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Abstract

Theories that emphasise the role of proximity and tacit knowledge in innovation processes highlight the importance of social interaction and networking for the diffusion of knowledge. A concept that captures the impact of human relations on economic activity is Social Capital. Using factorial analysis with data from the European Values Study we demonstrate empirically the multi-dimensionality of Social Capital. The obtained independent dimensions serve as inputs in a knowledge production function estimated for a sample of European regions. One of our major results is that the impact of Social Capital on regional innovation processes is significant and comparable to the importance of Human Capital. However, not all dimensions of Social Capital exhibit the same explanatory power. The dimension "Associational Activity" represents the strongest driving force for patenting activity. Hence, empirical evidence for the significance of weak ties in innovative processes is given.

Keywords: social capital, innovation, knowledge spillovers, economic geography,

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1 Introduction

The academic discourse in economic geography has been characterised in the last decade by two key concepts: knowledge as a source of competitiveness and the region as a platform for agglomeration. The first owes its notoriety to the shift of competitive advantage from cost-based to quality based (PORTER, 1990) and the rise of the knowledge based economy with emphasis on high technology industries (OECD, 1996). In such a setting "knowledge is the most important strategic resource and learning the most important process" (Lundvall in MORGAN, 1997, p. 493). The second was triggered by the emergence of powerful regional economies in the wake of ongoing globalisation. This phenomenon induced analysts to shift the unit of analysis from the nation to the region: „…it is cities and regions, and no longer nations that are the critical drivers of economic development" (ROBERTS and STIMSON, 1998, p. 469)

The two lines of research are linked by a concept developed by the philosopher of science Michael Polanyi: tacit knowledge. This kind of knowledge is best defined as disembodied know-how that can only be diffused in personal interaction and face-to-face contacts (HOWELLS, 2002). MASKELL and MALMBERG (1999) argue that the construction of information superhighways eliminated codified knowledge as competitive advantage because it now is ubiquitously available. Tacit knowledge however is diffused in idiosyncratic personal interaction and social networks that are not easily replicable in other locations. From these considerations a new paradigm emerged that puts collective learning processes rooted in the local community at the centre of analysis: the learning region concept. Learning regions are locations with a strong social and institutional endowment that exhibit continuous creation and diffusion of new knowledge and high rates of innovation (FLORIDA, 1995; MORGAN, 1997).

In short, this theoretical orientation emphasises "soft" factors such as social interaction and cultural characteristics in the analysis of "hard" outcomes such as innovative production and economic development. The methodical approach relies predominantly on discursive reasoning with case studies as empirical foundation (see discussion on methodology in the special issue of Regional Studies 2003 pp. 699 - 751). Accordingly, these contributions are criticised for their conceptual confusion and lack of analytical rigour. MARKUSEN (1999) diagnoses the literature with "fuzzy concepts, scanty evidence" and asks for more rigour and policy relevance.

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The objective of our analysis is to provide empirical evidence that Social Capital triggers the output of innovation processes. The criticism regarding the shortcomings of empirical evidence is addressed by an operationalisation of Social Capital with solid indicators. An essential component of the analysis is to check if Social Capital is a uni-dimensional construct or if it is composed of multiple independent dimensions. Finally, the investigation attempts to find out if there is a significant relationship between the identified dimensions and learning outcomes in the form of patent statistics and which of the dimensions exert the most evident impact.

The article proceeds as follows: section 2 provides a review of related literature, section 3 presents the data, section 4 describes the applied methods. In section 5 we present the results of the empirical analyses and section 6 concludes the paper with a discussion and suggestions for further research.

2 Related literature

If social interaction has an impact on innovation space becomes important as a platform for knowledge exchange. Physical proximity is the necessary prerequisite for continuous and meaningful social interaction. Based on interaction in a common location trust between persons is generated that serves as a lubricant for the diffusion and acquisition of knowledge. The social institutions and relational infrastructure of a community determine the frequency of interactions and hence are an input in the local production of innovations not traded in markets. The "relational turn" in economic geography is defined as a "theoretical orientation where actors and the dynamic processes of change and development engendered by their relations are central units of analysis" (BOGGS and RANTISI, 2003, p. 109)[1]. The input – output relations in such processes are extremely complex and therefore more easily expressed in descriptive form rather than mathematical notation. The criticism expressed by MARKUSEN (1999) relative to the dearth of empirical research in relational economic geography is shared by MARTIN (1999) and RODRIGUEZ-POSE (2001). OVERMAN (2004, p. 511) succinctly states: "On the basis of existing empirical evidence I do not think it is possible to conclude that conventions/relations are central to our understanding of economic geography and that traded interdependencies only play a limited role".

In fact, the most convincing empirical evidence for the importance of personal interaction and face-to-face contacts for economic activity does not come from economic geography but rather from innovation economics. If spatial proximity is important for social networks and for knowledge diffusion, then knowledge flows decay with distance. With the aid of a

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knowledge production function innovation economists documented that knowledge diffusion is bounded in space. The knowledge production function provides information on the impact of R&D investments of companies or research institutions to the innovative output of firms in the same location. In an overview of the literature DÖRING and SCHNELLENBACH (2006) distinguish between analyses observing aggregate data (with relation to regional density of innovations) and other focusing on micro-level data (firm data or patent citations)[2]. The results indicate that knowledge generated by universities and research laboratories of other firms spills over to firms nearby: "…there appears to be a widespread consensus that spatially confined knowledge-spillovers are an important empirical phenomenon with a significant impact on economic performance" (DÖRING and SCHNELLENBACH, 2006, p. 383).

