Insights On Education - Innovation Links And Impact

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ABSTRACT

This paper analyzes the characteristics of innovative enterprises in the EU in terms of education of employed personnel and its incidence on innovation output, given the key role of education in the innovation process. We use data from the Community Innovation Survey which allows the analysis of enterprises in a broader context of the objectives and strategies pursued by them. Our study identifies significant direct link between increasing the proportion of personnel with university studies employed by innovative firms and increasing turnover. The role of practices promoted by firms such as employment of qualified personnel is conducive for innovative output. These findings have important implications for policy makers and managers within the EU.

Keywords: *education, enterprise, human capital, innovation, universities.*
JEL classification: *O15, O31.*

INTRODUCTION

Given the rapid technological change, the ability of organizations to innovate or develop new products or services has significant influence on their long-term performance. Innovation is a key to organizational success, resulting in increased production and profits and gaining more market share in terms of better satisfying the customer requirements. Increasing innovativeness leads to success and to the ability to cope with continuous changes in the market. Innovative initiatives tend to depend significantly on the knowledge and experience of employees, which outlines the key inputs in the innovation process.

The idea that educated employees play a key role in innovation activities, and they, in turn, lead to increased productivity is not new. That follows from the theory of endogenous growth, addressing the link between education and economic growth, based on the contributions that Nelson and Phelps (1966) have had and subsequent Schumpeterian developments. Economic growth is expressed in terms of human capital stock which, in turn, affects the ability of innovation and increasing productivity.

Education and research are core activities in academia, giving relevance to the economy as far as externalities are provided due to the formation of individuals and generated knowledge, having the characteristics of quasi-public goods. In fact, maximizing knowledge externalities is the main reason for the existence of universities focused on training and research. Involvement in research projects by collaboration is based on interactions that characterize universities and businesses, affecting innovation. In this framework, the recruitment of graduates in the business sector is also included, which is the most obvious channel of interaction between the two. Another type of interaction is through setting up of new enterprises (by spin-offs and start-up), promoting innovation and productivity growth. The transition to the knowledge economy involves increasing in universities supply to the growing demand for knowledge and highly qualified staff in the business sector. From this perspective, universities play an indirect role in productivity growth and expansion of industry and services (Foray and Lissony, 2010). Universities also contribute directly to innovation by providing solutions and devices or through involvement in research activities.

In the following, we assume that increasing in employment of highly qualified personnel boosts innovation activity, grows production by knowledge development at the firm-level (Smith et al., 2005) and supports absorptive capacity (Cohen and Levinthal, 1990). Following this idea, we can formulate the hypothesis that firms can obtain better results in innovation when they use more specialists than firms less interested in employing of skilled labor force, and the first register, as a result, increasing production. Although the data availability has always been the touchstone in analyzes associated with causal links that are established between labor quality and innovation output, some studies highlight that, among other factors, human capital is a powerful catalyst in innovation. For example, Brynjolfsson and Saunders (2010) show that firms with a greater number of high skilled workers are likely to adopt new technologies and innovative systems. McMorrow et al. (2009) demonstrate the direct relationship between investments in research and development, education (measured by the number of years of schooling) and the total factor productivity. Romer (2001) argues that scientists and engineers are relevant for research activity. Using macroeconomic models, Barro (1997) and Aghion and Howitt (1998) show that human capital increases the probability of innovation and stress the importance of employees working in research and development etc.

In order to identify such causal relationships expressed above, we consider the analysis of innovative firms operating in the EU area, using the latest data provided by Eurostat in Commission Innovation Survey in 2014 (for the period 2010 - 2012) analyzing, in section 2, how the ”human resource” indicator progresses, knowing that it is viewed as a facilitator of innovation. In section 3 we analyze causal links associated with employment of personnel with university education by innovative enterprises and their objectives in innovation activity framed in their strategies and section 4 concludes.

