Academic Journal of Economic Studies
Vol. 4, No. 4, December 2018, pp. 34–41
ISSN 2393-4913, ISSN On-line 2457-5836

The Impact of R&D Collaboration on Technological Innovation in European Countries

Kamilia Loukil

Faculty of Economics and Management, University of Sfax, Tunisia, E-mail: kamilia.loukil@gmail.com

Abstract *The present study examines the impact of collaboration in research and development (R&D) on technological innovation in emerging and developing countries. For this purpose, we use data on R&D expenditures performed by the public sector and funded by the business sector and R&D expenditures performed by the business sector and funded by abroad for R&D collaboration, while technological innovation is measured by US patent applications. Linear regressions are applied on data for 22 countries during the period 2006-2013. Findings show that both types of collaboration increases the innovation level. The main conclusion of our study is that the promotion of R&D cooperation between all sectors of the economy is an effective instrument of innovation policy in European countries.*

Key words Innovation, R&D collaboration, public research, multinational companies, European countries

JEL Codes: O31, O33, O38

1. Introduction

Technological innovation is very important to economic growth. Therefore, it is crucial to examine its determinants. According to the innovation system approach, interaction and interdependence are the most important characteristics of innovation activities. Actors involved in innovation processes cooperate (Smith, 2000) and work in networks (Powel and Grodal, 2005) at different levels (For example users with producers) and between different stages of the process innovation (Edquist, 2005). Cooperation and networking are very beneficial for the generation of innovations (Lundvall and Borras, 1997). In fact, they expose companies to new sources of ideas, promote knowledge transfer, reduce uncertainty and enable the division of innovation work. Networking also helps companies increase their innovation capabilities and achieve what they would not be able to achieve on their own. This paper focuses on two types of collaboration in research and development (R&D): the interaction between the public and private research sectors and the interaction between national firms and Multinational Companies (MNC).

Several countries have implemented initiatives in an attempt to stimulate the research partnership between the business sector and public research organizations (universities and public research laboratories). These initiatives take various forms such as licensing contracts, research contracts between university researchers and companies (Tether and Tajar, 2008), joint publications (Hicks *et al*., 1996), the use of technical infrastructure of universities, attendance at conferences and meetings (Cohen et al., 2002), formation of new companies in the form of spin-offs and start-ups (Zucker and Derby, 2001, Zucker *et al*., 1998, 2002) and the mobility of researchers between academia and industry (Bania *et al.*, 1992). Such partnerships are likely to increase the rate of use and transfer of academic knowledge to the private sector.

Through cooperation and other contractual activities, MNC can confer positive spillovers on local firms. In fact, they are more innovative than local firms and are characterized by greater absorptive capacity. Local partners form joint ventures with foreign companies mainly to gain access to technological and management know-how as well as to benefit from the international reputation of the foreign partner (Tether, 2002). In addition, the partnership helps to limit their financial problems. The aim of this study is to answer the following questions: How does the collaboration between public research and industry sector affect the innovation level in European countries? What is the impact of R&D collaboration between domestic firms and multinational firms on the level of innovation in European countries? For this purpose, we apply multiple linear regressions on panel data relating to 22 European countries over the period 2006-2013. Our estimated results show that both R&D collaboration between public sector and business sector and R&D collaboration between business sector and abroad increase the innovative activities.

