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SYSTEMIC PROXIMITY IN EUROPEAN NANOTECHNOLOGY NETWORKS

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Abstract

In this paper, we investigate the role of systemic proximity in European nanotechnology networks. Systemic proximity represents the closeness between collaborators belonging to the same innovation system, thereby sharing the same set-up of formal and informal rules, the same policies as well as the same cultural background. We analyse whether collaboration is more likely for partners that are systemically close. With our analysis we add to a fuller picture of the variety of proximity by not only including organizational, technological and geographical but also including systemic proximity. We suggest that our findings regarding systemic proximity are particularly insightful for policy as systemic proximity encompasses the institutional framework provided by policy makers.

Jelcodes:O38,C39

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In this paper, we investigate the role of systemic proximity in European nanotechnology networks. Systemic proximity represents the closeness between collaborators belonging to the same innovation system, thereby sharing the same set-up of formal and informal rules, the same policies as well as the same cultural background. We analyse whether collaboration is more likely for partners that are systemically close. With our analysis we add to a fuller picture of the variety of proximity by not only including organizational, technological and geographical but also including systemic proximity. We suggest that our findings regarding systemic proximity are particularly insightful for policy as systemic proximity encompasses the institutional framework provided by policy makers.

Keywords:
Systemic proximity, network, publication, nanotechnology, European Union, EFTA.

JEL Classification:
O33, O14, 038, R12

Table of Contents

1. Introduction

As in other parts of the industrialized advanced world nanotechnology has become a major driving force to technological advancement and economic growth in Europe (Commission of the European Communities (CEC), 2009a, Bozeman et al., 2007, Islam and Miyazaki, 2009, Salerno et al., 2008). During the last decades it has had critical influence on former and current technological development not only for nanotechnology itself but also in related technological areas such as ICT and biotechnology.

In recent years there have been quite some theoretical and empirical efforts to disentangle different kinds of proximity which partly overlap and depend on each other. Theoretically, many kinds of proximity are discussed, e.g. organizational, technological, geographical, cognitive, sectorial, functional and social proximity (Boschma, 2005, Frenken et al., 2010, Maggioni and Uberti, 2009, and Petruzelli, 2008). Empirically, the analyses have been less succinct as data on various kinds of proximity is not abundantly available. Nevertheless, some former empirical analyses contribute to our understanding of proximity by showing that different types of proximity can overlap and be mutually dependent.

In this paper, we investigate whether and how systemic proximity co-evolve with geographical, technological and organizational proximity in influencing the likelihood of researchers to collaborate. The paper is organized as follows: First, we conceptualize systemic proximity and contrast it with the other kinds of proximity we include in our analysis, i.e. geographical, technological and organizational proximity. System proximity, in a nutshell, captures the kind of closeness between collaboration partners emerging from being part of the same regional and national innovation system (Section 2.). Based on that we suggest four hypotheses regarding the role of different kinds of proximity for the likelihood to collaborate. Then, we introduce the data we use for our analysis (Section 3.). We rely on publication data from the Web of Science to detect collaboration patterns, organizational and technological proximity, data from Google Earth representing geographical distance, data from Eurostat to account for economic differences of regional and national innovation systems as well as policy indicators to show the variety of the working of regional and national innovation systems. Following that, we introduce the model, show our results and explain what our findings on systemic and other kinds of proximity would mean for policy (Section 4.). We round our paper with a short summary of our results and some suggestions for future research (Section 5.).

2. Systemic and other kinds of proximity

Numerous kinds of proximity have been theoretically identified, i.e. geographical, cognitive, technological, social, organizational and institutional proximity (e.g. Knoben and Oerlemans, 2006, and Boschma, 2005). Scholars have provided many empirically founded results on geographical proximity. Fewer studies exist on other kinds of proximity. Recently, there have been some analyses for nanotechnology: A study for the U.S. concentrates on geographical proximity. It shows that there are regionally tied "nanodistricts" in the form of distinct types, such as government-dominated districts, university-dominated districts, and high technology districts have emerged (Shapira and

Youtie, 2008). There is a study on the importance of social proximity for micro and nanotechnologies using data of collaboration projects financed under the 6th framework of the European Commission (Autant-Bernard et al., 2007). In particular this study shows that the position of researchers in the network influences their choice of partners. In a former study we contributed to explaining how organizational, technological and geographical proximity affects the publication output in European nanotechnology (Cunningham and Werker, forthcoming). While geographical proximity directly positively influence publication organizational proximity only does so indirectly. For technological proximity we showed that organizations are doing best in terms of publication if they are close but not too close technologically.

