Technological collaboration and R&D alliances: an assessment of the impact on the technical and economical performance of EU regions

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Abstract
This paper investigates the impact of technological alliances on the technical and economical performance of regions in the EU-27 area. While recent research mainly focused on spillovers and externalities, especially on industry-science interactions, it can be noticed that limited attention has been paid to the whole spectrum of interactions (alliances) that could be present within a (regional) innovation system. Within this contribution we analyze the occurrence and nature of technological and R&D alliances at the level of NUTS2 regions. Building on data contained in the EPO Worldwide Patent Statistical Database (PATSTAT), we obtained exhaustive information on co-patents, distinguishing between different types of actors (firms, universities, PROs, individuals, governmental agencies) involved. These data have been complemented by R&D alliances data – the Cooperative Agreements and Technology Indicators (CATI) database – which have been allocated to the NUTS2 level. We constructed a panel dataset covering a 12 year time period (1994-2005); besides indicators pertaining to alliances and collaborations (co-patenting), economical and R&D indicators (Eurostat regional statistics) have been collected and introduced as dependent variable (GDP) or control variables (Investments in R&D, Human Resources in Science & Technology). Applying multivariate regression models allows assessing the distinctive impact of collaborative activities on the technological and economical performance of regions. Findings clearly indicate positive effects of technological alliances (measured by means of co-patenting), while the effects of commercial alliances (CATI) are less outspoken.

Keywords: university-firm collaborations, firm-firm collaborations, R&D and technological alliances, economic growth

1. Introduction

Firms are increasingly looking outside organizational boundaries for new ideas and knowledge in order to increase their innovative performance. In an era where successful ideas can sprout from any corner of the world, no company can believe to have all the capabilities to innovate on its own (e.g., Chesbrough, 2003). Moreover, the returns of internal R&D activities are more and more decreasing, i.e. firms' R&D expenditures raise more than innovative output (see Belderbos et al., 2004; Fritsch and Franke, 2004). For these reasons companies have been increasingly led to perform co-operative R&D and to establish technological collaborations, joint development agreements and other kinds of R&D partnerships in order to share resources with one or more other companies and thus reduce the cost of their R&D activities (see Hagedoorn, 2002). Empirical evidence of the positive impact of high innovation costs and risks on the propensity of firms to collaborate in R&D has been provided by several authors (e.g. Becker and Dietz, 2004; Abramovsky et al., 2005).

In this regard, Etzkowitz and Leydesdorff (1998) highlighted a complex and dynamic process of interactions between University, Industry and Government instrumental for transferring and creating new knowledge among the organizations involved. These processes can influence innovation performance (see Cohen and Levinthal, 1990) and act as sources of competitive advantage for private firms while at the same time resulting in an increased performance on the level of innovation systems as a whole (see Spencer, 2001). Indeed, Schumpeter (1942) already conjectured that innovation – resulting from the creation and application of new knowledge – should be seen as the engine of economic growth. According to these hypotheses, Varga (2001) focused on economic development policy promoting collaboration among universities and the local industry as a possible instrument to fuel economic growth, while Bercovitz and Feldman (2005) investigated Industry-University relationships, proving that they offer a competitive advantage to those firms able to absorb universities' fundamental discoveries and transform them into commercial products.

On the basis of these studies, several empirical researches have focused on the impact of knowledge transfer among different types of organizations on local economic development, distinguishing between collaborative and non collaborative relationships (see Wagner and Leydesdorff, 2005). Even if both approaches aim at exchanging and acquiring knowledge from sources external to the organisations they also differ significantly. Collaborative exchanges, such as R&D partnerships and technological collaborations, are mainly based on an interactive learning, which is related to an intentional interaction with other firms and scientific organizations (i.e. universities and research centres), whereas non collaborative flows better encompass unintentional knowledge spillovers (see Messeni Petruzzelli and Rotolo, 2008).

Several studies have considered industry-science interactions – both collaborative/intentional and non collaborative/unintentional – and found that they affect regional economic growth positively. In particular, Wang (2003) investigated the effects of universities and colleges on regional growth through knowledge spillovers, showing that counties with more academic institution have higher growth in terms of employment, while other research efforts have been devoted to industry-university cooperation in R&D and found that it positively stimulates regional economic growth (see Jinyoung et al., 2005; Bramwell and Wolfe, 2008). In Hill's (2006) opinion, one reason why university research generates local economic impacts has to do with impediments in the transfer of tacit knowledge. In fact, in many cases of scientific discoveries with revolutionary commercial potential, knowledge can only be transferred to industry through active working relationships with the scientist. Research universities also generate local economic impact because universities can provide a steady supply of highly qualified science and engineering graduates. A way in which university research is thought to influence the local economy is by stimulating corporate R&D activity. Industry laboratories directly promote local economic development by providing high-paying jobs for scientists and technical workers. They may also generate competitive advantages for local producers who make use of the innovations coming out of the labs.