2. Literature review

2.1. Promoting interaction between the public research sector and industry

Several types of interaction facilitate the transfer of knowledge between public research organizations and industry. The formation of new companies in the form of spin-offs, licensing contracts, research contracts between university researchers and companies and the mobility of researchers between academia and industry are the most cited mechanisms for transferring knowledge. It is through these interactions between the two sectors that companies can benefit from public research. Spin-offs are the knowledge transfer mechanisms between academia and industry that have attracted the attention of several policy makers. As new technologies are not easily patentable and universities are not always able to benefit from the full value of their technology through licensing agreements, academic researchers often seek more direct involvement in the commercialization process through the creation of spin-off companies. Breznitz and Feldman (2012) point out that the proximity of spin-offs to their home universities increases their contribution to the local economy. Therefore, the creation of local spin-off companies is the most direct way for universities to contribute to economic development. Spin-offs stimulate local economic growth by producing innovative products that meet consumer demand, creating jobs especially for individuals with tertiary education level and attracting investment in the development of university' technology. Zucker and Derby and their colleagues (1998a and b, 2001, 2002) focused on creating new firms and their interaction with universities. They have shown that university research is crucial in the creation of biotechnology start-ups. The license gives the company the right to use the intellectual property of the university having the form of patent or trademark. These formal transactions provide funding to the university and transfer knowledge and intellectual property rights to businesses (Jensen and Thursby, 2001; Siegel *et al*., 2003; Thursby *et al.,* 2001). In addition to generating new sources of revenue for universities, the licensing mechanism offers the opportunity to demonstrate that the university is actively engaged in disseminating attractive research results to the industry.

Research contracts take place when a company enters into contracts with a university researcher to carry out together R&D projects. These types of projects include applied research rather than basic research. Tacit academic knowledge becomes codified through researcher contracts with companies to develop an idea for commercialization. Companies benefit from knowledge that can generate profits and improve the skills of their scientific staff. Universities benefit from various types of advantages, such as increased revenues to fund basic research, access to highly qualified scientists, and research and employment opportunities for students. Adams et al (2001) showed that business collaboration with academics is a complement to their own research, stating that interaction with university-industry collaborative research centers increases R&D spending and the number of granted patents. Caloghirou *et al.* (2001) conducted a survey of 285 cases of collaborative projects funded under European Union programs involving at least one enterprise and one university. They found that collaboration provides companies with several benefits, namely: to benefit from research synergies that can reduce costs or improve R&D productivity, access additional resources and skills, obtain financing, and finally share the costs of R&D. Tether and Tajar (2008) explored the use of knowledge providers as a source of information in innovation activities by UK manufacturing and services firms. Knowledge providers are consulting firms, private research organizations and the public scientific base (universities and public research laboratories). The authors found that knowledge providers are more engaged by firms with more open approaches to innovation, high levels of absorptive capacity, greater social capital, and high capacity to engage with networks. The results also show that, in general, the use of knowledge providers makes it possible to complement firms' own internal innovation activities and to supplement other external sources of knowledge. Laursen and Salter (2004) conducted a study in the same context on 2655 firms to find out whether the innovations created during the period 1998-2000 benefited from the use of universities or not. They found that only a limited number of firms make direct use of universities as a source of information for their innovation activities. The authors noted that these results suggest that the direct contribution of universities to industrial practice is likely to be concentrated in a small number of industrial sectors. The results also indicate that R&D intensity, firm size and the industrial environment are important factors in explaining the tendency of firms to use universities in their innovation activities.

Academic consultation is the provision of a service by academics to external organizations. This service may consist of giving advice, solving a problem, generating or testing new ideas. This is particularly beneficial to universities as academic consultants generate revenue and build relationships with the business community at the local, national and international levels that not only increase the relevance of the knowledge generated within the university, but also help industrial researchers to enrich their approaches and research questions (Wright *et al*., 2008). The study by Cohen *et al.* (2002) showed that consultation is a channel through which academic research influences industrial R&D. The importance of R&D staff mobility from universities to businesses has been highlighted in several research studies. Bania *et al.* (1992) have shown that industrial research laboratories in the United States are located in regions with a highly skilled workforce. Zellner (2002) has demonstrated considerable socio-economic benefits from basic research through the transfer of tacit knowledge associated with the migration of scientists to the commercial sector. Moreover, the results of Cassia et al (2009) show that the output of the university in terms of scientific publications and human capital is related to the growth rate of companies.