Based on the theoretical findings on proximity and literature on regional and national innovation systems we develop an additional notion, i.e. *systemic proximity* in order to capture the cultural and institutional background stemming from various kinds of innovation systems. Systemic proximity emerges when economic agents stem from the same innovation system. Innovation systems create an environment where economic agents are subject to and are using the same formal and informal rules, the same policies and the same cultural background (Metcalfe, 2005). By using this rather broad definition we explicitly include the notions of social proximity on the micro-level, i.e. closeness based on friendship or past experience embodied in specific relationships, as well as institutional proximity on the macro-level, i.e. generally applicable norms and values (Boschma, 2005). The reason for this is that it is theoretically and empirically very difficult to disentangle social and institutional proximity. Therefore, we choose for systemic proximity, which gives us the opportunity to include a policy sensitive measure in our analysis.

Systemic closeness can emerge from the regional, national and global level. On the national and sometimes on the supra-national (e.g. EU-) level economic actors are subject to the same set-up and functioning of formal institutions (Metcalfe, 2005, and CEC, 2009a and b). On the regional level cultural aspects and similar informal rules ease knowledge flows and cooperation's (Werker and Athreye, 2004). Knowledge flows within regions do not only benefit from the same cultural background of agents and their closely-knitted networks but also from the regional specialisation in similar or closely connected technologies. In these cases knowledge production and exchange stems from the agglomeration of economic activities (Cooke et al., 1997).

In order to better determine the actual influence of systemic proximity, we include three major kinds of proximity, namely the well-established geographical proximity as well as technological and organizational proximity. *Geographical proximity* is normally defined as the pure spatial or physical proximity of economic actors (Boschma, 2005, and Meister and Werker, 2004). This notion of geographical proximity reflects the fact that being physically close is never sufficient to stimulate and enhance exchange of knowledge between partners and resulting innovation. However, physical closeness might augment other kinds of proximity. *Technological proximity* is an essential ingredient for successful collaborations as it provides a shared knowledge base for partners (Knoben and Oerlemans, 2006, and Nooteboom, 2000, and Boschma, 2005). It enables the partners to successfully exchange and use knowledge in their joint work building on shared technological experiences and knowledge bases. To carry out joint research projects collaboration partners have to be technologically close but not to close in order to be able to successfully combine their different knowledge bases (Cunnigham and Werker, forthcoming). *Organizational proximity* refers to closeness in terms of managerial arrangements regarding incentive structure and work organization, (Boschma, 2005, as well as Meister and Werker, 2004). Organizational proximity in terms of the types of the research organization carrying out the research, i.e. being an academic or a non-academic organization, influences publication output in nanotechnology only indirectly via technological closeness (Cunningham and Werker, forthcoming).

In accordance with our considerations and former findings on the proximity we formulate the following hypotheses (elaborate???). Regarding *systemic proximity* we suggest *that systemic proximity has positive influence on collaboration* ***(Hypothesis 1)***. Regarding geographical proximity we suggest *that geographical proximity has positive influence on collaboration* ***(Hypothesis 2)***. Regarding technological proximity we convey *that technological proximity has a positive influence on collaboration until collaboration partners become too different* ***(Hypothesis 3)***. Regarding *organizational proximity* we suggest *that it has a positive influence on collaboration* ***(Hypothesis 4).***

3. Measuring proximity in European nanotechnology networks

3.1 Publication data from the Web of Science

The term nanotechnology refers to a wide-ranging field of basic and applied research including various areas of application, such as physics, chemistry and medicine (Miyazaki and Islam, 2009). Often scholars distinguish between nanotechnology research and nanoscience (e.g. Miyazaki and Islam, 2009). Still others use nanotechnology as the synonym for both (e.g. CEC, 2009b, and Bozeman et al., 2007). The distinction between nanotechnology research and nanoscience is motivated by the traditional distinction between basic and applied research. This distinction suggests that the development of fundamental understanding and of practically usable results is the opposite ends of a continuum. However, pursuing fundamental understanding as well as finding practically usable results at the same time is not only possible but seems to be the most interesting part of activities in science and research (Stokes, 1997). Therefore, we will use nanotechnology as a synonym for nanotechnology research and nanoscience in our following analysis. We thereby acknowledge the fact that researching and developing nanostructures contribute to fundamental understanding as well as to practical use (e.g. Islam and Miyazaki, 2009).

