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Obstacles to innovation and policy implications: exploring the case of Romanian firms

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Abstract. *This paper analyses the weaknesses that characterize innovation in Romanian firms and the main obstacles encountered in innovation. Using CIS7 data referring to innovative firms operating in the manufacturing and services, our results reveals that the main obstacles faced by them are conditioned by the composition of the innovation expenditures and are located essentially within the sphere of lack of knowledge and technological opportunities and also the lack of internal resources for funding and low capacity to attract funding from the financial market. These measures can be the basis for the measures that can be adopted through government policies.*

Keywords: firm, innovation, research and development, government policies, Romania.

JEL Classification: O3.

1. Introduction

Innovation is a source of competitive advantage for firms, allowing them to survive and grow on the national and international markets. The interrelation between the ability of firms, industries and nations to advance technologically and the long-term economic performance has become obvious in the modern society.

This is also of interest to governments that monitor indicators of innovation in order to assess the strengths and weaknesses of innovation systems. It starts from the premise that education and research are the main determinants of innovation capacity and economic growth. In this context, the supply of knowledge is encouraged by supporting education and research activities in the public sector. Education can generate highly qualified staff to be used in various activities, and its absorption capacity in terms of assimilating knowledge and ability of recognizing the usefulness of new information can be used productively. The efficient spending of financial and human resources can result from the interaction of knowledge-generating sectors with knowledge-demand sectors that include innovative firms.

Currently, the literature on the factors affecting the decisions of firms to innovate is well developed, including in this framework the empirical studies using firm-level data as well. The way in which firms manage to use human, financial and informational resources in the innovation activity is being investigated. Despite the increasing number of studies (a survey is conducted by Smith, 2006, pp. 148-177), they have been made especially in European leaders and major innovators countries (Mohnen et al., 2006; Mairesse and Mohnen, 2002, etc.).

Few studies on firm innovativeness and factors affecting innovation, including obstacles to innovation have been made on the case of CEE countries. This paper analyzes the obstacles encountered by the Romanian innovative firms in manufacturing and services. Appropriate measures are identified to be adopted by the government policies to boost innovation by highlighting obstacles with the highest incidence on innovation inputs. Our concern is justified by the fact that Romania has been consistently in the modest innovators group according to the composite indicator of innovativeness (EIS, European Innovation Scoreboard) in the period 2006-2021.

Section 2 reviews the factors affecting the innovation in firms identified in the literature and the main constraints faced by innovative firms. Section 3 characterizes innovation in firms and analyses the obstacles to innovation. In this framework, we start from the premise that the obstacles identified can be used as explanatory variables for innovation inputs, including small share of expenditures in research and development (R&D) in the composition of the total innovation effort as a result of the innovation modes adopted by firms in Romania. In this respect, we consider separate testing models for the innovation inputs in manufacturing and service industries using CIS7 (Community Innovation Survey) data and section 4 concludes and discuss policy implications.

2. Innovation facilitators and barriers

It is well known that innovation process of developing of new products and services involves spending of financing resources. In this respect, projects financing can have several characteristics (Hall, 2009 and 2010; Hall & van Reenen, 2000) and decisions to invest can be conditioned by the market size (Schmookler, 1966), the technological opportunities and appropriability (Jaffe, 1998), that can vary depending on firm's size (Acs and Audretsch, 1991, pp. 39-59; Cohen and Kepler, 1996; Cohen, 2010, pp. 129-213).

The firm's size and its incidence on innovation is the subject of countless investigations in the literature aiming to test differences on enterprises groups. Clear evidences exist regarding the relative advantage of large firms through greater opportunities for funding high-risk R&D projects, obtaining higher yields to the total turnover on which the fixed costs are spread or, due to complementarities between R&D and other activities that are seen to be developed more easily in large companies, and also due to the large capacity to diversify business yields and reducing risk in innovation activity. Counterarguments have also been suggested (especially in Scherer and Ross, 1990) in associating of the large enterprises with diminishing the managerial control or, conversely, with an excessive control that would not be favorable for research caused, inter alia, by lower salaries to individual researchers and diminishing of creative impulses.

