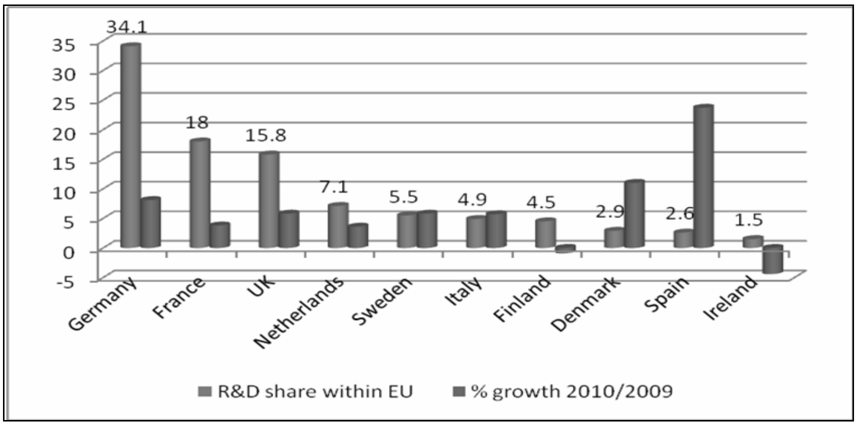
Figure 1. The top 1000 EU industrial companies by country



Source*: Processed by authors, based on data from the EU Industrial R&D Investment Scoreboard.*

R&D intensity decline. Data on the growth rates of the companies' R&D spending range from 23.7% in Spain to -0.9% in Finland (Figure 2). The R&D intensity (the ratio ofR&D investment to net sales of a given company) for the top 1000 EU industrial companies also displays a large variation between the Member States.

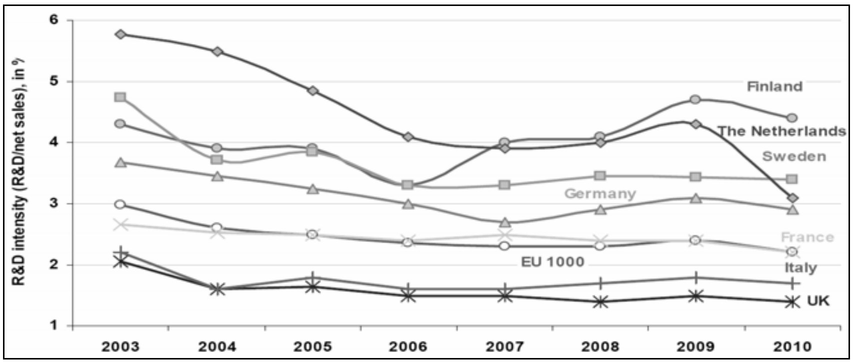
Figure 2. R&D growth for the main R&D investors in EU



Source*: Processed by authors, based on data from the EU Industrial R&D Investment Scoreboard.*

As the drop in net sales during the global economic crisis greatly surpassed the decline in R&D spending, the average R&D intensity of top 1000 industrial companies had increased in 2009. The economic recovery reversed the trend: in 2010 the sales oftop 1000 EU companies went up by an average of 11.8%, while their R&D investment increased by only 5.8%, causing the R&D intensity to resume its declining trend visible since 2003 (Figure 3). Lower R&D intensity can be observed in most EU countries in 2010 against 2009, with a few exceptions such as Denmark and Sweden (constant R&D intensity).