2.2. Promoting interaction between multinational companies and industry

Many studies have analysed cooperation between foreign and domestic firms. For example, Girratana and Torrisi (2002) conducted an analysis of the influence of cooperation agreements on the patenting of 15 European electronic companies during the period 1984-1997. They found that R&D cooperation with US entities positively influences the patenting performance of European electronics companies. They found no positive impact of the EU-funded co-operation agreements on the patents shares of these companies in global patents. They interpreted this difference by the complementarity of the resources of American partners with those of European companies. Zhou and Xin (2003) are interested in a cluster of information and communication technology in China. Their empirical study has shown that relations between MNC and local firms are hierarchical, but also fluid and increasingly contentious. On the one hand, the superiority of the MNC in terms of capital, technology and management has prevented local incentives from innovation. On the other hand, the difficulties of operating in a technologically less sophisticated market for high-tech services have forced the MNC to adopt a collaborative approach with local companies. Through this collaboration, local firms have had the opportunity to receive vital technological and organizational training from MNC and strategically develop their innovative capacity in the home market.

Cincera *et al.* (2003) used data from the 1996 R&D survey conducted by the Belgian Federal Office for Scientific, Technical and Cultural Affairs. The analysis shows that international cooperation in R&D, and especially cooperation with customers, suppliers and other companies, significantly improves the productivity growth of the company. Liefner *et al.* (2006) studied Zhongguancun Science Park (ZGC) in Beijing, which is considered to be the most innovative region in China. Their work is based on a quantitative survey conducted in 2003 on the companies in this park. In order to achieve technological catch-up, they use knowledge from foreign companies and universities and public research organizations. The results confirm that both sources of knowledge are equally important for ZGC firms. Cooperation with foreign companies helps ZGC companies get new ideas and enter the market with new products; while cooperation with universities is used mainly to design new products. Bakker *et al.* (2008) studied the impact of the diversity of national and international innovation partnerships on the innovation results of South African firms. A number of hypotheses were formulated and tested empirically using a sample of 617 industrial and service firms and applying ordinary least square regressions. The study is based on a survey conducted in 2001. The results show that having an innovation partnership, especially an international partnership, is beneficial to innovation results. However, the huge diversity of international partnerships prevents innovation.

Sun and Du (2011) analysed the impact of supplier-client links and technological links with foreign firms on the technological innovation of domestic firms. The study is based on data collected during a survey of more than 600 companies in the Chinese ICT sector. The results show that the firm's innovation benefits significantly from technological relations with foreign firms. Sastre (2015) analysed the impact of innovation cooperation on productivity growth in sales of new products on the market by exploiting data on Spanish companies. He differentiated between national and international partners. He considered the differences between local and foreign firms and between manufacturing and service firms. The results indicate that national and international partners are helping to improve innovation activities for manufacturers. However, there are negative effects due to simultaneous engagement in both strategies. For service companies, the results show that international cooperation is the only significant strategy for improving the productivity growth of innovative firms and there is no positive or negative effect of simultaneous cooperation with national and international partners. The results indicate that local industrial firms prefer to cooperate with foreign partners to access international technology. Foreign industrial affiliates seek national alliances to know the market or benefit from the low cost and good quality of local R&D.

3. Methodology of research

In this section, we first describe our sample. Next, we will define the variables used and their respective measures. Then, we will advance descriptive statistics. Finally, we will present the statistical models used in this study.

3.1. Sample Selection

The present study examines a sample of 22 European countries[1] for the period 2006-2013.

3.2. Selection of variables and measurement instruments

We will present below the variables and their measures. It is necessary to specify the dependent variable as well as the independent variables of the models to be estimated.

[1] Countries included in our sample are: Austria, Belgium, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

3.2.1. Dependent Variable

Patenting is often considered an appropriate proxy to the level of innovation (Griliches, 1990; Kanwar and Evenson, 2003; Furman *et al.,* 2002). In the present paper, we use data from the US Patent and Trademark Office (USPTO). Our measure of technological innovation is the number of patent applications filed by residents of a given country with the USPTO. Because of the time lag between the filing process and the granting of a patent, using data on patent applications rather than granted patents reflects the more immediate and faster innovative activity. Data on patent applications are transformed by taking their natural logarithms. Therefore, the dependent variable (PAT) is defined as the logarithm of the number of patent applications filed by a country's residents with the USPTO for a given year. As the level of international patenting is observed with a time lag, our empirical work requires a lag of 2 years between explanatory variables and the dependent variable. Therefore, data for independent variables are for the period 2006-2013, and patent applications relate to the period 2008-2015.