Over the time, the research on the relationship between the firm's size and R&D expenditure have been generated lots of models starting from the assumptions summarized above, followed by their testing using R&D intensity as the dependent variable and using a measure of firm's size as regressor. R&D increases proportionally with the firm's size in association with a lower increase in output (Cohen et al., 1987; Lerner, 2006) and the R&D productivity is reduced when the firm's size increases (Acs and Audretsch, 1991, pp. 39-59). Also, although it is suggested that large firms have an advantage by their higher capacity of sharing their fixed costs in achieving yields from R&D, this feature results from their better ability of revenue collection. The relative disadvantage of small firms can be mitigated by licensing of technologies or by rapid growth due to innovation (Cohen, 2010, pp. 129-213).

Regardless of their size, firms must have *financial resources* to innovate. Increasing the share of R&D expenditure in the total funds attaches certain features to R&D projects. As an investment activity, R&D distinguishes from other investments in real assets. First, a significant amount of financial resources are allocated to the staff (scientists and engineers) salaries. Their efforts to increase knowledge and the creation of intangible assets are sources of future profits for firms, but these adjustment expenditures are made gradually (Hall, 2009; Hall, 2010). Second, the R&D investment is expected to generate larger net revenues with higher standard deviation. Uncertainty is higher when the projects are implemented, which implies that the R&D strategy has an options-like character and should not be analyzed in a static framework. Also, since investments are made over time as new information arrives, uncertainty tends to be reduced at the end of the projects. The consequence of this fact is that the decision to invest has to be reassessed throughout the

life of the project. Third, innovation does not imply only a significant amount of financial resources, but also determines the reducing of guarantable assets, alongside increasing the proportion of intangible assets incorporated in the human capital, which determines that debt financing to be less adequate as the R&D increases in the total expenditures. Innovation by adopting new technologies and processes incorporates training costs of personnel, and registers non-recoverable expenditures as well. The uncertain nature of returns to innovation and the intangible character of the assets determine that financing innovation to be more difficult than ordinary investments using financial market mechanisms.

The increase in capital costs due to the risk perceived by capital providers may be a consequence of a reduction in financing innovation from retained earnings. A higher cost of capital than the rate of return (expressed more strongly to R&D) can involve discouraging innovation by reducing expenditures. The financial markets are recognized to be imperfect, resulting low investment expenditures manifested especially in small firms.

The innovation expenditures can be correlated with the *product demand* on the market. A part of the literature has been focused on the effects of market concentration on innovativeness. The various theoretical models adhere either to the Schumpeterian position that firms in concentrated markets have pronounced propensity to innovate or, on the contrary, it is argued (Gilbert and Newebery, 1982) that firms with monopoly power are more innovative and aim to avoid the costs associated with the loss of market power and entry of new companies in the markets space. Initially, the empirical models have investigated simple causal relationships, often between R&D expenditures and the market concentration (expressed as market share) with non-convergent results.

As stated by Cohen (2010), the market concentration (structure) is not itself an independent factor affecting innovation, but it may be a function of other variables, including even innovation. As a result, the correlation observed between the market structure and the R&D intensity may reflect either their co-determination or the impact of innovation on the market structure, that lead to difficulties in interpreting the results. Gilbert (2006) suggests that a low incidence of the market structure on innovation in the empirical studies is due to the industrial effects, which blurs the relationship between the two variables, the lack of control variables of theoretical importance, the limited data used in the econometric approaches or inadequate methods of investigation.

Demand, technological opportunities and appropriability are considered explanatory variables "more fundamental" than the market concentration (Cohen, 2010, pp. 129-213) affecting the firms' decision to innovate. Since the 1960s, numerous studies have been conducted to assess the importance of the demand as determinant of the propensity of firms to innovate. Market pull type assumptions are highlighted for the first time by Schmookler (1966), suggesting that the demand for new products determines the rate and direction in innovation. The theoretical literature shows two main aspects in which the inter-industry differences in demand may affect the propensity of firms to innovate. The first, shown by Schmookler, is the market size. Benefits from product or process innovation are

proportional to the size of the market. Inventiveness will intensify on the largest market when the cost of capital is constant and, also innovation will be stimulated as market is expected to grow rapidly. Second, the price elasticity of demand can affect the marginal return of R&D investments.

The benefits from reducing production costs (process innovation) are even higher as the demand is more elastic. On the other hand, the gains from product quality improvement (through product innovation) will be even higher as the demand is inelastic. Both the current market size (which, in general, has the greatest impact on the introduction of new products) and future (projected) market size influence innovation (Acemoglu and Linn, 2004).