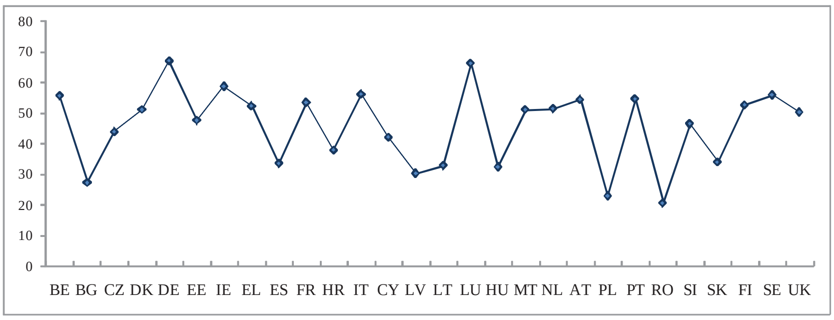
HUMAN CAPITAL - FACILITATOR OF INNOVATION

Although the role of human capital - with reference to skills, abilities and knowledge acquired by individuals - in innovation is not so often embedded in empirical studies in its relation to innovative output, it is explicitly highlighted in indicators of innovation. For instance, it is recognized and included as a facilitator of innovation in composite indicators used to assess the performance of innovation, considering the latter to be a result of components and relations established within the national innovation system. The composite indicators developed by the World Bank, the World Economic Forum or by the European Commission etc. which, according to the methods of aggregation used, compose various scoreboards, have the advantage of incorporating elements in connection with the activities of the national innovation systems affecting innovation outcomes.

The European Innovation Scoreboard (EIS) is the most used indicator in Europe, which enables comparisons in innovation performance between countries, being the synthetic expression of a set of sub-indicators (the enablers, firm activities and innovation output) with direct influence on the EIS composite indicator. In the period 2006 - 2013 there was an increase in the size of EIS from 0.493 in 2006 to 0.554 in 2013 (European Commission, 2014a). However, we can observe stability in its size in some countries situated in various performance groups, but significant differences registered as well between countries when the sub-component indicators are compared. That fact can be explained looking the number of innovative enterprises - indicator of innovativeness with major impact on the EIS - that varies from one country to another as we show in the figure below:

The proportion of innovative enterprises in the total enterprises

Figure 1



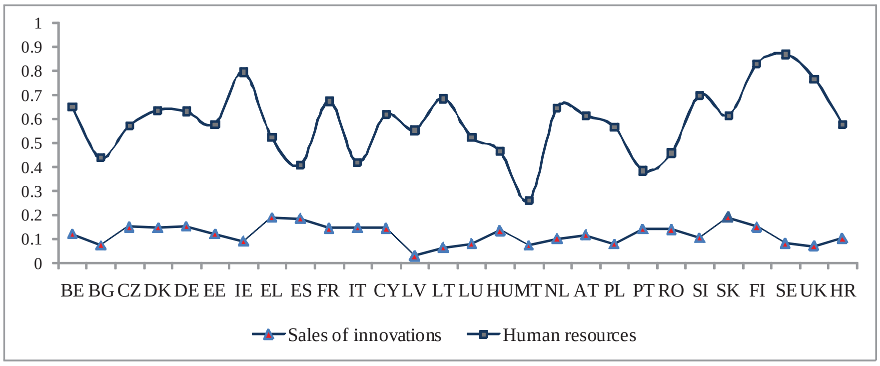
Data source: European Commission (2014b) - CIS 8 (all NACE core activities related to innovation)

Firms with technological (product and process) and non-technological (organizational and marketing) innovation are included in the EIS. The Oslo Manual definition is used in the EIS and CIS: "innovation is the implementation of a new or significantly improved product (good or service) or process, a new marketing method or a new organisational method in business practices, workplace organisation or external relations" (OECD, 2005, p. 46).

Significant differences in the size of composite sub-indicators have impact on the variation in the EIS. For instance, some countries with increasing in EIS innovativeness indicator above its level at the EU average have also experienced an improvement including in "human resources" sub-indicator (European Commission, 2014a). The latter measure the availability of educated and highly skilled labor force and correspond to the group of innovation facilitators, with reference to the main drivers of innovation performance that are outside the process of the enterprise decision-making. Figure 2, shows the evolution of the "human resources" sub-indicator in correspondence with an output indicator - sales due to innovation activities in countries of the European Union:

"Human resource" and "innovation output" indicators in member states of the EU

Figure 2.