3.2.2. Independent Variables

R&D collaboration between public research sector and industry is measured by R&D expenditures performed by the public sector and financed by the business sector (RDPBUS). Public sector is composed of government sector and higher education sector. Thus, the variable RDPBUS is the sum of R&D expenditures performed by the government and financed by the business sector (RDGOVBUS) and R&D expenditures performed by the sector of higher education and financed by the business sector (RDHEBUS). R&D collaboration between the sector of enterprises and Multinational Companies is measured by R&D expenditures performed by the business sector and financed by abroad, i.e., foreign enterprises (RDBUSFOR). Data are in Million Purchasing Power Standards (PPS) at 2005 prices. Data are transformed by taking their natural logarithms and are from EUROSTAT database.

Four control variables are used in the present study:

The level of economic development is measured by GDP per capita (GDP).

The human capital is measured by the tertiary education level (EDUC). The metric used is the gross enrollment ratio for tertiary school.

The size of the country is measured by the number of the population in thousands of people (POP).

The institutional framework is measured by the Economic Freedom Index of the Economic Report (Gwartney et al., 2014) taking a value between 1 and 10 (EFI).

Data on GDP, EDUC and POP are from World Bank's World Development Indicators.

Data on GDP and POP are transformed by taking their natural logarithms.

Data on economic freedom index are from the Fraser Institute.

3.3. Descriptive Statistics

Table 1 provides the descriptive statistics on the number of patents as well as the explanatory variables (RDPBUS, RDGOVBUS, RDHEBUS, RDBUSFOR, GDP, EDUC, POP, EFI).

Table 1. Summary statistics

Variable	Average	Median	Standard deviation	Minimum	Maximum
PAT	2189.813	605.5	3259.773	7	13296
RDPBUS	154.6074	77.4295	188.6777	4.748	680.595
RDGOVBUS	73.53515	26.005	104.5482	0.009	458.711
RDHEBUS	81.07224	41.1575	99.3941	1.416	348.995
RDBUSFOR	565.4745	218.716	909.2508	2.699	4195.433
GDP	30493.14	27227.72	16231.86	7418.416	61174.55
EDUC	60.08	66.45	11.05	44.77	94.92
POP	18223.46	9746.73	20633.9	1317.997	65998.57
EFI	7.395	7.4	0.321	6.42	8.12

3.4. Statistical models

In order to test the impact of R&D collaboration on technological innovation, the following models will be estimated:

$$PAT_{it+2} = β0 + β1\ RDPBUS_{it} + β2\ GDP_{it} + β3\ EDUC_{it} + β4\ POP_{it} + β5\ EFI_{it} + ε_{it} \quad (1)$$

$$PAT_{it+2} = β0 + β1\ RDGOVBUS_{it} + β2\ GDP_{it} + β3\ EDUC_{it} + β4\ POP_{it} + β5\ EFI_{it} + ε_{it} \quad (2)$$

$$PAT_{it+2} = β0 + β1\ RDHEBUS_{it} + β2\ GDP_{it} + β3\ EDUC_{it} + β4\ POP_{it} + β5\ EFI_{it} + ε_{it} \quad (3)$$

$$PAT_{it+2} = β0 + β1\ RDBUSFOR_{it} + β2\ GDP_{it} + β3\ EDUC_{it} + β4\ EFI_{it} + β5\ EFI_{it} + ε_{it} \quad (4)$$

$$PAT_{it+2} = β0 + β1\ RDPBUS_{it} + β2\ RDBUSFOR_{it} + β3\ GDP_{it} + β4\ EDUC_{it} + β5\ EFI_{it} + β6\ EFI_{it} + ε_{it} \quad (5)$$

Where:

i = 1, 2, …., 22; t = 1,…., 8.