In our analysis we will include the twenty-seven EU countries (Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom) as well as the four European Free Trade Association (EFTA) countries (Iceland, Liechtenstein, Norway, Switzerland). This geographical delineation makes a lot of sense because research in the EU and EFTA countries is closely connected (for a similar delineation see Cunningham and Werker, forthcoming).

We use the so-called Porter query to identify the nanotechnology related sub-set of data from the Web of Science (for details on the procedure see Cunningham and Werker, forthcoming).. The Web of Science offered by Thomson Reuters covers ten thousand high impact journals worldwide and includes 256 disciplines (Thomson Reuters, 2011).

As we want to analyze the subset of journals relating to nanotechnology we use the query design developed by Porter, Youtie, Shapira and Schoeneck: Their query design was carefully developed in consultation with nanotechnology experts and includes two fields of physics (applied physics and condensed matter), two fields of chemistry (physical chemistry and multidisciplinary chemistry), materials science (multidisciplinary materials science), as well as nanoscience and nanotechnology. Amongst others the database contains abstracts, keywords, the names of authors and their organizational affiliations. The subset of the database that we will use in the following contains more than 14,000 abstracts of nanotechnology related papers, published from 2008 until 2009. We restrict our analysis to this data because we are only able to unambiguously relate the authors to geographical places for this period of time. To appropriately credit collaboration we follow the scheme for fractionating co-patenting activities which was used in Maggioni et al. (2007). This means, we first divide the credit for the paper equally across all authors, and then award the respective organizations according to the affiliations of the authors.

In our analysis inter-organizational collaborations serve as a proxy for knowledge exchange, because the substantial efforts required are only reasonable if substantive knowledge sharing takes place (Katz and Martin, 1997). This indicator may provide valuable insights into the working of collaborations, particularly in science-based industries such as nanotechnology. To give an example, Frenken et al. (2010) also investigate collaborations in science-based industries, albeit with a different dependent variable than proposed here. This is notwithstanding the fact that publications only partially and, incompletely measure collaboration and knowledge exchange. For a critical review of the limitations of publication data as output indicators please refer to Nelson, 2009.

In the following, we investigate the one hundred most productive European organizations in the field of nanotechnology, i.e. those with at least one author affiliated in the EU or in the EFTA countries (for the discussion of the geographical delineation see Section 2.). They account for about 40% of the European total number of publications. For this disambiguated the names of the organizations in the database apportion research to participating organizations according to total authorship. For instance, an organization which contributes two out of five total authors receives a 40% credit for the paper as a whole. We do not include intra-organizational collaborations, i.e. we omit papers written by authors from the same organization. This is notwithstanding that internal collaboration within organizations is an important phenomenon. It is not the object of this particular study though.

3.2 Organizational, technological and geographical data

We extended and complemented the data of the one hundred most productive European organizations in nanotechnology related publications with organizational, technological and geographical information (for a similar approach see Frenken et al., 2010 as well as Cunnigham and Werker, forthcoming). In order to include *organizational information* we classified each organization according to its academic or non-academic character. Pure academic collaborations take place between partners stemming both from an academic background (academic/academic) while pure non-academic collaborations take place between partner stemming both from a non-academic background (non-academic/non-academic). These two types are closest in terms of organizational distance. Collaborators from a mixed academic and non-academic background (hybrid) show the largest organizational distance. We added *technological information* by calculating a technological research profile of each organization on the basis of the six major nanotechnology subject categories provided by the Porter query (Porter, Youtie, Shapira and Schoeneck, 2008) and an "all others" category. The more overlap two organizations have in terms of this profile the closer they are technologically. We completed our data with *geographical information* by geo-locating each organization using Google Earth based on the longitude and latitude for each organization, stored in fractions of a degree (Google Earth, 2011). Then, we related each organization to the NUTS (Nomenclature of Territorial Units for Statistics) system by using the two levels NUTS 1 and NUTS 2 (Eurostat, 2011 c). NUTS 1 relates to major socio-economic regions (e.g. Länder in Germany or regions in Belgium) and NUTS 2 to more disaggregated units often used for implementing specific regional measures (e.g. counties in the UK, regions in Romania or provinces in Belgium and the Netherlands).