The technology push approach emphasizes the importance of *technological opportunities* as determinants of innovation. The concept of technological opportunity incorporates a variety of phenomena, including the possibility of transforming knowledge into new products or processes, interactions with third parties (other firms, customers, suppliers, research institutions) that perform innovation activities, as well as easiness of knowledge externalities exploitation etc.

Even since the 1970s it has been emphasized the importance of acquiring new knowledge in innovation. In particular, Nelson and Winter (1982) argue that knowledge narrows the research options and allows attention to be focused on the most productive approaches. The consequence is that the research process is more efficient, fewer attempts are needed, fewer errors are recorded, and fewer options are necessary to be evaluated in order to obtain the desired result.

From this perspective, scientific knowledge provides an authentic guide to the processes of technological change. Increasing knowledge acquired in other organizations as collaborating firms on the market or higher education and research institutes can have a positive impact on the propensity of firms to invest in R&D, representing an important dimension of industrial technological opportunities. However, the empirical research in this direction is still one minor, and the results on the incidence of various factors on innovation will be different from one country to another.

For example, hampering factors to innovation such as the lack of financial resources and the technical knowledge are significant for firms in Catalonia (Segarra-Blasco et al., 2007), the lack of funds and reduced market demand are found as barriers to innovation in UK (D'Este et al., 2008) etc. Also, the distance from the technological frontier may involve specific barriers; the more firms are closer to it, as the more so their inability to identify qualified staff and partners becomes the main obstacle. The lack of external financing shapes another significant barrier for firms far from the technological frontier (Hölzl and Janger, 2011).

3. Innovation in Romanian firms and obstacles to innovation

3.1. Innovativeness characteristics in Romanian firms

According to the annual European Innovation Scoreboard (EIS), which provides a comparative assessment of the research and innovation performance of EU Member States, Romania has been constantly in the group of modest innovators, registering a trend that shows no progress in innovation activity reflected in the size of the composite index. Also, EIS sub-indicators show that Romania has significant spreads from the EU average in all areas, particularly related to the small share of innovative firms of the total firms, the extremely modest size of public expenditure allocated to research and development of the GDP, as well as low venture capital financing of innovative companies.

The *innovation facilitators* incorporate elements located outside the firm's decision, which are represented, in essence, by the human capital and public resources allocated to R&D of the GDP, including the participation of venture capital to financing innovation. Training of specialists in educational and research institutions is an important determinant of a nation's potential to innovate and growth in the long run, and this indicator is close to the level of the EU average in Romania.

However, keeping low and reducing public spending for education and research has serious negative consequences for the R&D performance within the innovation system. Although various initiatives have been undertaken to define the strategic research areas and by trying to strengthen the linkages between universities and industrial innovation by implementing science parks located in several university centers to promote local economic development, they remained in a declarative stage in the National Strategy of Research, Development and Innovation 2007-2013 and 2014-2020 by stopping the financing for various programs or by delaying implementation of new projects. In addition, the efficiency of public spending for R&D, the quality and accuracy in the evaluation of financial support applications for projects from public funds according to the National Plan for Research, Development and Innovation (NPRDI), the socio-economic relevance of several public-funded research projects and their relevance to the needs of the Romanian industry are still questioned. Also, the current weaknesses of the NPRDI consist of R&D underfunding from public resources, without a normative framework in assessing the effectiveness of R&D programs, and the poor correlation between R&D and the needs of restructuring and industrial development.

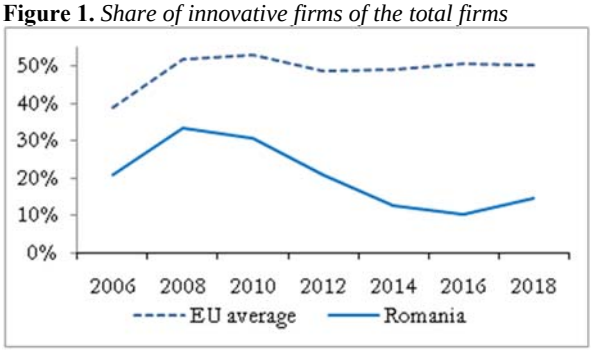
These have impacted negatively the level of financing resources allocated by the venture capital companies to innovative firms. The quasi-absence of business angels segment associated to the unstimulating context of creation and support of innovative firms in the early stages including through public-private partnership cannot, in principle, lead to an increase in the supply of venture capital which, in Romania does not exceed 0.04% of the GDP (check, for instance, the Invest in Europe website where this indicator is calculated annually in the CEE countries). Generally, the venture capital markets have been expanded in the CEE countries and a transition has been made from the traditional sectors to the

manufacturing and knowledge-intensive services. The foreign governmental agencies and not institutional investors are the main financiers of various R&D projects in firms in the CEE, including Romania. Due to their conservative attitudes, the institutional investors still play a minor role on the venture capital market (Diaconu, 2012, 2017).