Figure 3. R&D intensity trends in main R&D investing countries

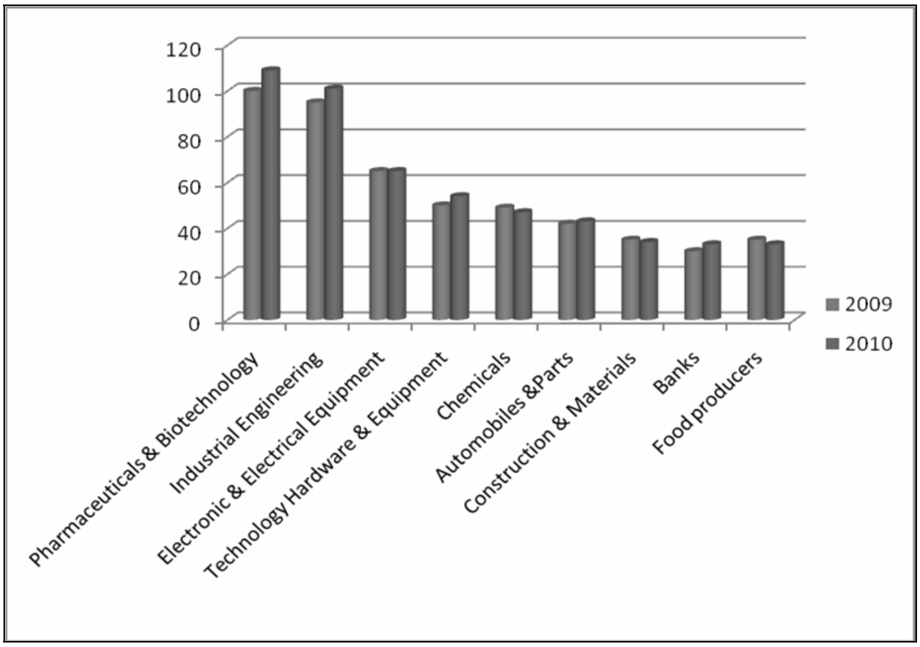


Source*: The EU Industrial R&D Investment Scoreboard.*

Impact of the crisis. There is considerable empirical evidence on the negative impact of the indebtedness of firms (and financial constraints, in general) on their investment in R&D; high-risk expenditures such as research projects rapidly drop or even disappear during periods of financial distress (Giudici and Paleari, 2000, Tiwari *et al*., 2007), but the precise impact on the R&D investment largely varies between countries (e.g. Bond *et al*., 1999, reports more severe effects in the UK than in Germany). Countercyclical corporate R&D investment behaviour is documented to provide companies significant competitive advantage when the economic and financial recovery arrives (e.g. Francois and Lloyd-Ellis, 2003). The 2008-2011 EU Industrial R&D Investment Scoreboards provide data proving that the top industrial firms maintained high R&D spending behaviour despite the onset of the economic crisis. The R&D investment continued to grow in 2008-2010 for the most European companies in the Scoreboard.

The top R&D sectors. In many EU countries, the aggregate R&D investment at national level relies to a large extent on a few sectors, still very strong despite the economic crisis. The highest R&D intensity is in Pharmaceuticals & Biotechnology, Technology Hardware & Equipment, Software & Computer Services, Leisure Goods and Health Care Equipment & Services, each one with an average R&D intensity over 6%. The top three industrial sectors that account for 50.8% of the total R&D investment are ***Pharmaceuticals & Biotechnology, Technology Hardware & Equipment and Automobiles & Parts***. Small changes in the concentration of R&D by industrial sector have occurred over the last years, reflecting stable R&D specialisation: the share of the top three sectors declined from 55.3% in 2004 to 50.8% in 2010 and that of the top 15 sectors from 94.0% to 91.8% (Figure 4). In 2010 the top 1000 EU companies increased their share in Automobiles & Parts, Software and Computer Services, Industrial Engineering and Aerospace & Defence, while decreasing the share in Pharmaceuticals & Biotechnology, Technology Hardware & Equipment and Chemicals. Nevertheless the Pharmaceuticals & Biotechnology remains the top R&D sector in the EU (and in the US, as well), its share surging from 12% to 18% over the past eight years, while the R&D share of the Automobiles & Parts companies remained constant at about 23% in the EU, while declining from 16% to 8% in the US.