3.3 Systemic information

Systemic information we added in the following way: We examine the following variables as proxies for national as well as regional systems of innovation. At the national level we examine three variables: *national expenditure on R&D, national high technology exports* and *national R&D personnel.* The variables are sourced from Eurostat (2012a). The data was collected for all sixteen nations in the study, using the most recent data available. In the tables which follow these variables are respectively abbreviated as national R&D, national HTE and national labor.

National expenditure on R&D is measured as a fraction of national gross domestic product. This measure measures combined public and private sector spending. Relative national spending on R&D is widely seen as an important benchmark for national science policy. In this study we examine combined R&D expenditures, although given sufficient data, it could also be interesting to disaggregate the source and sink of such spending. High technology exports is measured as a fraction of total national exports. High technology export is considered an important variable for measuring international competitiveness in science and technology. National R&D personnel is measured as a fraction of the total workforce. National capabilities for producing and maintaining a high technology workforce are widely considered to be an important precursor to technological competitiveness. These variables, and host of other qualitative and quantitative variables, were developed as "high technology indicators" by Newman et al. (2005).

At the regional level we examine four variables. These variables are *regional R&D spending, regional GDP per inhabitant, regional students in tertiary education,* and regional *employment in the industrial economy.* These variables are sourced from Eurostat (2012b). The data was collected for all eighty-six regions in the study.

Regional R&D spending is measured as a proportion of total national R&D spending. Regional R&D spending is of policy interest for many of the same reasons as national R&D expenditure. As above, this measures aggregate spending by all sectors. Furthermore, national resource allocation to the regional innovation systems has previously been identified as a significant determinant of scientific output (Cunningham 2009). GDP per inhabitant is assessed using a measure of purchase power parity (PPP) scaled such that 100 equals the average European region. This variable is an important compactor across regions, effectively measuring the value-creation capability of the regional workforce. Students in tertiary education are measured as a fraction of tertiary school-age population. This variable measures both aspiration to participate in the R&D system, as well as local high technology capability of the workforce. Note that irregularities in defining tertiary school age and education across nation means that this variable may exceed one hundred percent. Employment in the industrial economy is measured as a fraction of total economy, aggregating appropriate subsectors according to their industrial character. This variable measures both the availability of the qualified workforce, as well as the interests of the private sector in locating in the region. The local hard and soft infrastructure are partly determinants of industrial location choice.

The independent variables selected are relative, rather than absolute variables. This is important to note because both relative and absolute effects are of potential significance in the causative relationship between science and innovation policy and organizational output. All things considered, more populous, more richly funded nations and regions will likely outpace their smaller peers in absolute numbers of publications, citations and partnerships. However, national and decision-makers must manage the allocation of often fixed resources as best as possible. Thus, the relative variables are of particular policy significance. Furthermore the statistical tests which follow will be stricter, and therefore more incisive of policy influences, without absolute magnitudes of system inputs.

We deal with missing data using the following techniques. Where data is missing by year, we take the most recent available data. Where data is missing by NUTS 2 region, but aggregated at NUTS 1, we inherit the data of the next larger region. Where regional data is missing, but other data at the regional or national data is available, we use a well-established method for imputing missing values (Dempster et al. 1977). Our missing data model involves a three factor solution.

We further transform the data to appropriately handle ordinal and proportional scaling. Two variables are ordinally scaled – regional GDP per inhabitant and regional students in tertiary education. Treatment of these variables involves taking the natural logarithm. The remaining five variables are ratio scaled. Treatment of these variables involves taking the log-odds. This effectively transforms the variable into a continuous scale ranging from negative to positive infinity.

Based on the organizations discussed above we include *three control variables,* namely total earned publications (publication), total earned citations (citation), and total number of partners in collaborations (partners). All three control variables are measured by organization, across the entirety of all partnerships and publications. These are the dependent variables investigated as dependent variables in this study. These variables have been investigated by many other researchers a proxies for scientific output (c.f. Godin 2003). As one example, Cunningham and Werker (forthcoming) examined both these variables and these organizations. The authors used these measures of scientific output as controls in a larger study of inter-organizational collaboration.