Increasing the supply of venture capital is a necessary condition but it is not sufficient to raise the number of innovative firms. The world leaders in the field of venture capital have adequate means of stimulating entrepreneurship and the demand for venture capital. Romania needs a culture of risk taking, and exit mechanisms on the secondary financial markets for small enterprises as well. A low level of venture capital funding, such as it is in Romania, reflects a lack of financial resources and innovative firms.

The firm's activity expressed in the EIS composite indicator comprises sub-indicators associated with the R&D and non-R&D investments, cooperation and entrepreneurship, and intermediate innovation output. The unsatisfactory size of financial resources allocated to innovation by firms is mainly the result of the small share of innovative firms, which is much lower than that registered in the EU average, with an upward trend until 2008, subsequently registering a sharp decline (figure 1):

Figure 1. *Share of innovative firms of the total firms*



Source: Eurostat database (CIS4-CIS11) – innovation core activities.

In the same framework, the innovative firms allocate the lowest level of funds for research, below the EU average. In contrast, non-R&D expenditures have outpaced the EU average, which can be motivated by the need for technological renewal and production organization. This is also a result of a low capacity to innovate through creative effort, low collaboration with other companies and research institutes and an expression of the effects of industrial structure dominated by low-tech groups and significant share of non-innovative SMEs (Diaconu, 2013, pp. 270-349).

As consequence, innovation output indicators remain at levels also well below the EU average. Thus, the contribution of high-tech exports in manufacturing is on average 0.38% of the balance of trade in 2012--2018 (compared to 1.28% of the EU average). Nevertheless, the share of turnover from new to the market and new to the firm products of the total turnover (14.27%) is close to the EU average (14.38%). These indicators are important in assessing the creative effort of firms. However, the "new to the market" indicator is less suitable for international comparisons, as long as the firm's market cannot

be distinguished. Firms can operate on local, national or international markets with various levels of development. Therefore, an indicator built using firm-level data that clarifies the firms' market can be more appropriate in comparing the innovation performance.

Innovation in firms remains affected by weaknesses and significant discrepancies compared to the EU average, such as the lack of internal financing resources, the lack of equity funds from business angels and venture capital firms, the lack of financial support from public resources, weak collaboration with other firms and public research institutions as partners and the fragility of the entrepreneurship. Obviously, the lack of high risk projects funding, low technological opportunities resulting from poor collaboration in business, the lack of information on the markets etc. are obstacles to innovation intensity, which are variable from one firm to another depending on firm's size, sector of activity, and the composition of innovation expenditures.

3.2. Obstacles to innovation in Romanian firms

While it can be admitted that not all firms confront the same barriers to innovation and of the same intensity, we consider that some common features on the main factors hampering innovation can be highlighted. CIS (Commission Innovation Survey) conducted by Eurostat centralizes data every two years, the last were published in 2021 which refers to the period 2016-2018 and provides information on barriers to innovation resulting from interviewing both innovative and the non-innovative firms. CIS questionnaire asks questions about highly important factors hampering innovation activities (FH) resulting groups of innovative and non-innovative responding firms. The variables which we include in our analysis are summarized in the table below:

Table 1. *Important factors hampering innovation*

Variable	Description
FH1	Enterprises that claim the lack of qualified personnel
FH2	Enterprises that claim the lack of information on technology
FH3	Enterprises that claim the lack of information on the markets
FH4	Enterprises that claim the difficulty in finding cooperation partners
FH5	Enterprises that claim the markets dominated by established enterprises
FH6	Enterprises that claim uncertain demand for innovative products
FH7	Enterprises that claim no need to innovate due to prior innovations
FH8	Enterprises that claim no need to innovate due to no demand
FH9	Enterprises that claim the lack of funds within the enterprise or group
FH10	Enterprises that claim the lack of external financing
FH11	Enterprises that claim the innovation costs too high