If the literature on the role of knowledge spillovers and externalities in shaping local economical performances is diverse (see also Döring and Schnellenbach, 2006), at the same time, it can be noticed that limited attention has been paid to the whole spectrum of interactions (alliances) that could be present within a (regional) innovation system. Besides industry-science linkages, alliances between firms (see Romer, 1986, 1990) as well as collaborations involving governmental agencies (including Public Research Organizations) might be beneficial for the innovative – and hence wealth creating – performance of regions. Within this contribution we analyze the occurrence and nature of technological and R&D alliances at the level of NUTS2 regions across Europe (EU-27). More specifically, this paper aims at investigating how technological collaboration and R&D partnerships affect local economic growth.

The paper is structured as follows. In Section 2, the research focus is presented, specifying the two hypotheses concerning how technological and R&D collaborations can impact regional technical and economical performance. In Section 3, the methodology is explored, with special focus on the data sampling and on the estimation model building. Main results and findings are shown in Section 4. Finally contributions, implications and future developments are discussed in Section 5.

2. Research focus and hypothesis

The development of innovation often requires knowledge from beyond organizations' boundaries in order to overcome the existing technological base and shape new dynamics (Burgelman, 1983). To the extent that innovations are patented, the number of patents can be considered as a proxy of innovative output (e.g. Jaffe et al., 1993; Flor and Oltra, 2004; Singh, 2005; Gambardella et al., 2007; Nooteboom et al., 2007). Thus it seems reasonable to consider the amount of patents applied by an organization as affected by its aptitude to exchange and acquire knowledge from sources external to its boundaries. This results in a first hypothesis:

> *H1: the propensity to perform collaborative R&D activities characterizing the organizations of a region has a positive direct effect on the likelihood to have patented inventions developed in that region.*

More technological activity in its turn is expected to translate into additional economical activity. Taking into account all the companies belonging to the same economic system (region, country, …), this might lead to a growth of the total value of sales in this geographic market[1], i.e. the total expenditures for all final goods and services produced. Since the latter sentence is the definition of Gross Domestic Product GDP, i.e. the basic indicator to measure the economical performances of an economic system, our second hypothesis is:

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[1] Under the assumption that exports don't exist: in fact, the commercializable output of R&D activities may be all exported into other countries, and this would mean no sales growth in the local market. Moreover, sales might increase because of imports.

H2:.while the propensity to perform collaborative R&D activities characterizing the organizations of a region will have a positive direct effect on local technological performances (H1), the effect on economical activity will be indirect only (via technological performances).

Both research questions focus on technological collaborations and R&D alliances and in particular on their direct and indirect impact on regional technological and economical performance. As explained in the following section, we rely both on co-patent data and the CATI alliances database to measure collaboration. An additional aim of the paper consists in exploring the different impact of these two collaborative R&D activities.

3. Methodology

This section provides the description of the sample data and the estimation model, in particular the variables introduced and the indicators used.

3.1 Data

The analyses are based on the information collected and processed from three different databases: the EPO Worldwide Patent Statistical Database (PATSTAT), the Cooperative Agreements and Technology Indicators (CATI) database and Eurostat regional statistics database.

Building on data contained in PATSTAT, we obtained exhaustive information about patents, including co-patents. In particular, we were able to obtain their count (applicant-based) by region – NUTS2 level of Eurostat classification – and by year. Applying sector allocation algorithms allows to make a distinction between different types of actors (firms, universities, PROs, individuals, governmental agencies) involved in patenting (see Van Looy et al., 2006), resulting in differentiated indicators depicting the local inclination to perform collaborative technological and R&D activities.

These data have been complemented by R&D alliances data (from the CATI database) which have been allocated at the NUTS2 level, according to the address of the partners involved. As for patents and co-patents, we were able to get a full count of R&D alliances by region and by year.

Besides indicators pertaining to technological collaboration (co-patenting) and R&D alliances, economical (GDP) and R&DI indicators (Investments in R&D, Human Resources in Science & Technology) have been collected from the Eurostat regional statistics database. Combined, this results in a panel dataset covering a 12 year time period (1994-2005) for all the regions of the EU-27 area (265 regions). Table 1 summarizes the variables under study.