Figure 4. The 10 most numerous sectors among the 1000 EU industrial companies



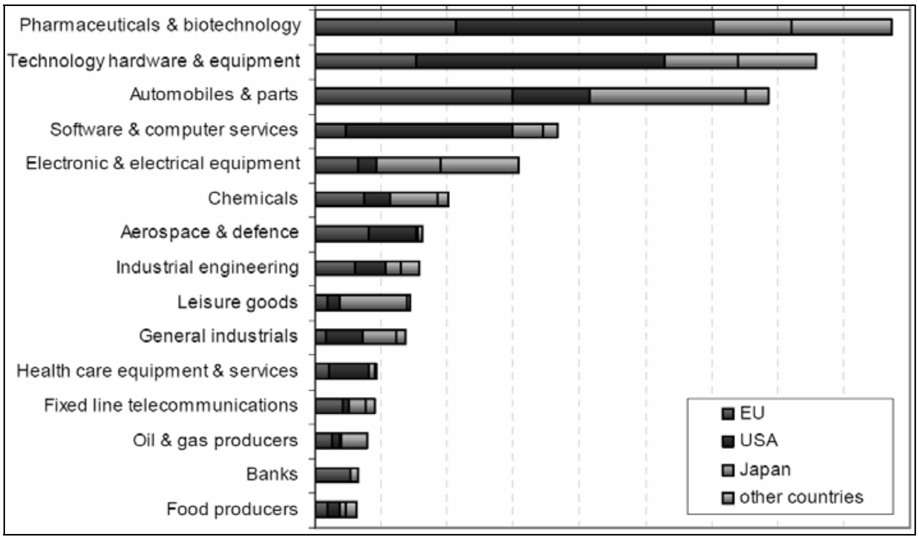
Source*: Processed by authors, based on data from the EU Industrial R&D Investment Scoreboard.*

The R&D ranking by sector clearly confirms the dominance of the same top 3 sectors not only in the EU, but in the US, Japan and other countries as well (Figure 5). EU companies are contributing by 50.5% to the total R&D investment in Aerospace & Defence, by 43.7% to Automobiles & Parts and by 36.2% to the Chemicals sectors. The US highest contribution goes to Software & Computer Services (69.1%), followed by Technology Hardware & Equipment (49.6%) and Pharmaceuticals (44.7%); Japan provides 35.2% of the total R&D investment in Chemicals and 34.5% in Automobiles & Parts.

The top five sectors by R&D intensity account for 68.6% of the total R&D investments for the US, 39.4% for Japan and only 34.3% for the EU-based companies.

EU-US R&D comparison. Concerns about the EU's innovative performance are usually related to a deficit in R&D investments as compared to the US and Japan. Despite efforts towards increasing the research efforts, the EU has witnessed persistently lower R&D intensity than the US.

Figure 5. R&D investment by industrial sector and share of the world regions, 2010