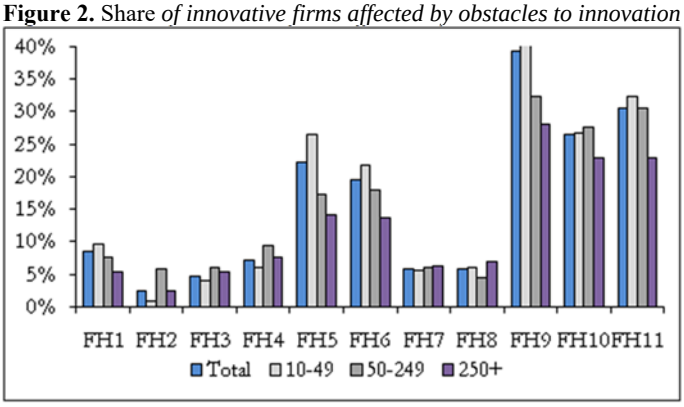
Source: CIS7 variables selected by the author.

The first step in our analysis is to calculate the partial corrections between the variables, since we expect the existence of complementarities. In this respect, the lack of funds within the enterprise or group (FH9), the lack of finance from sources outside the enterprise (FH10) and the innovation costs too high (FH11) are closely linked. The lack of internal funding determines an increase in cost of capital, and the lack of external financing limits the size of the projects to the level of internal funds. In the same framework, the lack of qualified personnel (FH1), the lack of information on technologies (FH2), the lack of

information on the markets (FH3) or the difficulty in identifying collaboration partners (FH4) can be seen as obstacles related to the lack of technological opportunities. Objectively, the qualified personnel can be considered as facilitator of innovation which allows the access to specialized knowledge, including from collaboration with various partners and the ability to identify potential markets. Also, the market dominated by established enterprises (FH5) and uncertain demand for goods and services (FH6) increase the operational risk of projects impacting the financing method, the projects size and type. Ultimately, the firm's decision to innovate in the current period can be affected by projects undertaken in the previous periods (FH7) or by no demand for innovations (FH8).

According to CIS data, firms with technological innovation introduce new or significant improved products or processes. A preliminary data analysis by types of factors hampering innovation is shown in figure 2, considering the share of firms affected by them by firm's size (small – with a number of employees between 10 and 49; medium – with a number of employees between 50 and 249; large – with more than 250 employers) in manufacturing industries where the innovative firms are more concentrated than in services. We note that the factors associated with the cost of innovation incorporate the main obstacles, followed by those concerning the product market. In the same framework, the small firms appear to be the most affected by all factors hampering innovation, followed by the medium firms. In fact, the total share of small innovative firms (13.46%) is much lower than the large firms (44.42%) according to CIS7 data, and the same characteristics can be found in services where the share of innovative small firms is 10.36%, while large firms summarizes 29.69%.

Figure 2. Share *of innovative firms affected by obstacles to innovation of the total innovative firms*

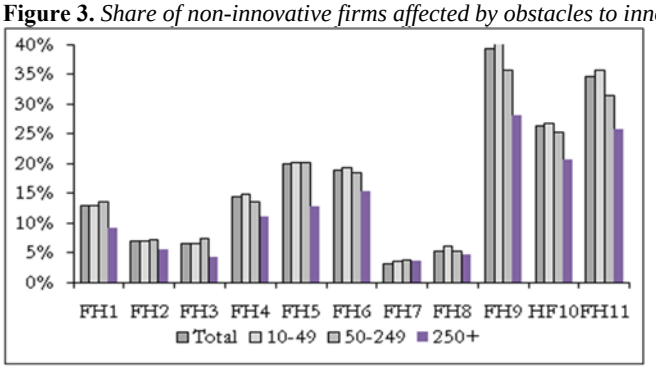


Source: Eurostat database (CIS7) – manufacturing industries.

Very often an obstacle is encountered when an activity is undertaken. Figure 2 shows that the main factors affecting innovation in innovative firms are associated with a lack of funding resources.