Variables	Definition
Dependent variables	
GDP per population in PPP (*GDPpp_PPP*)	One-year regional domestic product measured by Purchasing Power Parity
Patents per population (*Patpp*)	One-year amount of patents per inhabitant allocated into a region according to an applicant-based criterion
Explanatory variables	
Co-patents with lag 1 (*Copat_1*)	Amount of co-patents allocated into a region (according to an applicant-based criterion) one year before compared to the dependent variable
Alliances with lag 1 (*Alliances_1*)	Amount of R&D alliances allocated into a region one year before compared to the dependent variable
Control variables	
Human Resources in Science and Technology with lag 1 (*HRSTpp_1*)	Regional amount of Human Resources employed in Science and Technology in the previous year compared to the dependent variable, expressed as percentage of population
Business Expenditures in R&D with lag 1 (*BERD_share_1*)	Regional Business Expenditures in R&D in the previous year compared to the dependent variable, expressed as percentage of GDP
Region (*NUTS2*)	NUTS2 level of Eurostat's classification of European regions
Time – linear effect (*Time*)	Year (period 1994-2005) - 1993, i.e. 1994 = 1, 1995 = 2, …
Time – squared effect (*Time2*)	*Time* * *Time*
Patents per population with lag 1 (*Patpp_1*)[2]	Amount of patents per inhabitant allocated into a region, according to an applicant-based criterion, one year before compared to the dependent variable

Table 1: Variables of the model

3.2 Dependent variables

According to the hypotheses formulated in Section 2, two different dependent variables have been introduced.

With reference to hypotheses 1, the first dependent variable is represented by the technological performances of EU-27 regions during the period 1994-2005, measured by the amount of patents. We normalized it by population to take into account the mere size of the region. Multiplying it by 1000, we obtained our first dependent variable, i.e. *Patpp*. This continuous variable is modeled as a scale variable, assuming it follows a normal distribution.

The second dependent variable is represented by the economical performances of EU-27 regions. They can be evaluated by GDP (Gross Domestic Product), measured in different ways.

In particular, we considered the GDP measured by Purchasing Power Parity exchange rate (*GDP_PPP*): it is the exchange rate based on the purchasing power parity of a currency relative to a selected standard (usually the United States dollar). It can equalize the purchasing power of different currencies in their home countries for a given

[2] Only with reference to the economical performances as dependent variable (hypothesis 2).

basket of goods, also taking into account the inflation rates of different countries (or regions). The PPP-based GDP measuring decrease the disparity in GDP between high and low income (GDP) countries, because it compensates for the weakness of local currencies in the international markets.

Normalizing it by population, to compensate for population growth, allows to get our second dependent variables, i.e. *GDPpp_PPP* (GDP per population measured by PPP), related to the hypothesis 2 formulated in Section 2. Its value is expressed by euro/(1000*inhabitants).

3.4 Explanatory variables

The explanatory variable is represented by the propensity of EU-27 regions to perform collaborative R&D activities. It can be related to their aptitude to establish both technological collaboration and joint R&D with other organizations. So we identified two indicators to evaluate the propensity to collaborate in R&D: on the one hand, the amount of co-patents (*Copat*), i.e. patents with more than one applicant; on the other hand, the number of R&D alliances (*Alliances*), such as joint development agreements, joint ventures and other forms of R&D cooperation. They are both discrete variables, but they have been modeled as scales because of the broad range of values they can assume.

In particular, we introduced in the model as explanatory these variables with lag 1 (*Copat_1* and *Alliances_1*), hypothesizing that the local propensity to collaborate has influence on the technological and on the economical performances of the following year.

3.3 Control variables

In order to check for other factors influencing regional technological and economical performance, the following control variables have been introduced:

- Human Resources in Science and Technology, with lag 1 and normalized by population (*HRSTpp_1*);
- Business Expenditures in R&D, with lag 1 and expressed as percentage of GDP (*BERD_share_1*).

They are an input-based measures of organizations' innovative effort, i.e. they measure the amount of input into their R&D activities, even if they don't provide any measure of innovation produced, because R&D activities may not lead up to any innovative output. They also take implicitly into account the efficiency of R&D process, because a certain innovation output may have been realized with different levels of 'input factors'. They are both continuous variables, modeled as scales.

Then, we checked for the region (*NUTS2*), to control for unobserved, time –in variant, differences between regions.

Finally, we controlled for time, evaluating both the linear effect (*Time*) and the squared effect (*Time2*) . They are modeled as scales.

With reference to the economical performances (hypothesis 2), we also checked for the local technological performances of the previous year, measured by the number of patents per inhabitant (*Patpp_1*).

4. Findings

The analyses and findings that we present in this section focus on two questions. First, we've investigated the determinants of technological/innovative performances, in terms of patenting, at NUTS2 level, assuming it has influence on the economical ones.