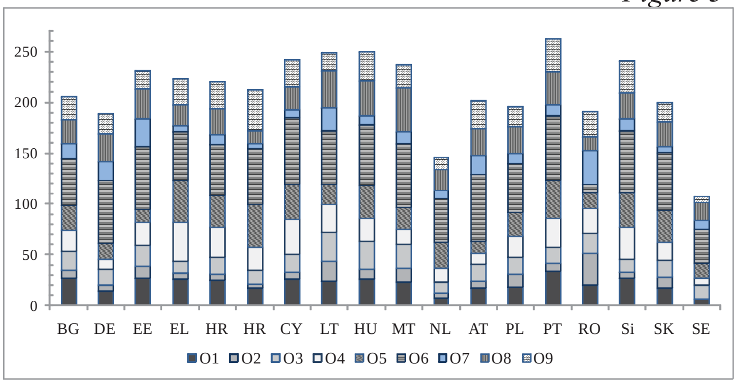
Data source: European Commission (2014b) - CIS 8 (all NACE core activities related to innovation)

As we can observe, the size of the "human resource" sub-indicator registers significant differences among the EU countries, but such differences caught in "innovative sales" appear to be less obvious. This is because the influences of other factors such as financing problems faced by innovative firms, the access to the new markets for goods, the demand size etc. express combined influence on innovative activities and output registered by firms as well. Obviously, since the ”human resource” sub-indicator includes information on education of workforce in the labor market and does not refers to the labor force actually used by enterprises, it is not an appropriate measure to be used to highlight its effect on the innovative output. This is another reason why, from the data in figure 2, the link between ”human resource” and innovation performance cannot be established.

The CIS8 data published by Eurostat in 2014 for the period 2010 - 2012 enable us to identify and compare the most important factors that hinder innovation activities and, in that context, the role exercised by the lack of qualified personal” can be identified. Figure 3 shows the proportions of (non-mutually exclusive) responses given by innovative enterprises on the most important obstacles perceived by them in their activity:

Innovation obstacles perceived by innovative firms

Figure 3



Data source: European Commission (2014b) - CIS 8 (all NACE core activities related to innovation)

Innovation obstacles - symbols used in figure 3

Table 1

Symbol	Enterprises:
O1	- considering high costs of access to new markets highly important
O2	- considering innovations introduced by competitors highly important
O3	- considering dominant market share held by competitors highly important
O4	- considering a lack of adequate finance highly important
05	- considering a lack of demand highly important
O6	- considering strong price competition highly important
O7	- considering a lack of qualified personnel highly important
O8	- considering strong competition on product quality highly important
O9	- considering high costs of meeting regulations highly important

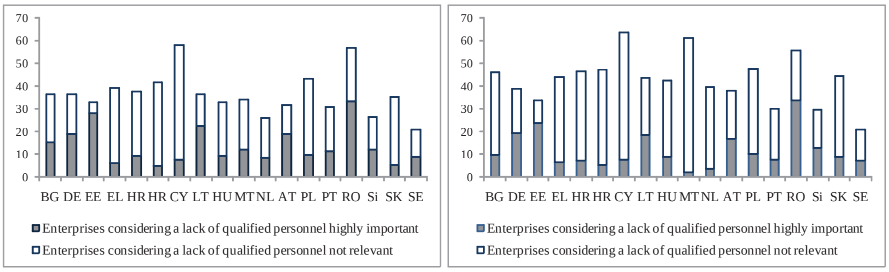
Source: European Commission (2014b) - CIS 8.

In general, the most important obstacles to innovation activity appear to be those related to the firms’ market, including strong price competition and the lack of demand. Also, the lack of adequate finance seems to be highly important alongside high costs of access to new markets and of meeting regulations. Although the lack of qualified personnel does not appear to be the most important, it is considered as a factor of hampering innovation by innovative and non-innovative enterprises as well. This fact can be emphasized more strongly using the firms' responses to the CIS questionnaire by countries and type of enterprise:

The lack of qualified personnel - important factor of hampering innovation

a. innovative enterprises **b. non-innovative enterprises**

Figure 4.