We find similar proportions between non-innovative firms that claim obstacles, by firm's size. Figure 3 shows that the main factors hampering innovation are found in the sphere of the lack of funding:

Figure 3. *Share of non-innovative firms affected by obstacles to innovation of the total non-innovative firms*

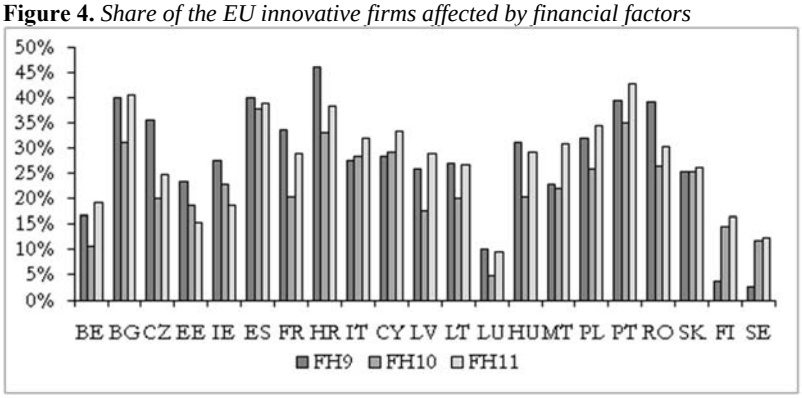


Source: Eurostat database (CIS7) – manufacturing industries.

However, the variables "obstacles to innovation" are not always very useful for understanding the difference between innovators and non-innovators since responses may either indicate a perception (what they see as a barrier to innovation) or reflect their actual experience (OECD, 2009). Firms with strong innovation activity may encounter obstacles to innovation, while non-innovative firms may have different experiences. The completion of a questionnaire related to obstacles to innovation, based on the two groups of enterprises, innovative and non-innovative, would be more appropriate to be carried out according to the firms' innovative status.

Exploring the data available for other EU Member States on the funding resources as obstacles to innovation encountered by innovative firms, we observe that Romanian firms are among the most financially constrained. Thus, 39.62% of the total innovative firms claim the lack of internal funding (FH9) and this share is exceeded only by the Croatian firms (46.28%), from Bulgaria (40.10%), Spain (39.95%) and Portugal (39.63%). The lack of external financing (FH10) is shown for 26.42% of innovative Romanian firms. This percentage is exceeded by the companies from the above mentioned countries. In addition, firms from Cyprus (29.16%) and Italy (28.43%) claim the lack of external financing. Finally, the share of Romanian firms in which the cost of innovation is considered to be too high (FH11) is 30.43% and it is also one of the highest in the EU (figure 4).

Figure 4. *Share of the EU innovative firms affected by financial factors*



Source: Eurostat database (CIS7) – all core NACE activities.

In order to identify factors with the highest incidence on innovation inputs we use multiple linear regression models specified by the following general equation:

$$Y_i = \beta_{0i} + \sum_j \beta_j X_{ij} + \varepsilon_i \quad (1)$$

where:
Y_i – the dependent variable is represented by the innovation inputs used by innovative firms in *i* sector;
X_{ij} – the exogenous variables;
β_j parameters that capture the *j* factor influence on the dependent variable;
ε_i – an independent and identical distributed error term for *i*.

The CIS7 database includes groups of firms with technological innovation in manufacturing and services. Since we do not have firm-level data, we included all firms from the 27 NACE sectors in the analysis, which enable us to highlight the most important obstacles to innovation.

The dependent variables considered in the model include elements of the total innovation expenditure: in-house and external R&D, acquisition of machinery, equipment, software and external knowledge, Inno_exp. Its size on the two main representative components for Romanian firms: expenditure for (in-house and external) research and development, RD_exp, and expenditure for acquisition of machinery, equipment and software, K_exp, in absolute terms (thousands of euros) are included also in separate models.

The independent variables include the share of firms with technological innovation which have experienced barriers to innovation activity of the total product and/or process innovative companies. We conduct the analysis with all variables considered in the models and formulate the following hypothesis: the increase in the share of firms affected by the obstacles to innovation has adverse affect on the innovation inputs (Inno_exp, R&D_exp and K_exp) used by innovative firms.

Table 2 summarizes the correlation matrix between all variables. It can be observed that the factors with significant impact on Inno_exp are FH2 and FH9, which means that the lack of technological opportunities expressed by the lack of information on technologies, and the lack of internal funding represent the main obstacles on the firm's decision to innovate; partial correlations reflecting strong negative impact. The same factors act on K_exp as well, explaining the reduction in the expenditures for acquisition of machinery, equipment and software. The obstacles identified previously appear to be responsible for the variation in RD_exp.