In particular, we've been interested in technological collaboration (co-patenting) and in R&D alliances. Then we analyzed the direct impact of the latter on regional economical performances, in terms of GDP growth.

Descriptive statistics of the amount of co-patents and R&D alliances per inhabitant and per region are shown in Table 2 and Table 3. They report the output for the top-25 EU regions (Table 2 in relation to co-patents, Table 3 to R&D alliances). The tables clearly indicate a different occurrence of co-patents and alliances: for example, the most collaboration-inclined region form the view point of co-patenting (DE21 – Oberbayern) has an average number of co-patents (56.85), over 12 years, five times bigger than the mean number of alliances of the region with more R&D partnerships per inhabitant (BE31 – Prov. Brabant Wallon, 10.42 alliances on average).

Descriptive Statistics

		Copatents (per population)				
		Valid N	Minimum	Maximum	Mean	Standard Deviation
NUTS2	Oberbayern	12	28,72	76,93	56,85	17,42
	Prov. Brabant Wallon	12	8,96	67,87	39,88	19,66
	Île de France	12	27,73	53,08	39,10	7,27
	Prov. Vlaams Brabant	12	10,08	52,83	33,79	13,60
	Stuttgart	12	16,42	42,26	31,34	6,59
	Darmstadt	12	16,07	44,62	31,19	8,46
	Karlsruhe	12	15,88	41,02	30,55	8,88
	Région de Bruxelles-Capitale	12	13,68	39,82	28,78	8,91
	Åland	12	,00	113,64	28,71	40,13
	Mittelfranken	12	12,57	43,92	26,41	10,41
	Köln	12	15,33	37,47	25,53	7,75
	Tübingen	12	15,20	33,49	25,41	5,83
	Rheinhessen-Pfalz	12	7,08	36,60	24,21	10,28
	Freiburg	12	13,47	34,95	23,10	7,54
	Düsseldorf	12	14,37	34,26	22,91	5,71
	Wien	12	9,74	35,35	22,84	7,64
	Luxembourg (Grand-Duché)	12	4,77	47,29	22,56	11,46
	Braunschweig	12	8,93	41,10	22,05	9,86
	Hovedstaden	12	12,25	30,01	21,74	5,45
	Hamburg	12	6,44	35,07	21,35	10,28
	Noord-Brabant	12	11,17	36,04	21,27	7,86
	Utrecht	12	13,21	32,57	21,01	5,76
	Stockholm	12	17,24	24,45	20,52	2,80
	Rhône-Alpes	12	12,16	27,92	19,66	4,90
	Oberpfalz	12	,95	33,94	18,62	11,35

Table 2: Descriptive statistics of co-patents per millions of inhabitants

This seems to be confirmed by Table 4, where the correlations between the independent variables are displayed. As expected, co-patents and alliances are quite correlated, since both represent an indicator of the innovative effort performed by organizations, even if co-patenting is an output-based measure, whereas the amount of R&D alliances an input-based one. But this correlation is not complete (0.660).

Moreover, on the one hand, some regions (DE21, BE31, FR10 – Île de France, BE24 – Prov. Vlaams Brabant, DE71 – Darmstadt, DE12 – Karlsruhe, BE10 – Région de Bruxelles-Capitale, DEA2 - Köln, DEB3 – Rheinhessen-Pfalz, DK01 - Hovedstaden, DE60 – Hamburg, NL41 – Noord-Brabant, SE11 – Stockholm) are the best-performing both from the view point of co-patents and R&D alliances. On the other hand, in the alliances top-25 there are regions, mainly English ones (UKJ1 – Berkshire, Bucks and Oxfordshire, UKH1 – East Anglia, UKI – London, UKM5 – North Eastern Scotland and UKJ2 – Surrey, East and West Sussex), not present in co-patents top-25.