Data source: European Commission (2014b) - CIS 8 (all NACE core activities related to innovation)

The data in figure 4a show that the most affected are enterprises in Romania (33.4%), Estonia (28.1%) and Lithuania (22.4%), which are at a significant distance from firms in other countries in terms of the perceived lack of qualified personnel with adverse impact on innovation. In the same sample of countries (figure 4b), non-innovative enterprises are identified to be the most affected by the lack of qualified personnel (Romania - 33.9%, Estonia - 23.6%, Lithuania - 18.7%). Both sides in figure 4 (a and b) display comparisons between innovators and non-innovators resulting, as we have expected, that the innovative enterprises can be more affected by the lack of qualified personnel, given the role of education in increasing productivity and facilitating the dissemination of technology.

EMPLOYEES EDUCATION AND BUSINESS STRATEGIES AND GOALS - CORRELATIONS AND INTERPRETATIONS

To a large extent, human capital incorporates the level of education acquired through schooling and formal training in firms. The first component refers to the number of years of schooling that the employees possess. Firms benefit of the education level of employees, given that education boosts the capacity of understanding, creation and processing of information. Moreover, the workforce that have a certain level of education show greater ability to absorb knowledge and exploit opportunities than workforce with lower levels of schooling. A direct link between education and innovation is demonstrated by some authors (Knight et al., 2003). Liu and Buck (2007) included the education level in order to explain innovation output in China identifying a significant effect as well. Therefore, a higher level of employees education facilitates the absorption ad transferring of knowledge in innovations and that increases turnover obtained by firms, reduces costs, increases market share etc., in according with the firms' strategies.

Starting from this conceptual support, we consider of interest to investigate whether growing in employees education leads to increasing in enterprises performance in which they work. In this respect, we use the available data in the period 2010 - 2012, published in 2014 in the CIS 8, expressing education of employees in terms of proportions of employees with university education in total employees in the EU countries. In this context, we refer to innovative firms in all core NACE activities related to innovation and we use firms that have a certain proportion of employees with university education in the total employees. The classification of innovative firms according to this criterion is found in the CIS 8 in the form of the following indicators:

Enterprises classification by % of employees with university education

Table 2

Symbol	Enterprises:
u_0	- with 0 % of employees with university education
u_1_4	- with 1 % to 4 % of employees with university education
u_5_9	- with 5 % to 9 % of employees with university education
u_10_24	- with 10 % to 24 % of employees with university education
u_25_49	- with 25 % to 49 % of employees with university education
u_50_74	- with 50 % to 74 % of employees with university education
u_m75	- with more than 75 % of employees with university education

Source: European Commission (2014b) - CIS 8.

The number of innovative enterprises by number of employees with university education, in various member and candidates states at the EU, which we dispose, are summarized in table 3, alongside the total turnover (in thousand euros) of enterprises:

Number of innovative enterprises by type of employees with university education

Table 3.

Country	u_0	u_1_4	u_5_9	u_10_24	u_25_49	u_50_74	u_m75	Total	Turnover (turn)
Belgium	335	733	966	1908	1602	999	1395	7938	457163679
Bulgaria	321	969	460	726	533	322	589	3920	40026723
Germany	17038	10786	16563	24126	9862	6871	5149	90395	4287731000
Estonia	39	204	146	317	282	317	355	1660	16306721
Greece	699	1625	1044	1746	1241	764	720	7839	106003346
Croatia	374	485	436	528	374	238	189	2624	39102552
Italy	23210	16002	6461	9394	5376	3103	1907	65453	1654964825
Cyprus	33	14	62	220	163	99	77	668	12479178
Latvia	49	212	236	294	311	149	190	1441	14373881
Hungary	334	860	743	1168	778	522	514	4919	121944563
Malta	110	33	93	72	46	25	19	398	7254101
Netherlands	27	1308	2031	4611	1825	1448	1717	12967	521901584,00
Poland	924	422	1147	3859	2778	1451	1925	12506	374017826
Portugal	1846	2924	1298	1597	734	587	661	9647	135833755
Romania	20	1183	1220	1655	894	404	589	5965	60020588
Slovenia	82	239	288	580	366	233	170	1958	36970577
Slovakia	79	364	352	665	366	267	209	2302	76580698
Serbia	633	861	598	692	463	229	227	3703	3647475

Data source: European Commission (2014b) - CIS 8 (all NACE core activities related to innovation).