In this case, the perceived significant cost of innovation, FH11, has a negative impact as well. Correlations can be also found between explanatory variables differing by intensity; significant ones result to be between FH1 and FH11, FH7 and FH10, FH5 and FH6, FH4 and FH9, FH10, FH11, and between FH9, FH10 and FH11.

Table 2. *Pearson correlations between the variables analyzed*

	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH9	FH10	FH11	Inno_exp	RD_exp	K_exp
FH1	1													
FH2	0.805** (0.000)	1												
FH3	-0.156 (0.436)	0.031 (0.877)	1											
FH4	0.007 (0.971)	-0.029 (0.885)	0.294 (0.137)	1										
FH5	0.194 (0.332)	0.198 (0.323)	0.235 (0.238)	0.118 (0.557)	1									
FH6	0.160 (0.426)	0.096 (0.634)	0.321 (0.102)	-0.195 (0.331)	0.654** (0.000)	1								
FH7	-0.183 (0.361)	0.028 (0.890)	-0.075 (0.711)	-0.221 (0.267)	-0.022 (0.912)	-0.071 (0.725)	1							
FH8	0.036 (0.859)	0.021 (0.917)	0.221 (0.267)	0.246 (0.215)	-0.014 (0.945)	-0.351 (0.072)	0.278 (0.160)	1						
FH9	0.262 (0.187)	0.198 (0.323)	-0.024 (0.905)	-0.63** (0.000)	0.379 (0.051)	0.718** (0.000)	0.087 (0.664)	-0.235 (0.238)	1					
FH10	0.164 (0.414)	0.202 (0.311)	-0.268 (0.176)	-0.48** (0.010)	0.127 (0.527)	0.252 (0.205)	0.479* (0.011)	-0.253 (0.202)	0.464* (0.015)	1				
FH11	0.516** (0.006)	0.394* (0.042)	-0.256 (0.197)	-0.51** (0.004)	0.130 (0.519)	0.339 (0.084)	0.012 (0.952)	-0.047 (0.815)	0.703** (0.000)	0.494** (0.009)	1			
Inno_exp	-0.296 (0.133)	-0.391* (0.044)	-0.303 (0.125)	0.033 (0.869)	-0.202 (0.312)	-0.367 (0.060)	-0.163 (0.415)	0.072 (0.720)	-0.433* (0.024)	-0.319 (0.104)	-0.230 (0.249)	1		
RD_exp	-0.291 (0.141)	-0.386* (0.047)	-0.333 (0.090)	0.042 (0.836)	-0.193 (0.335)	-0.353 (0.071)	-0.165 (0.412)	0.016 (0.936)	-0.432* (0.024)	-0.293 (0.138)	-0.257 (0.196)	0.994** (0.000)	1	
K_exp	-0.298 (0.132)	-0.392* (0.043)	-0.289 (0.144)	0.030 (0.884)	-0.205 (0.304)	-0.371 (0.056)	-0.162 (0.419)	0.097 (0.631)	-0.431* (0.025)	-0.330 (0.093)	-0.217 (0.277)	0.999** (0.000)	0.998** (0.000)	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

We build several models and select the best regression model able to explain the relationship between the variables. In this respect, we use all the variables considered and remove the weakest independent variable at every step. The parameters of the models are estimated using linear regression. The coefficients resulted, the standard errors, and the values of econometric tests are centralized in table 3. The final results of each econometric model include statistically significant values only.

Table 3. *Regression models coefficients*

	Model 1 Dependent variable Inno_exp		Model 2 Dependent variable RD_exp		Model 3 Dependent variable K_exp	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
FH4					-41530.404	21062.364
FH2	-17631.775	10685.836	-5347.622	3256.366	-10908.968	7600.033
FH3	-43727.757	20627.869	-14280.720	6286.068		
FH9	-10876.928	7277.777	-3483.566	2217.805	-14972.485	6048.157
HF10	-11831.804	9967.384	-3229.011	3037.427	-8578.104	7021.009
Constant	1269739.547	319051.682	389739.961	97226.738	1288563.199	380908.726
R-squared	0.413		0.421		0.401	
F-statistic	3,874		3,997		3,688	
Durbin-Watson	2.102		2.239		2.089	

Source: author's calculation.