Descriptive Statistics

		Alliances (per population)				
		Valid N	Minimum	Maximum	Mean	Standard Deviation
NUTS2	Prov. Brabant Wallon	12	,00	29,60	10,42	11,14
	Stockholm	12	,00	13,93	6,66	3,18
	Berkshire, Bucks and Oxfordshire	12	,00	11,30	6,48	2,99
	East Anglia	12	,00	14,12	6,16	3,61
	Oberbayern	12	,00	9,12	6,06	2,20
	Hovedstaden	12	,00	9,19	4,59	3,26
	Noord-Brabant	12	,00	7,40	4,20	2,21
	London	12	,00	5,89	3,09	1,60
	Prov. Vlaams Brabant	12	,00	8,70	2,94	2,69
	Hamburg	12	,00	9,80	2,90	3,22
	Rheinhessen-Pfalz	12	,00	6,61	2,80	1,74
	Île de France	12	,00	3,96	2,32	,95
	Darmstadt	12	,00	4,63	2,16	1,54
	Köln	12	,00	4,71	2,11	1,20
	Région de Bruxelles-Capitale	12	,00	9,43	2,07	2,70
	Limburg (NL)	12	,00	5,27	2,05	1,65
	Karlsruhe	12	,00	5,29	2,03	1,36
	North Eastern Scotland	12	,00	3,98	1,66	1,66
	Etelä-Suomi	12	,00	3,51	1,56	1,03
	Southern and Eastern (IE)	12	,00	4,66	1,53	1,43
	Noord-Holland	12	,00	5,27	1,50	1,52
	Prov. Antwerpen	12	,00	4,24	1,41	1,32
	Surrey, East and West Sussex	12	,00	3,89	1,41	1,07
	Zuid-Holland	12	,00	3,31	1,41	,93
	Cheshire	12	,00	5,03	1,27	1,56

Table 3: Descriptive statistics of R&D alliances per millions of inhabitants

Correlations

		HRSTpp_1	BERD_share_1	Copat_1	Alliances_1	Patpp_1
HRSTpp_1	Pearson Correlation	1,000	,460**	,319**	,301**	,444**
	Sig. (2-tailed)		,000	,000	,000	,000
	N	2381,000	1276	2381	2381	2377
BERD_share_1	Pearson Correlation	,460**	1,000	,416**	,411**	,636**
	Sig. (2-tailed)	,000		,000	,000	,000
	N	1276	1325,000	1325	1325	1301
Copat_1	Pearson Correlation	,319**	,416**	1,000	,660**	,637**
	Sig. (2-tailed)	,000	,000		,000	,000
	N	2381	1325	2915,000	2915	2866
Alliances_1	Pearson Correlation	,301**	,411**	,660**	1,000	,599**
	Sig. (2-tailed)	,000	,000	,000		,000
	N	2381	1325	2915	2915,000	2866
Patpp_1	Pearson Correlation	,444**	,636**	,637**	,599**	1,000
	Sig. (2-tailed)	,000	,000	,000	,000	
	N	2377	1301	2866	2866	2866,000

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

Table 4: Correlation between independent variables

Table 4 reveals a significant number of missing values for *BERD_share_1* (only 1325 valid cases compared to 3180 total observations). This is the reason why we decided to remove *BERD_share_1* as a control variable, because it would have implied to run the analyses only on 1325 cases.

4.1 Determinants of regional technological performances

The first analysis reveals the determinants of technological/innovative performances, in terms of patenting, at NUTS2 level. In particular, we're interested in technological collaboration (co-patenting) and in R&D alliances.

Table 5 and Table 6 show the results of an ANOVA analysis with patents per population as dependent variable. In Table 6 also the NUTS2 region as fixed effect is taken into account. Parameter estimates are displayed in the Appendix (see Table 9 and Table 10). The amount of patents per population is significantly higher for regions where firms were more inclined to co-patent and to establish R&D alliances in the previous year, regardless of considering the fixed effect of the region. The B coefficients of *Time* and *Time2* reveal that technological performances improve slowly but constantly in time, on the whole. *HRSTpp_1* has a significant (positive) effect which disappears when introducing the region as as fixed effect. Similar results are obtained when applying a random effect model.

Tests of Between-Subjects Effects

Dependent Variable:Patpp

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	20,757[a]	5	4,151	485,087	,000
Intercept	,252	1	,252	29,482	,000
HRSTpp_1	2,064	1	2,064	241,217	,000
Copat_1	2,178	1	2,178	254,439	,000
Alliances_1	2,073	1	2,073	242,269	,000
Time	,095	1	,095	11,128	,001
Time2	,108	1	,108	12,663	,000
Error	20,291	2371	,009		
Total	56,752	2377			
Corrected Total	41,049	2376			

a. R Squared = ,506 (Adjusted R Squared = ,505)

Table 5: ANCOVA : impact of organizations' collaborative R&D on regional technological performances ()

Tests of Between-Subjects Effects

Dependent Variable:Patpp

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	38,603[a]	256	,151	130,707	,000
Intercept	,001	1	,001	1,170	,279
NUTS2	17,846	251	,071	61,628	,000
Time	,079	1	,079	68,845	,000
Time2	,051	1	,051	44,185	,000
HRSTpp_1	,003	1	,003	2,392	,122
Copat_1	,495	1	,495	428,879	,000
Alliances_1	,005	1	,005	4,120	,043
Error	2,446	2120	,001		
Total	56,752	2377			
Corrected Total	41,049	2376			

a. R Squared = ,940 (Adjusted R Squared = ,933)

Table 6: ANCOVA to assess the impact of organizations' collaborative R&D on regional technological performances (with NUTS2 as fixed effect)

4.2 Determinants of regional economical performances

The second analysis aims at investigating to what extent technological capabilities affect economical performance and whether technological collaboration (co-patenting) and R&D alliances directly or indirectly impact regional GDP figures.