PAT = Ln(number of patent applications filed in the USPTO); RDPBUS = Ln(R&D expenditures performed by the public research sector and financed by the business sector); ; RDGOVBUS = Ln(R&D expenditures performed by the sector of government and financed by the business sector) ; RDHEBUS = Ln(R&D expenditures performed by the sector of higher education and financed by the business sector) ; RDBUSFOR = Ln(R&D expenditures performed by the business sector and financed by foreign companies); GDP = Ln(GDP per capita); EDUC = Gross enrolment ratio for tertiary school; POP = Ln(Population in thousands of people); EFI = Economic freedom index; ε is regression residuals.

Linear models are estimated by the software STATA 12.

4. Presentation and interpretation of results

Before presenting findings, we proceed to analyze the independence of the explanatory variables. This is the multi collinearity test. To check the condition of absence of multi-collinearity, we use the simple correlation matrix and assume a limit of 0.8. According to the correlation matrix, strongest correlations are found between the metrics relative to R&D collaboration and population. The correlation coefficient between RDHEBUS and RDBUSFOR is equal to 0.81. The correlation coefficient between RDPBUS and POP is equal to 0.82. Thus, these two sets of variables should not be introduced in the same model in order to guarantee reliability of results.

4.1. Analysis of simple correlations

We begin our analysis by examining simple correlations. The matrix of simple correlations allows us to examine the correlation coefficients in order to study the null hypothesis of the absence of correlation between two variables. Table 2 summarizes the results found.

Table 2. Simple correlations between the dependent variable and the explanatory variables

Simple correlations with the variable Ln(number of US patent applications)		
Explanatory variables	Predicted sign	Correlation
RDPBUS	+	0.7824***
RDGOVBUS	+	0.5389***
RDHEBUS	+	0.8072***
RDBUSFOR	+	0.9441***
GDP	+	0.8341***
EDUC	+	0.0565
POP	+	0.6540***
EFI	+	0.3531***
***: significant correlation at 1% threshold.		

The analysis of simple correlations shows that the variables relative to collaboration in research and development between different sectors are as expected positively and significantly associated with the innovation level. The level of economic development, population and economic freedom index has the predicted positive sign and are significant at 1% threshold. For the variable relative to human capital, the correlation is positive but not significant.

4.2. Findings

To test the impact of R&D collaboration between the different sectors of the economy on innovation level, we have estimated five models where the dependent variable is natural logarithm of patent applications filed in USPTO (PAT) and the explanatory variables of interest are R&D performed by the public research sector and funded by the business sector and R&D performed by the business sector and funded by abroad. Before examining results, it is necessary to verify some tests applied on the panel data.

First, the homogeneous or heterogeneous specification of the data generating process should be checked. If the test performed (individual presence test) shows that there are individual specificities, the Ordinary Least Squares (OLS) method is inappropriate and in this case, we apply Hausman test to determine whether the coefficients of the two estimates (fixed and random) are statistically different.

In models (1), (2), (3), (4) and (5) the Lagrange multiplier test gives values of 340.71; 389.64; 391.89; 369.04 and 377.67 respectively and the associated p-values are below the threshold of 1%. We then reject the null hypothesis of absence of specific effects, so it is necessary to introduce individual effects. The probabilities of the Hausman test in the first and the fifth models are respectively 0.0000 and 0.0001 < 1%. Based on the Hausman test, we choose the fixed effects model for these two specifications. In models (2), (3) and (4), the probabilities are equal respectively to 0.5556; 0.3788 and 0.5457, which are greater than 1%. So, we choose the random effects model for these specifications.