According to the methodology used in the CIS 8 on these indicators, each enterprise falls into one category. However, we find from the data analysis that they are highly correlated so, introducing them as independent variables to explain the performance achieved by innovative firms could lead to inadequate results. We use, in a first stage, the principal component analysis (PCA) in order to overcome this shortcoming, but also to highlight, in a broader context, existing associations between variables reflecting the use of personnel with university education by enterprises and their strategies and goals. By that method, we can reduce the number of variables that relate both to the use of personnel with university education by innovative firms and their goals; to identify whether significant correlations establish between the two types of indicators, namely the personnel used and goals; to identify if there are variables associated with the two types of indicators and the main components which result from their combination. If the last hypothesis is confirmed, we are able to identify the extent by which increasing in firm performance can be explained by at least one component formed from PCA.

In order to perform PCA analysis, we introduce the data above, alongside the indicators related to the goals of innovative firms such as reducing of costs, increasing of market share, increasing of profits and turnover. Since these dimensions do not incorporate information on the novelty of the products or services, that are of interest in terms of influences exercised by highly qualified human factor, we introduce these aspects in analysis identified in the CIS 8 as elements of enterprises' strategy. Another indicator that refers to the goods or services novelty is the number of enterprises that consider that introducing new or significantly improved goods or services is highly important. We use the indicator which refers to the "enterprises that consider developing new markets outside Europe highly important" (m_OEU) as a measure of products novelty, having the possibility of making comparisons with the "enterprises that consider developing new markets within Europe highly important" (m_EU) indicator.

The designations and symbols of the variables incorporating goals and strategy elements of innovative enterprises, which we include into analysis are presented in the following table:

Strategies and goals of innovative enterprises - as highly important and not relevant

Table 4

Symbol	Enterprises:
	Strategies
m_EU	- that consider developing new markets within Europe highly important
m_OEU	- that consider developing new markets outside Europe highly important
	Goals
dc	- considering a decrease in costs highly important
n_dc	- considering a decrease in costs not relevant
ims	- considering an increase in market share highly important
n_ims	- considering an increase in market share not relevant
ipm	- considering an increase in profit margins highly important
n_ipm	- considering an increase in profit margins not relevant
it	- considering an increase in turnover highly important
n_it	- considering an increase in turnover not relevant

Source: European Commission (2014b) - CIS 8.

We use the same sample of countries for the values of variables above in which operate firms in all NACE core activities related to innovation. Descriptive statistics are summarized in the following table:

Descriptive statistics - goals and strategies

Table 5

Symbol	Mean	Std.dev.	Min	Max
m_EU	4926.83	9852.31	174.00	34347.00
m_OEU	6457.78	13190.09	190.00	48559.00
dc	7355.11	13427.77	260.00	47691.00
n_dc	469.61	892.15	11.00	3130.00
ims	5348.06	8879.12	182.00	31595.00
n_ims	1271.56	2700.54	24.00	9317.00
ipm	6650.06	13342.24	266.00	63152.00
n_ipm	773.67	1519.30	23.00	6019.00
it	7925.72	14393.85	54.00	54281.00
n_it	475.00	899.45	11.00	3193.00

Source: author's calculation.

Descriptive statistics analysis shows that there are discrepancies between the values of the indicators regarding the goals of innovative firms and their strategies in many countries. In order to emphasize better those disparities and to group the variables that are not influenced by the same factors, we use principal component analysis (PCA).

In this respect, we select Kaiser's criterion for choosing the number of factorial axes, namely the components which result form PCA. The Bartlett's test is another indication of the strength of the relationship among variables. Table 6 shows the results for the KMO and Bartlett tests. The value for KMO is good, meaning that pattern of correlations are relatively compact and hence factor analysis should yield distinct and reliable factors. The Bartlett's test of sphericity is significant as well ($p < 0.001$), and therefore principal component analysis is appropriate.

KMO and Bartlett's Test

Table 6.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.688
Bartlett's test of sphericity	Approx. Chi-Square	1209.55
	df	136
	Sig.	0.00

Source: author's calculation.