Table 7 and Table 8 display the results of an ANOVA analysis with GDP per population (measured by Purchasing Power Parity exchange rate) as dependent variable. In Table 8 also the NUTS2 region as fixed effect is taken into account. Parameter estimates are displayed in the Appendix (see Table 11 and Table 12). On the whole, it can't be observed that differences between regions in terms of GDP are positively associated with differences in terms of the propensity to engage in co-patenting or alliances (Table 7). At the same time, when focusing on variation within regions (Fixed effect results, Table 8), a positive impact of especially co-patenting does become visible. In addition, technological performances (Patpp) as well as human capital (HRSTpp1) are positively related to differences in GDPpp both between, and within regions.

Tests of Between-Subjects Effects

Dependent Variable:GDPpp_PPP

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	50903,960[a]	6	8483,993	307,890	,000
Intercept	5084,922	1	5084,922	184,535	,000
HRSTpp_1	8519,467	1	8519,467	309,177	,000
Patpp_1	8093,149	1	8093,149	293,706	,000
Copat_1	71,401	1	71,401	2,591	,108
Alliances_1	81,636	1	81,636	2,963	,085
Time	98,100	1	98,100	3,560	,059
Time2	1,288	1	1,288	,047	,829
Error	65305,998	2370	27,555		
Total	988857,376	2377			
Corrected Total	116209,957	2376			

a. R Squared = ,438 (Adjusted R Squared = ,437)

Table 7: ANOVA to assess the impact of organizations' collaborative R&D on regional economical performances (without NUTS2 as fixed effect)

Tests of Between-Subjects Effects

Dependent Variable:GDPpp_PPP

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	113848,867[a]	257	442,992	397,570	,000
Intercept	4895,676	1	4895,676	4393,705	,000
NUTS2	62944,907	251	250,777	225,064	,000
Time	611,563	1	611,563	548,857	,000
Time2	34,447	1	34,447	30,915	,000
HRSTpp_1	55,047	1	55,047	49,403	,000
Patpp_1	60,555	1	60,555	54,346	,000
Copat_1	18,644	1	18,644	16,733	,000
Alliances_1	3,301	1	3,301	2,962	,085
Error	2361,091	2119	1,114		
Total	988857,376	2377			
Corrected Total	116209,957	2376			

a. R Squared = ,980 (Adjusted R Squared = ,977)

Table 8: ANOVA to assess the impact of organizations' collaborative R&D on regional economical performances (with NUTS2 as fixed effect)

5. Contributions and implications

While recent scholars' efforts have been focused on non collaborative, unintentional knowledge transfer between organizations (spillovers and externalities), especially on industry-science interactions, it can be noticed that limited attention has been paid to the whole spectrum of interactions (alliances) that could be present within a (regional) innovation system. This contribution aimed at analyzing the occurrence and nature of technological and R&D alliances at the level of NUTS2 regions.

Descriptive statistics already reveal a different occurrence between co-patents and alliances: the former occurs five times more than the latter. This may be due to a limitation of the CATI database, from which R&D alliances data have been extracted. In fact, CATI was built from the information reported by the most important newspaper and trade journal articles, implying:

- taking into account only agreements that are made public by companies;
- articles in newspapers and journals that are likely to be incomplete;
- small/regional firms probably not well represented because of limited coverage by the press;
- a bias against those countries that are not covered by English press caused by the fact that most of the articles are in English (although also Dutch and German press is covered).

This different occurrence between co-patents and CATI alliances can be read also as a different propensity towards certain forms of R&D collaboration varying form region to region. In fact, on the one hand, some regions are the best-performing both from the view point of co-patents and R&D alliances. This may mean that these regions are characterized by firms that make R&D partnerships flowing into technological collaboration (co-patenting). On the other hand, there are regions best-performing in partnerships, but not in terms of co-patenting, and vice versa. This leads us to not consider on the whole co-patents and alliances as indicator of the same phenomenon (R&D collaboration).

Applying fixed effects regression models allows assessing the distinctive contribution of collaborative R&D activities towards economical performances. Our findings clearly indicate positive effects of technological collaborations (measured by means of co-patenting) and R&D alliances, but only indirect, i.e. via technological/ innovative performances (patenting), that turn out to lead economical ones. This confirms our two hypotheses.