The Breush-Pagan test allows us to detect heteroskedasticity. In models (1), (3) and (5) the probabilities of the test are equal respectively to 0.0000; 0.0091 and 0.0000 confirming the presence of heteroskedasticity problem for these estimated models. In models (2) and (4), the probabilities are equal respectively to 0.0219 and 0.0269 which are superior than 1%, confirming the absence of heteroskedasticity problem for these models. The Wooldridge test allows us to detect the auto-correlation whose null hypothesis is the absence of auto-correlation errors. In models (1), (3) and (5) the probabilities of the test are equal respectively to 0.0065; 0.0066 and 0.0077 confirming the presence of an auto correlation problem for these estimated models. In models (2) and (4), the probabilities are equal respectively to 0.0137 and 0.0218 which are superior than 1%, confirming the absence of heteroskedasticity problem for these models. In the following, we present the results of the linear regressions with correction of the heteroskedasticity and auto correlation problems in the first, third and fifth specifications. Table 3 provides the results of the five linear regression models.

Table 3. Results of the five linear regression models

Independent variables	Dependant variable: PAT									
	Specification (1)		Specification (2)		Specification (3)		Specification (4)		Specification (5)	
	Coef. β	SE	Coef. β	SE	Coef. β	SE	Coef. β	SE	Coef. β	SE
Constant	-16.122	1.659***	-26.777	2.139***	-27.354	1.218***	-19.803	2.135***	-12.452	1.22***
RDPBUS	0.375	0.055***							0.364	0.047***
RDGOVBUS			0.079	0.034**						
RDHEBUS					0.053	0.036				
RDBUSFOR							0.336	0.047***	0.407	0.046***
GDP	2.163	0.171***	2.528	0.201***	2.414	0.113***	1.905	0.196***	1.513	0.127***
EDUC	0.005	0.003	0.009	0.003**	0.006	0.002**	0.007	0.003**	0.002	0.003
POP			0.829	0.121***	0.983	0.048***	0.637	0.106***		
EFI	-0.212	0.127*	-0.168	0.145	-0.088	0.093	-0.194	0.129	-0.068	0.123
Observations	176		176		176		176		176	
F/Chi2	298.51***		298.51***		1554.27***		441.91***		976.41***	
R2	0.92		0.93		0.84		0.94		0.82	

Coefficients and Standard Errors are given in this table.
*, **, ***: Coefficients are significant at 10 %, 5 % and 1 %.
PAT = Ln(number of patent applications filed in the USPTO) ; RDPBUS = Ln(R&D expenditures performed by the public research sector and financed by the business sector); ; RDGOVBUS = Ln(R&D expenditures performed by the sector of government and financed by the business sector) ; RDHEBUS = Ln(R&D expenditures performed by the sector of higher education and financed by the business sector) ; RDBUSFOR = Ln(R&D expenditures performed by the business sector and financed by foreign companies); GDP = Ln(GDP per capita); EDUC = Gross enrolment ratio for tertiary school; POP = Ln(Population in thousands of peaple); EFI = Economic freedom index

In all specifications, the Fisher/Chi2 statistic testing the joint significance of the explanatory variables is significant at 1%. This allows us to reject the null hypothesis that the regression coefficients β are zero. Therefore, our models are globally significant.

According to the specification (1), the coefficient relative to R&D expenditures performed by the public sector and funded by the business sector has the predicted positive sign (0.375) and it is significant at 1% threshold. It implies that an increase in the level of R&D collaboration between public and private research sectors by 10% raises the international patenting level by 3.75%. Thus, collaboration in research and development between public research sector and the industry is beneficial for technological innovation level of European countries. Our result corroborates the studies of Adams *et al.* (2001), Caloghirou *et al.* (2001) and Tether and Tajar (2008).

In the second and third models, we introduce two variables relative to the collaboration in R&D between the two components of public research sector and the sector of industry: RDGOVBUS and RDHEBUS. According to the specification (2), research performed by the sector of government and funded by the sector of business has a positive and significant effect (at 5% threshold) on technological innovation. The coefficient relative to RDGOVBUS implies that an increase in the level of R&D collaboration between government and private research sectors by 10% raises the international patenting level by 0.79%. In contrast, according to the specification (3), the coefficient relative to the research performed by the sector of higher education and funded by the sector of business is positive but not significant. This result suggests that the cooperation in research and development between enterprises and universities has no influence on the level of technological innovation of European countries.