Two main components are obtained from PCA analysis and they cumulatively explain 98.7% of the total variance. We implement varimax rotation to facilitate the interpretation of these components and the results are summarized in table 7:

Rotated component matrix

Table 7

Variable		Component	
Designation	Symbol	1	2
Enterprises with more than 75 % of employees with university education	u_m75	**0.912**	0.339
Enterprises with 10 % to 24 % of employees with university education	u_10_24	**0.902**	0.429
Enterprises with 5 % to 9 % of employees with university education	u_5_9	**0.887**	0.444
Enterprises with 50 % to 74 % of employees with university education	u_50_74	**0.885**	0.464
Enterprises with 25 % to 49 % of employees with university education	u_25_49	**0.841**	**0.532**
Enterprises considering an increase in profit margins highly important	imp	**0.818**	**0.564**
Enterprises considering an increase in turnover highly important	it	**0.755**	**0.653**
Enterprises that consider developing new markets outside Europe highly important	m_OEU	**0.735**	**0.673**
Enterprises considering an increase in profit margins not relevant	n_ipm	0.333	**0.927**
Enterprises with 1 % to 4 % of employees with university education	u_1_4	0.417	**0.898**
Enterprises with 0 % of employees with university education	u_0	0.454	**0.885**
Enterprises considering an increase in turnover not relevant	n_it	**0.521**	**0.848**
Enterprises considering a decrease in costs not relevant	n_dc	**0.527**	**0.841**
Enterprises considering an increase in market share not relevant	n_ims	**0.677**	**0.734**
Enterprises that consider developing new markets within Europe highly important	m_EU	**0.677**	**0.732**
Enterprises considering an increase in market share highly important	ims	**0.691**	**0.718**
Enterprises considering a decrease in costs highly important	dc	**0.692**	**0.712**
Extraction method: Principal Component Analysis. Rotation method: Varimax with Kaiser normalization.			

Source: author’s calculation.

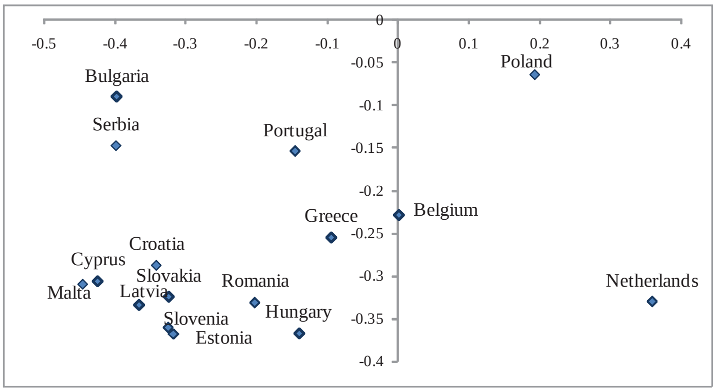
In order to interpret the results, we consider the values greater than 0.5 (in absolute value) only, which are marked in bold in table 7. As it can be seen, the first component is closely correlated with eight variables describing, on the one hand, the highest proportion of employees with university education (between 5% and 75%) and, on the other hand, goals of growing in profit and turnover, framed in a strategy of developing of new markets outside Europe. Significant correlations of these three variables can be observed including with component 2, but there are stronger correlations with component 1. In the same framework, component 2 is highly correlated with other variables that incorporate, to a largest extent, elements associated with enterprises goals, significant correlations are also identified with two variables related to firms operating with the lowest proportions of personnel with university education. A firms common goal, which is significantly correlated with component 2, emerges especially to resist on the goods market, given that the strongest correlations establish with enterprises that consider that ‘’an increase in profit margins is not relevant’’ (which can mean that increasing in turnover or, conversely, reducing in costs is not relevant) and ‘’an increase in turnover is not relevant’’ (which can mean that increasing in profits by cutting in costs could be more relevant). The correlation between component 2 and the variable reflecting that an increase in market share is highly important is stronger than the correlation between the same component and the variable associated with enterprises considering an increase in market share is not relevant but, in the same time, the ‘’enterprises that consider developing new markets within Europe highly important” variable is stronger correlated with component 2.

As a result, we can interpret the two components as incorporating high innovative enterprises (component 1) and medium-low innovative enterprises (component 2). The first comprises the highest proportions of personnel with university education, having increasing in profit and turnover as the main goal included mostly in a strategy of ‘’developing new markets outside Europe’’. The second component relates especially to those firms that do not aim at increasing in profit or turnover, but the maintenance and development of markets with a high probability of being local or regional, incorporating the lowest proportion of employees with university education.