4. European nanotechnology networks: systemic and other kinds of proximity

In this study we hypothesize that the one hundred organizations discussed above are systemically embedded in a regional as well as a national system of innovation. As a consequence, science policies at the regional and national level determine in large part the productivity of these organizations in producing highly cited research, and in developing productive collaborative relationships with other organizations.

4.1 Descriptive Statistics

When looking at the data it is striking that the top one hundred organizations we will analyze in the following are located in 16 nations, across 86 NUTS 2 regions. As a nation Germany has the most entrants in the list. One Spanish and two German regions had three distinct researching organizations in the region: the regions of Karlsruhe (Germany), Berlin (Germany) and Madrid (Spain).

A summary of the dependent and independent variables are presented in table 1. The nations and regions investigated in this study do not differ significantly on these variables from the European Union nations as a whole.

INSERT TABLE 1 ABOUT HERE

A table of correlations reveal a significant degree of correlation in the data set. The regional and national variables are correlated. In addition, both these sets of variables are strongly correlated with the dependent variable of organizational science output.

4.2 The Model

The data is modeled using multivariate regression. As noted there are three dependent variables (i=1,...,3), and seven independent variables (j=1,..,7) plus a constant. After adding normally distributed noise, the model specification is the following:

$$y_i = \beta_{i0} + \beta_{ij} x_j + N(0, \sigma^2)$$

Results

INSERT TABLES 3 TO 5 ABOUT HERE

Nanotechnology publication in the organization is strongly dependent upon regional and national capabilities. Nanotechnology citation in the organization is strongly dependent upon regional and national capabilities. Nanotechnology partnership is strongly dependent upon regional and national capabilities. The results are uniformly statistically significant, with national and regional characteristics predicting some 21% to 33% of organizational performance in science output.

INSERT TABLE 6

Both regional and national characteristics are needed to fully explain these results. Lipovetsky and Conklin (2001) propose a method for correctly apportioning variance explained between independent variables when these variables are mildly or even strongly correlated. This technique is known as Shapley value regression. Table 6 displays the Shapley values for national versus regional characteristics in determining scientific output. The role of regions differs significantly according to which output indicator is being examined. Regions are most significant in determining the number of research partnerships available to universities. Regions are secondarily significant in determining scientific output. Nations are most significant in determining highly cited work. This table also demonstrates that regions are fully, and distinctly, significant in predicting scientific output than nations.

4.2 Systemic and other kinds of proximity explaining European nanotechnology networks

National R&D spending is strongly associated with scientific publication, citation and partnership in nanotechnology. National high technology exports are strongly associated with scientific publication, citation and partnership in nanotechnology. National high technology labor force is inversely related to scientific publication, citation and partnership in nanotechnology. Regional tertiary education is strongly related to scientific publication, citation and partnership in nanotechnology.

Regional R&D spending is inversely related to scientific publication and citation in nanotechnology. Regional purchasing power parity is inversely related to scientific publication, citation and partnership in nanotechnology. Regional high-technology employment is positively related to publication and citation, but negatively related to nanotechnology partnership. These results are counter-intuitive, but I would argue this is theoretically justifiable given the regional development role of universities, which are the prime publishers. Furthermore we argue this is theoretically justifiable given the regional development role of universities, which are the prime publishers. Furthermore these results suggest results which are indicative of a more “closed” or perhaps “industrial” or “development-based” innovation system.

5. Conclusions

We conclude that there are systematic influences reaching from national innovation policies, to regional characteristics, to individual characteristics of organizations. These national and regional affects have direct and measurable effects on the organization in terms of productivity, but they also have relational effects, changing the availability of collaboration partners, and enhancing the productivity of research alliances.

Further analysis would benefit from an enhanced model that might look like the following. Level 0 is the national level. Level 1 is the regional level. Level 2 is the organizational level. National capability variables predict regional R&D capabilities. Also at the regional level are systemic variables such as high technology employment, and enrollment in tertiary school. Furthermore, at the regional level there are economic variables including national R&D spending and purchasing power parity. Regional R&D predicts the conversion of previous publication to future collaboration at the organizational level. Also at the organizational level are other proximity variables including physical, technical and organizational. Systemic differences in regional capabilities (at level 1) may also drive organizational proximity.