Our findings show on the one hand, the low effect of R&D collaboration between the sector of industry and public research laboratories and, on the other hand the insignificant effect of R&D collaboration between the sector of industry and that of universities. However, they suggest that although the marginal independent effect of collaboration in R&D between the private sector and each component of public research sector, the combined effect is significantly high. Thus, we conclude that the public research centres and laboratories and the institutes of higher education are complementary: it is only when enterprises cooperate with the two types of public organizations that international patenting is well improving.

In specification (4), we introduce the variable relative to R&D collaboration between national enterprises and multinational companies. The coefficient relative to RDBUSFOR is positive and significant at 1% threshold. It implies that an increase in the level of R&D collaboration between national firms and MNC by 10% raises the international patenting level by 3.36%. Our result highlights the key role of such cooperation for technological innovation in European countries. It is consistent with previous empirical works such as Liefner *et al.* (2006) and Bakker *et al.* (2008). In the fifth specification, we introduce both variables relative to the two types of R&D collaboration: between the sector of business and 1) public research organizations (laboratories and universities) and 2) the foreign enterprises. Results confirm the last findings: the effects of each type of cooperation are positive and significant at 1% threshold. Concerning control variables, we note that as expected the level of economic development, human capital and population stimulate technological innovation in European countries.

5. Conclusions

The purpose of the present paper was to assess the effect of R&D collaboration on technological innovation in European countries. Analysis of theoretical issues and previous empirical studies shows that cooperation in research and development allows increasing the propensity of innovation. Using linear regressions on panel data, we extend the existing works. Our findings suggest that cooperation in research field between the business sector and the public sector increases the innovation level of European countries. They also suggest that the R&D collaboration between businesses and foreign enterprises is advantageous for innovation level. Our study contributes to the already substantial body of innovation literature. It has important implications, especially on political level. In fact, policy makers desiring to stimulate innovation may want to encourage the cooperation in research and development between all sectors of the economy.

References

Adams, J.D., Chiang, E.P., Starkey, K. (2001). Industry-University cooperative research centers. *Journal of Technology Transfer* 26 (1-2): 73-86.

Bakker, R.M., Oerlemans, L.A.G., Pretorius, T. (2008). Domestic and international innovation partnerships: Do they matter for innovation outcomes of South African Firms? *South African Journal of Economics* 76: 518–536.

Bania, N., Calkins, L.N., Dalenberg, D.R. (1992). The effects of regional science and technology policy on the geographic distribution of industrial R&D laboratories. *Journal of Regional Science* 32 (2): 209-228.

Breznitz, S.M., Feldman, M.P. (2012). The engaged university. *Journal of Technology Transfer* 37:139-157.

Caloghirou, Y., Tsakanikas, A., Vonortas, N.S. (2001). University-Industry cooperation in the context of the European framework programmes. *Journal of Technology Transfer* 26: 153-161.

Cassia, L., Colombelli, A., Paleari, S. (2009). Firms' growth: Does the innovation system matter? *Structural Change and Economic Dynamics* 20: 211-220.

Cincera, M., Kempen, L., Pottelsberghe, B van., Veugelers, R., Sanchez, C.V. (2003). Productivity growth, research and development (R&D) and the role of international collaborative agreements: some evidence for Belgian manufacturing companies. *Brussels Econnomic Review-Cahiers Economiques de Bruxelles* 46 (3).

Cohen, W.M., Nelson, R.R., Walsh, J.P. (2002). Links and impacts: The influence of public research on industrial R&D. *Management Science* 48 (1): 1-23.

Edquist, C. (2005). Systems of Innovation: Perspectives and Challenges. In Fagerberg, J., Mowery, D.C., Nelson, R.R. (Eds.), *Oxford Handbook of Innovation*, Oxford University Press: 181-208.

Furman, J.L., Porter, M.E., Stern, S. (2002). The determinants of national innovative capacity. *Research Policy* 31: 899-933.

Girratana, M., Torrisi, S. (2002). Competence accumulation and collaborative ventures: Evidence from the largest European electronics firms and implications for EU technological policies. In: Lundan, S. (Ed.), *Network knowledge in international business*, Edward Elgar, Cheltenham, UK: 196-215.