The regression results from the first model indicate that the total innovation expenditure (Inno_exp) is negatively influenced by the increases in the share of firms claiming the lack of information on technologies (FH2) and markets (FH3), the lack of funds within the enterprise or group (FH9) and the absence of external financial resources (FH10). The same factors with similar proportions affect the expenditure for research and development (RD_exp), although their intensity is different. The estimators of the regression equation from the model 3 show that the expenditure for acquisition of machinery, equipment and software, K_exp, is significantly correlated with the share of firms that claim difficulties in identifying cooperation partners (FH4), the lack of information on technologies (FH2) and lack of funding from internal and external resources (FH9 and FH10). The models can explain a large proportion of the variability of the total innovation expenditure ($R^2 = 0.413$), and also on the two components ($R^2 = 0.421$ and $R^2 = 0.401$ for RD_exp and K_exp) and standard econometric tests have also good results (table 3).

Summing up, our analysis identifies that innovation expenditures are influenced by the lack of technological opportunities and knowledge as well as by the lack funding resources, which are the main obstacles responsible for reducing innovation effort in Romanian firms. However, innovation expenditures and output remain severely affected by the low level of expenditure on research performed by firms. Industrial restructuring and increasing of innovation performance involve enhancing measures to be taken by the government policy, especially in supporting research and development in firms.

4. Conclusions and policy implications

The results we obtain on the main obstacles to innovation in Romania are not surprising. In general, the abandonment of projects by firms is low (under 3% according to Eurostat). This leads to the conclusion that the obstacles can reduce the number of innovators and innovation effort in firms. Such indicators are below the EU average and have further implications on the results obtained by firms form innovation. In the same framework, our results are consistent with other indicators of innovation, including the small number of innovative firms and their concentration in a few sectors of the economy (Diaconu, 2013, pp. 270-349). The options for different mechanisms of boosting innovation must take shape in relationship to the variables that characterize the innovation activity and its obstacles.

Our study on the effects of the main obstacles to innovation expressed by innovation inputs suggests that they are interdependent and reinforce each other. We identify that the main obstacles are the lack of technological opportunities and knowledge (lack of technological and market information, lack of cooperation partners) and the lack of funding (within the enterprise or group and from sources outside the enterprise), while the obstacles associated with the market (markets dominated by established enterprises and uncertain demand for innovative goods or services) and other factors (no need to innovate due to prior innovations and due to no demand for innovations) appear to be less important. The two main groups of factors are complementary.

For instance, the influence of active diffusion of knowledge (resulted from collaborative activities with other firms or institutions) and non-interactive diffusion (derived from using acquisition of knowledge) on innovation is well recognized. Transfer of knowledge through collaborative innovation activities and interaction with suppliers and customers can provide the missing inputs and learning processes that the firm cannot easily acquire. Also, collaboration in innovation activities can reduce the costs of innovation, facilitating the identification, adaptation and acquisition of relevant information and risks sharing that maximize the innovation results. This is why various government initiatives promote collaborative relationships between firms and research institutions, or between innovative firms, suppliers and customers, leading to behavioral additionality.

Nevertheless, several explanations regarding the significant share of firms that do not innovate in collaboration include concerns on sharing benefits or information disclosure to the contract partners (Arundel and Borody, 2003, pp. 158-182). The need for collaboration can be related to the technological characteristics of fixed assets used by firms, their growing complexity requiring external expertise activities.

Romanian firms are modestly involved in collaborative activities. The active diffusion through collaboration has positive impact by reducing barriers associated with failure to obtain funding for projects due to the uncertain results or low absorption of knowledge. We consider these barriers more important for small firms, having the highest probability of dealing with these difficulties. Despite the potential benefits of collaboration agreements, small firms are the least involved in collaboration.

The most practiced are cooperation agreements with suppliers and customers, and the least common are agreements with higher education institutions (5.10%) and research institutions (3.01% of the total innovative firms). These results are the consequence of reducing public financial support for innovation through direct and indirect mechanisms, including a low access to the research results funded from public resources. Firms in Romania are characterized by a level of collaboration among the lowest in the EU (Diaconu, 2013, pp. 270-349). That is why it is necessary the collaboration activities of firms with research and higher education institutions to be stimulated by the government policies, as sources of knowledge and technological opportunities, which would increase the innovative capacity. In the same framework, the supply side of financial resources needs a special attention. Stimulating both the demand and the supply sides can mitigate significant vulnerabilities that hinder the economic development based on knowledge: the concentration of economic and creative capacity in a few sectors that cause the dependence on imported technologies and external sources of knowledge in other sectors, as well as insufficient funding from venture capital.

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