A more detailed analysis on the links between the two components in the European space can be achieved by one of the graphical tools permitted by PCA method, that allows the distribution of the firms operating in various countries to be studied and their placement compared to other firms from other countries at the same time. The graph obtained by combining the component 1 (on the ‘’ox’’ axis) with the component 2 (on the ‘’oy’’ axis), which shows the distribution of firms by country in the four quadrants created by the ox-oy two-dimensional space, is shown in figure 5. In this framework, the place where each country is distributed can be seen, depending on the positioning of the two principal components under consideration.

Graphical representation of the combination of components 1 and 2

Figure 5



The firms by country can be distributed as follows:

- firms from Germany can be identified (not shown in the figure, with significantly higher coordinates) in quadrant 1 (+, +), namely in the positive space created by the two components (1 and 2). According to European Commission (2014), Germany is one of the innovation leaders;
- in quadrant 2 (+, -) firms operating in Belgium and Netherlands are placed. Those countries are in the group of the innovation followers. Surprisingly, we found that firms operating in Poland (a moderate innovator country) are placed in the same quadrant;
- quadrant 3 (-, -) incorporates firms from innovation followers (Estonia and Cyprus), but especially from moderate innovators (Portugal, Greece, Hungary, Malta, Slovenia, Slovakia) and modest innovators (Romania, Latvia and Bulgaria).

The results in the graph above are consistent with the grouping of the EU countries by innovation performance, according to the EIS indicator so, they confirm the accuracy of our analysis. In order to identify how increasing in enterprises' performance can be explained by at least one of the components resulted from PCA analysis we use a multiple linear regression model specified by the following general equation:

$$Turn_i = \beta_{0i} + \beta_1 C_{1i} + \beta_2 C_{2i} + \varepsilon_i \qquad (1)$$

in which, $Turn_i$ - dependent variable - turnover registered for each group of firms operating in the country *i*; C_{1i}, C_{2i} - the two principal components scores considered as exogenous variables; β_1, β_2 - parameters that summarize the principal components contribution to the dependent variable; ε_i - an independent and identical distributed error term for *i* with zero mean and σ^2 variance.

OLS regression coefficients

Table 8

	Dependent variable "turnover"		
	Coefficient	Std. error	p
Component 1	924006408.94	28325274,119	0.00
Component 2	457574384.01	28325274,119	0.00
(Constant)	442573504.00	27527218,466	0.00
R-squared	0.989		
F-statistic	662.55		
Durbin-Watson	1.53		

Source: author's calculation.

Our results indicate that although both groups - high innovative enterprises (expressed by the component 1) and medium-low innovative performers (expressed by the component 2) - are factors that explain increasing of turnover, the greater coefficient of the component 1 indicates a greater contribution of that component to the turnover increase. The standard econometric tests show good results, and both variables introduced are highly statistically significant. This result demonstrates that the higher proportion of employees with university education is found within the high innovative enterprises and represents an innovation and increasing production facilitator.

CONCLUSIONS

Our results confirm that innovation is fostered as human capital increases and indicate direct effects of independent variables, namely the employee schooling in universities, on the turnover obtained by enterprises. Employment of personnel with university education falls into the firm's decision-making process, alongside formal training performed in that context.

Direct effects also identified attest the results obtained by other authors mentioned above and we could expect that the link between schooling and innovation to be stronger if various levels of education had been introduced. This limitation of our study, as a result of the lack of data, would be interesting for future research, including other firm-specific practices such as providing of formal training. In fact, the role played by enterprises in employment of specialists but also in improving of human capital through specific practices such as providing formal training is obvious. In the same context of the limitations of the present study we place the impossibility to reflect stronger the incidence of human capital on the novelty of products or services due to lack of data at the firm level.

However, beyond the practical implications for the management of innovative firms in which the selection, recruitment and training of specialists, as well as financing of research and development (R&D) projects are of importance, we must notice that competences in the innovation system are build, to a large extent, in universities. Therefore, it would be interesting to consider shaping a response to the following question in the future: what types and levels of education and training are most appropriate for certain types of (product or process/radical or incremental innovation? This requires the study of interactions between the components and activities of innovation system, so that human capital and financial resources to be effectively allocated.