Griliches, Z. (1990). Patent statistics as economic indicators: A survey. *Journal of Economic Literature* XXVIII: 1661-1707.

Gwartney, J., Lawson, R., Hall, J. (2014). *Economic Freedom Dataset*. In Fraser Institut (Ed.), Economic Freedom of the World: 2014 Annual Report.

Hicks, D.M., Isard, P.A., Martin, B.R. (1996). A morphology of Japanese and European corporate research networks. *Research Policy* 25: 359-378.

Jensen, R., Thursby, M. (2001). Proofs and prototypes for sale: The Licensing of university inventions. *The American Economic Review* 91 (1): 240-259.

Kanwar, S., Evenson, R.E. (2003). Does intellectual property protection spur technological change? *Oxford Economic Papers* 55 (2): 235-264.

Laursen, K., Salter, A. (2004). Searching high and low: what types of firms use universities as a source of innovation? *Research Policy* 33: 1201-1215.

Liefner, I., Hennemann, S., Xin, L. (2006). Cooperation in the innovation process in developing countries empirical evidence from Zhongguancun, Beijing. *Environment and Planning* A 38 (1): 111-130.

Lundvall, B.A., Borras, S. (1997). The globalising learning economy – Implications for innovation policy. *The European Commission* DG XII-TSER, Bruxelles.

Powell, W., Grodal, S. (2005). Networks of innovators. In Fagerberg, J., Mowery, D., Nelson, R. (Eds.), *The Oxford Handbook of Innovation*, Oxford University Press, Oxford.

Sastre, F.J. (2015). The effect of national and international R&D cooperation: differences between manufactures and services. *Int. J. Services Technology and Management* 21 (1/2/3): 146-162.

Siegel, D., Waldman, D., Link, A. (2003). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: An exploratory study*. Research Policy* 32 (1): 27-48.

Smith, K. (2000). Innovation as a systemic phenomenon: rethinking the role of policy. *Enterprise & Innovation Management Studies* 1 (1): 73-102.

Sun, Y., Du, D. (2011). Domestic firms innovation and networking with foreign firms in China's ICT industry. *Environment and Planning* 43: 786-809.

Tether, B., Tajar, A. (2008). Beyond industry-university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science base. *Research Policy* 37: 1079-1095.

Tether, B.S. (2002). Who co-operates for innovation, and why: An empirical analysis. *Research Policy* 31: 947-967.

Thursby, J.G., Jensen, R., Thursby, M.C. (2001). Objectives, characteristics and outcomes of university licensing: A survey of major U.S. universities. *Journal of Technology Transfer* 26: 59-72.

Wright, M., Clarysse, B., Lockett, A., Knockaert, M. (2008). Mid-range universities'linkages with industry: Knowledge types and the role of intermediaries. *Research Policy* 37: 1205-1223.

Zellner, C. (2002). Evaluating the social economic benefits of publicly funded basic research via scientists career mobility. *Research Evaluation* 11 (1): 27-35.

Zhou, Y., Xin, T. (2003). An innovative region in China: Interaction between multinational corporations and local firms in a High-Tech cluster in Beijing. *Economic Geography* 79(2): 129-152.

Zucker, L.G., Darby, M.R. (2001). Capturing technological opportunity via Japan's star scientists: Evidence from Japanese firms' biotech patents and products. *Journal of Technology Transfer* 26 (1): 37-58.

Zucker, L.G., Darby, M.R., Armstrong, J. (1998 a). Geographically localized knowledge: spillovers or markets? *Economic Inquiry* XXXVI: 65-86.

Zucker, L.G., Darby, M.R., Armstrong, J.S. (2002). Commercializing knowledge: university science, knowledge capture and firm performance in biotechnology. *Management Science* 48 (1): 149-170.

Zucker, L.G., Darby, M.R., Brewer, M.B. (1998 b). Intellectual human capital and the birth of US biotechnology enterprises. *The American Economic Review* 88 (1): 290-306.