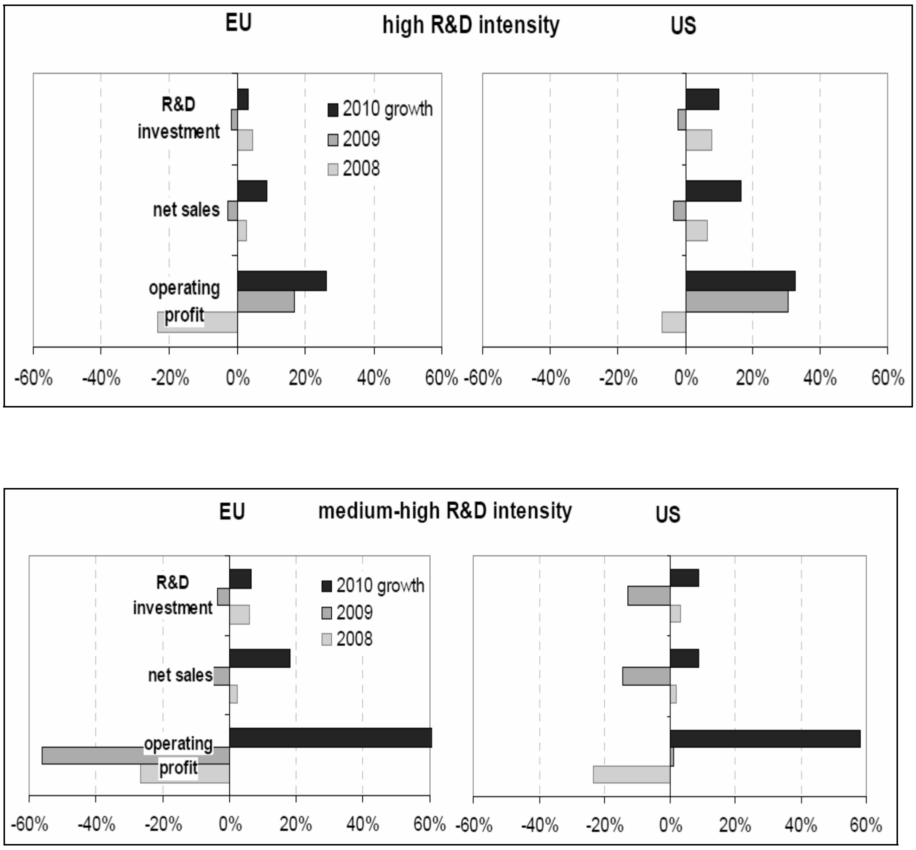


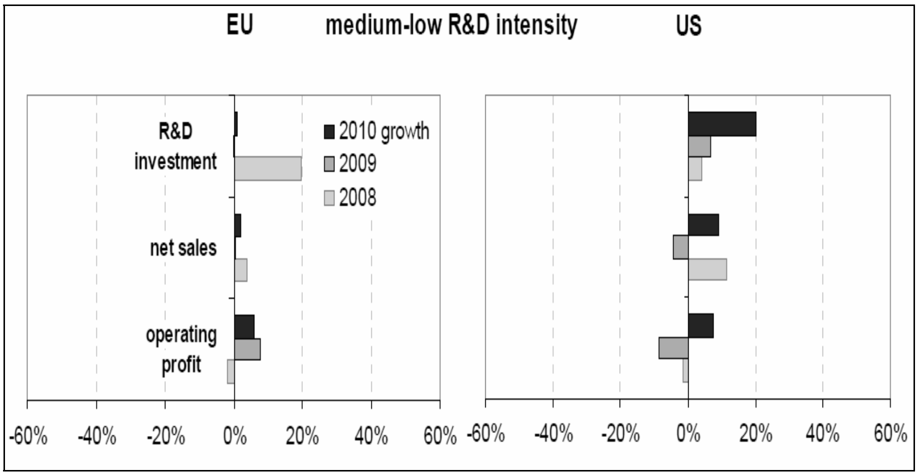
Source*: The EU Industrial R&D Investment Scoreboard.*

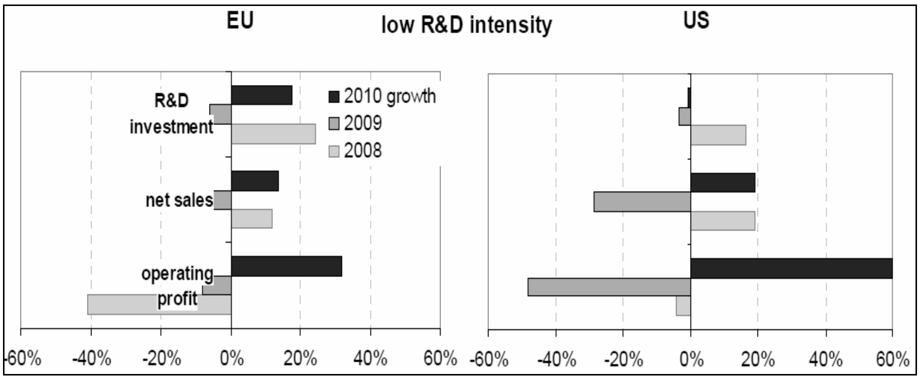
The mainstream of the empirical literature on the EU-US gap in R&D intensity and performance points to three interconnected factors that can explain their differences. In explaining the EU-US innovative performance differentials, the first and the most important factor to consider is the specific industrial structure. High R&D intensive sectors (the ICT sector, in particular) have a bigger share in the US economy, as compared to the EU and this gap is widening continuously, as in the last two decades structural changes in the US favoured higher R&D-intense sectors to a larger extent than in the EU.