Taking into account the results of PCA analysis, and factors that hamper innovation as well, we reveal that the innovative firms particularly operating in countries that are in the group of modest innovators, including Romania, have difficulties regarding the lack of specialists. For instance, although the gap, mainly in tertiary education and doctoral studies, with the highest innovation potential, have declined steadily after 2007, there is still a significant gap between the sub-indicators at the EU average and those related to Romania. Training and increasing the number of specialists is crucial from the perspective of using indigenous capacity for innovation and technology absorption especially in these countries, including Romania.

Universities have a double major role, a formative one of highly qualified labor force and of performing basic and applied research. Maintaining low expenditure for education and research has serious negative consequences for the performance of universities in the innovation system. Although some initiatives have been taken in defining of strategies in research areas and by seeking to strengthen the links between universities and industrial innovation by implementing science parks located in several universities to promote local economic development, they have remained in declarative stage in Romania. On the contrary, financing of various programs has been stopped or the implementation of new projects has been delayed. In addition, the efficiency of public spending on R&D, the quality and fairness in evaluating of projects that request public financial support, the socio-economic relevance of some public funded research projects and their relevance to the specific needs of the Romanian industry is still questioned.

Universities are the most important public organization performing research not only in Romania, but also in other countries. Government funding of R&D projects is achieved through grants. The innovation system also includes public research institutions performing the same type of research as universities, including applied and technological development. In other words, different organizations perform the same activities in the innovation system, even if they are confronted with inadequate infrastructure for a high performance research, and inappropriate distribution of researchers in various areas and regions, defective collaboration between researchers of distinct organizations and between them and the business environment. The current weaknesses in the innovation system consist also in underfunding of public R&D, the lack of a legal framework for assessing of R&D effectiveness, and a weak correlation between R&D and the needs for restructuring and industrial development.

References

1.Aghion P., Howitt, P. (1998), Endogenous Growth Theory. MIT Press, Cambridge, MA.
2. Barro R. J. (1997), Determinants of Economic Growth: A Cross-Country Empirical Study, Lionel Robbins Lectures, MIT Press, Cambridge, MA.
3. Brynjolfsson E., Saunders A. (2010), Wired for Innovation. How Information Technology is Reshaping the Economy, MIT Press, Cambridge, MA.
4. Cohen W. M., Levinthal D. A. (1989), Innovation and Learning: The Two Faces of R&D, The Economic Journal, 99(397), pp. 569–59.

5. Diaconu M. (2012), Performance paradigms in the innovation activity: the case of Romania, Actual Problems of Economics, pp. 292-302.
6. European Commission (2014a), Innovation Union Scoreboard, http://ec.europa.eu/enterprise/policies/ innovation/policy/innovation-scoreboard/index_en.htm.
7. European Commission (2014b), Community Innovation Survey 8 (2010 - 2012). Eurostat. http://epp.eurostat.ec.europa.eu/ portal/page/portal/statistics/search_database.
8. Foray D., Lissony F. (2010), University Research and Public-Private Interactions, In Hall B., Rosenberg N. (eds.), Handbook of Economics of Innovation, Volume 1, Elsevier, pp. 275-314.
9. Knight J., Weir S., Woldehanna T. (2003), The role of education in facilitating risk-taking and innovation in agriculture, Journal of Development Studies, 39(6), pp. 1–22.
10. Liu X., Buck T. (2007), Innovation performance and channels for international technology spillovers: Evidence from Chinese high-tech industries, Research Policy, 36(3), pp. 355–366.
11. McMorrow K., Roeger W., Turrini A. A. (2009), The EU-US total factor productivity gap: An industry-level perspective, CEPR Discussion Papers, Working paper 7237.
12. Nelson R., Phelps E. (1966), Investment in Humans, Technological diffusion and Economic Growth, American Economic Review Proceedings, LVI, pp. 69-75.
13. OECD (2005), Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, OECD Publishing, Paris.
14. Romer P. M. (2001), Should the government subsidize supply or demand in the market for scientists and engineers? National Bureau of Economic Research, Working Paper 7723.
15. Smith K. G., Collins C. J., Clark, K. D. (2005), Existing Knowledge, Knowledge Creation Capability, and the Rate of New Product Introduction in High-Technology Firms, Academy of Management Journal, 48(2), pp. 346–357.