In continued work we hope to develop a fully hierarchical model which examines national and regional variation in scientific input. We hypothesize that variations in these parameters correspond to systemic measures of the national system. We further hypothesize that collaboration is inhibited or forestalled between partners who operate in very different systems as measured by these parameters. The research interest in such an extended model is the fact that it may provide tangible evidence of known, yet hard to measure, systemic differences in national and regional innovation systems.

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Table 1. Descriptive Statistics

Variable Name	Ave.	Untransformed Ave.	Std. Dev.
Publication	2.593	13.381	0.287
Citation	3.013	20.351	0.381
Partnership	1.913	6.774	0.225
National R&D	-3.861	2.061%	0.569
National HTE	-1.905	12.952%	0.888
National Labor	-4.455	1.149%	0.344
Regional R&D	-3.868	2.047%	0.811
Regional GDP	0.159	117.214	0.402
Regional Edu	-0.492	37.945%	0.454
Regional Ind	-1.243	22.383%	0.839

Table 2. Correlations Between Variables

		1	2	3	4	5	6	7	8	9	10
1	Publication	1.000									
2	Citation	0.868*	1.000								
3	Partnership	0.603*	0.651*	1.000							
4	National R&D	-0.026	0.242*	0.210*	1.000						
5	National HTE	0.211*	0.433*	0.343*	0.520*	1.000					
6	National Labor	-0.021	0.248*	0.161*	0.942*	0.506*	1.000				
7	Regional R&D	0.146*	0.257*	0.329*	0.677*	0.318*	0.656*	1.000			
8	Regional GDP	0.250*	0.360*	0.341*	0.283*	0.290*	0.307*	0.320*	1.000		
9	Regional Edu	-0.113*	-0.287*	-0.107*	-0.306*	-0.459*	-0.225*	-0.012	0.195*	1.000	
10	Regional Ind	-0.268*	-0.254*	-0.208*	0.065*	-0.301*	0.038*	-0.055*	-0.529*	-0.259*	1.000

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

Table 3. Predicting Publication as a Function National and Regional Capabilities

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.454	.206	.205	.256

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	84.102	7	12.015	183.041	.000a
Residual	324.387	4942	.066		
Total	408.489	4949			

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	4.222	.156		27.083	.000
National R&D	.117	.006	.331	18.327	.000
National HTE	.152	.012	.213	12.827	.000
National Labor	-.177	.011	-.280	-16.192	.000
Regional R&D	-.052	.006	-.152	-8.673	.000
Regional PPP	-.229	.021	-.453	-10.908	.000
Regional Edu	.031	.006	.097	5.052	.000
Regional Industrial	.014	.033	.017	.437	.662

Table 4. Predicting Citation as a Function of National and Regional Capabilities

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.573	.328	.327	.312

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	234.994	7	33.571	344.278	.000
Residual	481.895	4942	.098		
Total	716.889	4949			

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	6.611	.190		34.795	.000
National R&D	.101	.008	.216	13.001	.000
National HTE	.281	.014	.297	19.442	.000
National Labor	-.302	.013	-.361	-22.674	.000
Regional R&D	-.051	.007	-.111	-6.896	.000
Regional PPP	-.242	.026	-.362	-9.481	.000
Regional Edu	.073	.008	.169	9.578	.000
Regional Industrial	.214	.040	.193	5.385	.000

Table 5. Predicting Partnership as a Function of National and Regional Capabilities

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.573	.328	.327	.312

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	234.994	7	33.571	344.278	.000
Residual	481.895	4942	.098		
Total	716.889	4949			

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	6.611	.190		34.795	.000
National R&D	.101	.008	.216	13.001	.000
National HTE	.281	.014	.297	19.442	.000
National Labor	-.302	.013	-.361	-22.674	.000
Regional R&D	-.051	.007	-.111	-6.896	.000
Regional PPP	-.242	.026	-.362	-9.481	.000
Regional Edu	.073	.008	.169	9.578	.000
Regional Industrial	.214	.040	.193	5.385	.000

Table 6. Shapley Value of R Square

	Apportioned R Square	
Dependent Variable	National	Regional
Publication	.103	.103
Citation	.200	.127
Partnership	.102	.163