Several recent empirical studies addressed the EU-US gap in R&D spending and results from the industrial structure perspective. For instance, Moncada-Paternò-Castello (2011) de-composed the overall R&D intensity into an intrinsic part (investment behaviour) and a structural one (sector mix) and found no systematic underinvestment in the EU R&D, compared to the US and Japan, but significant differences in the sector composition of the three economies. Data revealed the weight of the high R&D intensity sector group to be considerably lower for EU. This lower specialisation in sectors with high R&D intensity, especially in the ICT sectors, entails the lower overall R&D intensity of the EU (Ciupagea, 2006; Moncada-Paternò-Castello *et al*., 2010). The aggregation of the 37 industrial sectors into four categories: high, medium-high, medium-low and low R&D intensity allows for an in-depths comparison between the EU and the US. EU innovation data relative to that in the US by 2008-2010 (Figure 6) clearly shows both the EU underinvestment in high R&D intensity sectors and the EU lower performance in these sectors. The US companies are specialised in high R&D intensive sectors, accounting for 68.6% of total R&D of the US companies. The EU companies are specialised in medium-high R&D intensive sectors (48% of total R&D of the EU companies) and have a higher share of small R&D intensive sectors as well, but its performance relative to that in the US is lower in these sectors as well. This trend was stable despite the troubles brought about by the economic crisis.

Figure 6. EU-US comparison by R&D intensity level, 2008-2010







Source*: The EU Industrial R&D Investment Scoreboard.*

At the very top of the R&D ranking, the largest firms in the EU and the US show little dissimilarities in terms of R&D investment. The differences are sizeable for the group of small firms. The relatively small and young US companies have higher capacity to grow, especially in high R&D intensity sectors, as compared to their EU counterparts. As the SMEs account for about 99% of all EU companies, but only 3% of them perform R&D activities (Potočnik, 2009), it implies their impact on private-sector R&D intensity in the EU is limited. Moreover, the share of R&D activity performed by small- and medium-sized enterprises (SMEs) in the EU (23%) is substantially higher than in the US (14.1%), adding to the EU-US R&D intensity gap (Veugelers, 2006). Nevertheless, it is believed that a rise in the number of SMEs engaged in R&D could help to improve the dynamism of the EU economy.

3. ECONOMIC EFFECTS OF THE INDUSTRIAL COMPANIES' R&D INVESTMENTS

3.1. Variable definition and model specification

As resulted from the above considerations, measures to encourage private investment in research are an important part of the EU R&D policy. Since companies' motivation to innovate depends on their capabilities to draw concrete benefits from R&D investments, assessing the economic effects of research is an important part in formulating the appropriate EU industrial, entrepreneurship and innovation policies. In this section we analyse, by means of regression modelling, the effects of the main R&D variables on the economic results of the top EU industrial companies.

The ***variables of interest*** in our econometric analysis are related to the research and development field: R&D investment, R&D per employee and R&D intensity. The R&D investment variable in our models includes only the own cash investment of the companies, while R&D undertaken under contract for customers or joint venture R&D investment is excluded. Since the companies are allocated to the country of their registered office, differences from other statistical data, such as BERD data, which measures R&D activity within the countries independently of the source of funding), do occur. Another difference between official statistics appears in the calculation of R&D intensity, based on net sales (in the *Scoreboard*) instead of value added.

Economic predictors are also used as ***control variables*** in the models: the number of employees, capital expenditure as percent of net sales and market capitalization.

Three multiple regression models have been built, the ***dependant variables*** being the net value of the top company's sales, the net sales growth in 2010 relative to 2009, and the operating profit as percent of net sales. Table 1 describes all the variables included in the econometric models. All data used in the regression analyses come from the *2010 and 2011 EU Industrial R&D Investment Scoreboards* issued by the European Commission.

Table 1. The variables involved in the econometric models

VARIABLE	Description	Unit of measurement
RD_INV	**R&D investment** is the cash investment funded by the EU industrial companies in the database.	€m
EMPL	**Number of employees** is the total consolidated average employees or yearend employees when the average is not stated.	persons
MARKET_CAP	**Market capitalisation** is the share price multiplied by the number of shares issued at a given date.	€m
RD_EMPL	**R&D per employee** is the simple ratio of R&D investment to employees.	€/person
RD_RATIO	**R&D intensity** is the ratio of R&D investment to net sales of a given company or group of companies.	%
CAP_RATIO	**Capital expenditure as percent of net sales.** Capital expenditure is expenditure used by a company to acquire or upgrade physical assets such as equipment, property, industrial buildings.	%
PROFIT	**Operating profit as percent of net sales.** Operating profit is calculated as profit (or loss) before taxation, plus net interest cost (or minus net interest income) minus government grants, less gains (or plus losses) arising from the sale/disposal of businesses or fixed assets.	%
SALES	**Net sales** in the database correspond to the usual accounting definition of sales, excluding sales taxes and shares of sales of joint ventures & associates.	€m
SALES_GR	**Net sales growth** in 2010 relative to 2009.	%