Anyway, the effects of R&D alliances are less outspoken, since GDP is higher for regions where firms are more inclined to establish partnerships (direct effect), but this is significant only at the 0.1 level.

These findings support the relevance of investigating the economic growth and the industrial development in knowledge-based cities and regions. Several knowledge and technology transfer policies have been in fact aimed at firms for encouraging them to approach research centers and universities, e.g. through financial support and funds linked to the presence of research partners. Science or Technology Parks have also been built widely around multinational enterprises as strong anchor tenants, as well as Living laboratories developing test beds for new products, new technology and services. Our findings show the potential relevance of companies establishing technological collaborations and performing collaborative R&D activities for regional economic and industrial development: if they are more inclined to co-operate in R&D with other organizations, they can reach an incremented and more high-quality innovation output, fostering local economic growth.

We acknowledge some limits of our work that imply the directions for future developments and further research. The main one is probably the simplicity of our estimation model: more complex estimation techniques, such as Structural Equation Modelling, might better fit the data, providing a strong check of the robustness of the model and results. Variables depicting the nature of collaboration (Industry-Science; Industry-Industry) could also be added in the model, examining their respective roles (similar, distinctive, complementary, …).

References

Abramovsky L., Kremp E., Lopez A., Schmidt T. and Simpson H., 2005, "Understanding co-operative R&D activity: Evidence from four European countries", Working paper 05/23, The institute for fiscal study, London, UK

Becker W. and Dietz J., 2004, "R&D cooperation and innovation activities of firms-evidence for the German manufacturing industry", Research Policy, 33, 209-223

Bercovitz J. and Feldman M., 2005, "Fishing upstream: firm innovation strategy and university research alliances", Paper presented at the DRUID Tenth Anniversary Summer Conference 2005 on DINAMICS OF INDUSTRY AND INNOVATION: ORGANIZATIONS, NETWORKS AND SYSTEMS, Copenhagen, June 27-29

Belderbos R., Carree M. A., Diederen B., Lokshin B. and Veugelers R., 2004, "Heterogeneity in R&D co-operation strategies", International Journal of Industrial Organization, 22, 1137-1263

Burgelman R. A., 1983, "A process model of internal corporate venturing in a diversified major firm", Administrative Science Quarterly, 28, 223-244

Bramwell A. and Wolfe D. A., 2008, "Universities and the regional economic development: the entrepreneurial University of Waterloo", Research Policy, 37 (8), 1175-1187

Cameron G., 1998, "Innovation and Growth: a survey off the empirical evidence", Nuffield College, Oxford, UK

Chesbrough H. W., 2003, "Open Innovation. The new Imperative for Creating and Profiting from Technology", Boston: Harward Business School Press

Cohen W. M. and Levinthal D. A., 1990, "Absorptive capacity: A new perspective on learning and innovation", Administrative Science Quarterly, 35 (1), 128-152

Döring T. and Schnellenbach J., 2006, "What Do We Know About Geographical Knowledge Spillovers and Regional Growth? – A Survey of the Literature", Regional Studies, 40 (3), 375-395

Etzkowitz H. and Leydesdorff L., 1998, "The endless transition: A 'triple helix' of university-industry-government relations", Minerva, 36, 203-208

Flor M. L. and Oltra M. J., 2004, "Identification of innovating firms through technological innovation indicators: an application to the Spanish ceramic industry", Research Policy, 33, 323-337

Fritsch M. and Franke G., 2004, "Innovation, regional knowledge spillovers and R&D cooperation", Research Policy, 33, 245-255

Gambardella A., Giuri P. and Liuzzi A., 2007, “The market of patents in Europe”, Research Policy, 36, 1163-1183

Hagedoorn J., 2002, “Inter-firm R&D partnerships: an overview of major trends and patterns since 1960”, Research Policy, 31, 477-492

Hill K., 2006, “University Research and Local Economic Development”, A Product of Arizona State University’s, Productivity and Prosperity Project (P3)

Jaffe A. B., Trajtenberg M. and Henderson R., 1993, “Geographic localization and knowledge spillovers as evidence by patent citations”, Quarterly Journal of Economics, 108, 577-598

Jinyoung K., Sangjoon J. L. and Marschke G., 2005, “The Influence of University Research on Industrial Innovation”, NBER Working Paper No. 11447, National Bureau of Economic Research, Cambridge, MA

Koput K. W., Powell W. W. and Smith-Doerr L., 1996, “Interorganizational collaboration and the locus of innovation: Networks of learning”, Admistrative Science Quarterly, 41, 116-145