*Variable source: *http://iri.jrc.ec.europa.eu/research/docs/2010vol_II_1.pdf.*

The linear multiple regression models are specified by the following general equation:

$$\boldsymbol{Y_{t,i} = \beta_0 + \Sigma_j \beta_j K_{tij} + \varepsilon_{ti}}, \tag{1}$$

Where: $\boldsymbol{Y}_{t,i}$ represent the dependent variable (the operating profit as percent of net sales, the net sales growth, and the value of the net sales, respectively), $\boldsymbol{K_{tij}}$ are the exogenous variables, and $\boldsymbol{\beta_j}$ are the parameters that summarize the *j* factor contribution to the dependent variable, *t* stands for the year and *i* for the company. Last, ε_{ti} is an independently and identically distributed error term for *i* and *t* with zero mean and variance σ^2.

The database employed in our econometric analysis was drawn from the *2010 and 2011 EU Industrial R&D Investment Scoreboards* issued by the European

Commission. The data refer to the R&D efforts and main economic results of the top 1000 industrial companies of the EU in the fiscal years 2009 and 2010. Given the lack of data on several variables for some of the industrial companies in the *Scoreboard,* after adjustments the number of companies actually included in the models varies between 966 and 780, depending on the variables used in the final specification of each econometric model.

3.2. Results

In this section, we present the results of running the regressions specified in the equation (1) using data for the 1000 top EU industrial companies, in 2009 and 2010. The parameters of the models were estimated using Ordinary Least Squares (OLS) and the estimated regression coefficients, alongside their corresponding standard errors and the values of standard econometric tests, are shown in Table 2 for the 2009 data and in Table 3 for 2010 data. Only the statistically significant variables were preserved in the final specification of each econometric model.

Table 2. OLS regression coefficients for models 1 and 2, 2009 data

Variable	**Model 1: Dependent Variable: PROFIT**		**Model 2: Dependent Variable: SALES**	
	Coefficient	Std. Error	Coefficient	Std. Error
RD_INV			3.0677*	0.686777
EMPL			0.0852*	0.006655
MARKET_CAP			0.6745*	0.027523
RD_EMPL	1.3335*	0.100301		
RD_RATIO	-1.6617*	0.003381		
CAP_RATIO	-3.4934*	0.165182		
Constant	21.4936**	7.161014	156.0131	341.1236
Observations	*966*		*780*	
R-squared	*0.9999*		*0.7032*	
F-statistic	*8848716**		*612.8390**	
Durbin-Watson stat	*2.0083*		*2.191914*	

**significant at 0,1% **significant at 1%.*

Source: *processed by the authors based on data from http://iri.jrc.ec.europa.eu/research/docs/2010vol_II_1.pdf.*

The regression results from the first model indicate that the profit (as percent of net sales) is positively influenced by increases in R&D per employee[1] and is

[1] It is noteworthy that the employment growth in high R&D-intensive sectors was less affected by the economic downturn, suggesting that R&D spending positively impacts the employment.

negatively linked to R&D intensity and capital expenditure. The unexpected negative correlation between profit and R&D intensity may be explained, partially at least, by the economic downturn effects on company financial results in 2009. The second model indicates that the net sales of the top industrial companies are positively correlated with the R&D investment, the number of employees and the market capitalization. This is in line with studies that reported a link between industrial R&D intensity and the net sales (e.g. Ciupagea, 2006).

The model is statistically significant and explains in a very large proportion the variability of the profit ratio (R^2=*0.9999*) and net sales (R^2=*0.7032*) across the top EU industrial companies. All the variables included in these two models are highly significant. The standard econometric tests also yield good results (see Table 2).

The regression estimations from the third model (Table 3) indicate that in 2010 the dependant variable net sales is significantly correlated with R&D investment, the number of employees and the market capitalization, all acting as positive factors of influence, in accordance with the 2009 model results.