Messeni Petruzzelli A. and Rotolo D., 2008, “Do Proximity Dimensions Drive Exploitative or Explorative Innovations? The Case of Toyota Motor Corp.”, XIX Riunione Scientifica Annuale AiIG, Palermo, Italia, October 23-24

Nooteboom B., Haverbeke W. V., Duysters G., Gilsing V. and van den Oord A., 2007, “Optimal cognitive distance and absorptive capacity”, Research Policy, 36, 1016-1034

Romer P. M., 1986, “Increasing Returns and Long-Run Growth”, Journal of Political Economy, 94 (5), 1002-1037

Romer P. M., 1990, “Endogenous Technical Change”, Journal of Political Economy, 98 (5), 71-102

Schumpeter J. A., 1942, “Capitalism, socialism and democracy”, New York: Harper and Row

Singh J., 2005, “Collaborative networks as determinants of knowledge diffusion patterns”, Management Science, 51, 751-770

Spencer J. W., 2001, “How relevant is university-based research to private high technology firms? A United States-Japan comparison”, Academy of Management Journal, 44, 432-440

Van Looy B., Du Plessis M. and Magerman T., 2006, “Data production methods for harmonized patent indicators: Assignee sector allocation”, EUROSTAT Working Paper and Studies, Luxemburg.

Varga A., 2001, “Agglomeration and the Role of Universities in Regional Economic Development”, in Lengyel I. (Eds.), 2003, “Knowledge Transfer, Small and Medium-sized Enterprises, and Regional Development in Hungary, JATEPress, 15-31

Wagner C. and Leydesdorff L., 2005, “Network structure, self organisation, and the growth of international collaboration in science”, Research Policy, 34, 1608-1618

Wang Hui-chen, 2003, “Long-term Effects of Institutions of Higher Education on the Regional Economy”, University of Michigan, Department of Economics

Yamin Mo. and Otto Juliet, 2004, “Patterns of knowledge flows and MNE innovative performance”, Journal of International Management, 10 (2), 239-258

Appendix

Parameter Estimates

Dependent Variable:Patpp

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	-,065	,012	-5,430	,000	-,088	-,041
HRSTpp_1	,538	,035	15,531	,000	,470	,606
Copat_1	,001	,000	15,951	,000	,001	,001
Alliances_1	,011	,001	15,565	,000	,009	,012
Time	,011	,003	3,336	,001	,005	,017
Time2	,000	,000	-3,558	,000	-,001	,000

Table 9: ANOVA to assess the impact of organizations' collaborative R&D on regional technological performances (without NUTS2 as fixed effect) – Parameter Estimates

Parameter Estimates

Dependent Variable:Patpp

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	-,029	,011	-2,585	,010	-,052	-,007
Time	,010	,001	8,297	,000	,008	,013
Time2	,000	,000	-6,647	,000	,000	,000
HRSTpp_1	,038	,024	1,547	,122	-,010	,085
Copat_1	,001	,000	20,709	,000	,001	,002
Alliances_1	,000	,000	-2,030	,043	-,002	-3,260E-5

a. This parameter is set to zero because it is redundant.

Table 10: ANOVA to assess the impact of organizations' collaborative R&D on regional technological performances (with NUTS2 as fixed effect) – Parameter Estimates

Parameter Estimates

Dependent Variable:GDPpp_PPP

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	9,223	,679	13,584	,000	7,892	10,555
HRSTpp_1	36,320	2,066	17,583	,000	32,270	40,371
Patpp_1	21,066	1,229	17,138	,000	18,655	23,476
Copat_1	,007	,004	1,610	,108	-,001	,015
Alliances_1	,071	,041	1,721	,085	-,010	,152
Time	,351	,186	1,887	,059	-,014	,716
Time2	-,003	,013	-,216	,829	-,027	,022

Table 12: ANOVA to assess the impact of organizations' collaborative R&D on regional economical performances (withoutNUTS2 as fixed effect) – Parameter Estimates

Parameter Estimates

Dependent Variable:GDPpp_PPP

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	11,257	,353	31,864	,000	10,564	11,950
Time	,923	,039	23,428	,000	,846	1,000
Time2	-,015	,003	-5,560	,000	-,020	-,009
HRSTpp_1	5,323	,757	7,029	,000	3,838	6,808
Patpp_1	4,912	,666	7,372	,000	3,606	6,219
Copat_1	,010	,002	4,091	,000	,005	,015
Alliances_1	,025	,015	1,721	,085	-,004	,054

a. This parameter is set to zero because it is redundant.

Table 12: ANOVA to assess the impact of organizations' collaborative R&D on regional economical performances (with NUTS2 as fixed effect) – Parameter Estimates