Table 3. OLS regression coefficients for models 3 and 4, 2010 data

Variable	**Model 3: Dependent Variable: SALES**		**Model 4: Dependent Variable: SALES Growth**	
	Coefficient	Std. Error	Coefficient	Std. Error
RD_INV	1.9653*	0.8794		
EMPL	0.0925*	0.0088		
MARKET_CAP	0.7266*	0.0302		
RD_INV growth			0.0769**	0.0319
EMPL growth			0.8315*	0.0728
CAP_RATIO growth			0.0107**	0.0049
Constant	-29.3008	446.7209	14.6168*	2.4062
Observations	*796*		*966*	
R-squared	0.6567		0.1683	
F-statistic	505.0604*		64.9010*	
Durbin-Watson stat	*2.580*		*2.191914*	

**significant at 0,1% **significant at 1%.*

Source*: processed by the authors based on data from http://iri.jrc.ec.europa.eu/research/docs/2010vol_II_1.pdf.*

The last model adopts a different perspective, focusing on the dynamics of R&D investment and economic performance. In the fourth model the dependant variable (net sales growth in 2010 relative to 2009) is regressed against the growth of the R&D variables, alongside the dynamics of other relevant factors of influence. The results indicate that besides the growth in classical production factors (labour and capital) R&D investment growth in 2010 relative to 2009 is a positive element of influence for the net sales growth. The standard econometric tests for the last two models also yield good results and all variables included are highly statistically significant, although the fourth model explains in a considerably smaller proportion the variability of the net sales growth across the top EU industrial companies (Table 3). Since the analysis is limited to the data available in the Scoreboard, potentially important indicators that may have been omitted explain this outcome.

Summing up, our analysis found support for R&D spending as an important and stable factor of influence for the top EU industrial companies' economic performance.

4. Conclusions and lessons for Romania

Corporate R&D investment and its economic effects are the result of the interplay of a host of factors, only partly (and mostly indirectly) under the influence of policy makers. Nevertheless, a precise understanding of the nature of research and innovation and of the potential economic impact of R&D investment is vital in shaping the appropriate R&D policy. Romania may learn from the experience of the top R&D investors how to guide its prioritisation measures and to better exploit its innovation capacity.

Our study on the effects of the main R&D variables on the economic results of the top EU industrial companies suggests that the relationship between R&D investment and performance is stable even in times of economic crisis. The net sales of top EU industrial companies significantly depended upon R&D investment, the number of employees and the market capitalization, all acting as positive factors of influence, both in 2009 and 2010 models. The constant positive effect of R&D on economic performance was revealed by the variables' dynamics as well: besides the growth in classical production factors (labour and capital), the R&D investment growth in 2010 relative to 2009 has proved to be a significant element of influence for the growth in net sales.

The recent EU innovation policy gave increased attention to making the Internal Market, more innovation friendly creating a sound framework for Intellectual Property Rights and providing a comprehensive "lead-markets" strategy, that aims at removing the barriers to the uptake of new products and services. It is considered that EU innovation policies are too much industry and technology centered, despite services owning the highest share the economy. Especially the non-technological innovations, that are particularly suited in services, should be encouraged in order to better exploit their great performance potential.

European and national level policies should form a coherent mix, in which all measures combine and each local policy is adjusted to local needs, focusing on specific market and systemic failures. In Romania's case, innovation deficit in resources and performance calls for increased measures focused on innovation demand enhancing. Romania is lagging behind most EU countries and other developed countries in terms of both the research potential and innovation performance (Sandu and Paun, 2009) due to low inputs for R&D and innovation, as well as to rather low co-operation capacity of firms with knowledge creating partners (Dachin, 2009; Sandu, 2010; Todose et al. 2011). As in most EU Member States, Romanian S&T policy is traditionally based on using public funding to build R&D capacities, while the firms are lacking incentives to innovate. In the current post-crisis environment Romania clearly needs a shift in its R&D policy towards measures to boost corporate R&D investments, to facilitate co-operation between complementary R&D actors, to stimulate diffusion and uptake of knowledge, thus increasing the efficiency of the resources used. As the institutional building aiming at encouraging innovation based on partnership is strongly supported from public sources, one question to be answered is weather the public support should stimulate innovation in R&D poles or increase the capacity of underdeveloped regions to absorb new technologies, while reducing the agglomeration effects (Dachin, 2009; Roman, 2010).

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