However, the analyses neglect to illustrate the mechanisms with which the spillovers are mediated (BRESCHI and LISSONI, 2001). CAPELLO and FAGGIAN (2005) undertake a notable attempt to identify the sources of knowledge spillovers in an empirical analysis. They assert that collective learning is performed with relational capital[3] through three different channels: high mobility of labour force, close relationships with suppliers and customers, and spin-offs. They test this hypothesis with micro-data of a survey conducted with managers from 217 firms in Northern Italy and find that relational capital in the form of new employees hired from other firms and importance attached to cooperation with customers/suppliers exerts a positive and significant impact on the firm's innovative capacity.

CAPELLO and FAGGIAN also point out that the term relational capital bears resemblance to a concept that has become increasingly fashionable in economics: Social Capital. This kind of capital is represented by norms of reciprocity and trust that facilitate the interaction between inhabitants of a community[4]. They dismiss the adoption of the concept of Social Capital for the following reasons: "Social capital exists wherever a local society exists, while relational capital refers to the (rare) capability of exchanging different skills, interacting among different actors, trusting with each other and cooperating even at a distance with other complementary organizations" (2005, p. 77). Yet, the presence of Social Capital in every society by itself doesn't say anything about its effects: it may well be that local levels of trust and social networking serve as a catalyst for the transmission channels of relational capital and hence exert an indirect impact on innovative capacity of firms. Another possibility is that relational capital constitutes a dimension of Social Capital.

To explain diffusion of knowledge based on Social Capital requires an exposition of the mechanism at work. Social Capital is a broad term that encompasses many attitudes and social manifestations, but which of them foster the dissemination of information and ideas? The

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work of Granovetter provides valuable insight in this respect. In an early contribution (1973) GRANOVETTER attempts to relate micro-level interactions to macro-level patterns with an analysis of social networks. He points out that relationships between people can exhibit either frequent contacts and deep emotional involvement (close friends) or sporadic interactions with low emotional commitment (loose acquaintances). Networks with relationships of the first kind display strong ties, distant acquaintances form weak ties.

If an individual shares a strong tie with two individuals it becomes highly likely that also these two individuals are connected with each other either by a strong or by a weak tie. This hypothesis is supported by GRANOVETTER (1973, p. 1362) with cognitive balance theory and empirical evidence. GRANOVETTER goes on to introduce the concept of a bridge: "A line in a network which provides the only path between two points" (1973, p. 1364). Given that the hypothesis before mentioned holds true and that every person has more than one close tie, it follows that only weak ties can be bridges (though not all are). Information from networks between different people can circulate through weak ties. Removing a weak tie therefore could potentially cause far more damage to transmission of knowledge than elimination of a strong tie. Individuals with integration in high-density networks will only obtain information of close friends (that quickly becomes redundant with ongoing rounds of circulation), whereas individuals with access to low-density networks can get hold of information from distant parts of the network. Hence, a social network without weak ties exhibits subcultures with high degrees of social isolation.

In a follow-up article ten years later GRANOVETTER (1983) reviews a range of empirical studies testing the weak ties hypothesis. Two analyses directly pertain to the diffusion of innovations. The first was conducted by LIN, DAYTON and GREENWALD (1978) with an experiment where participants were given the task of forwarding a booklet to designated but previously unknown target persons through a chain of personal acquaintances. In addition the participants had to indicate if the person the booklet was forwarded to was a friend or only an acquaintance (by indicating recency of contact and type of relationship). Their basic finding was that in successful chains more weak ties were utilised than in uncompleted ones. The second analysis was performed by FRIEDKIN (1980) with questionnaires to faculty members in seven biological science departments of a large American university. In these questionnaires he assessed if the respondent had talked with some other members on recent work (weak tie). If both reported talking to another the relationship was termed a strong tie. Friedman discovered 11 local bridges in the network (whereby a local bridge is not the only but the shortest path that connects two points not directly combined). All of these 11 local

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bridges were weak ties. In the conclusion GRANOVETTER (1983) emphasises that these and other results are encouraging but not conclusive. With reference to Friedkin GRANOVETTER points out that in addition to illustrating the importance of weak ties one needs to show "…that something flows through these bridges and that whatever it is that flows actually plays an important role in the social life of individuals, groups and societies" (1983, p. 229).[5]

The importance of these bridges as carriers of useful economic knowledge was highlighted with a renewed interest in location theory and a novel perspective on industrial clusters. As clusters became increasingly fashionable as sources of competitive advantage the rise of the knowledge based economy gave them a new (social) spin: "Industrial clusters (whether spatial or not) differ from the agglomeration model in that there is a belief that such clusters reflect not simply economic responses to the pattern of available opportunities and complementarities, but also an unusual level of embeddedness and social integration" (GORDON and MCCANN, 2000, p. 520). Considerable scientific effort has been devoted to investigate forms and consequences of social embeddedness of firms and economic production. The emphasis in the empirical analyses was placed on diffusion of knowledge through social networks. Research was particularly focused on measuring the impact of access to a variety of sources of knowledge acquisition. A vast majority of these studies adopt a micro level-approach. RUEF (2002) analyses sources of innovative capacity with a sample of start-ups and their organizational innovations. He finds that the ability of entrepreneurs to obtain non-redundant information from social networks is a critical prerequisite for the development of innovations. A similar approach is chosen by AMARA and LANDRY (2005) with results from the 1999 Statistics Canada Innovation Survey. They illustrate that firms that introduce innovations on a global or national level tend to draw information from a larger variety of sources of information (in particular research sources) than firms that introduce products new only to the firm. The approach of LEVIN and CROSS (2005) differs as these authors analyse the results from a survey of employees in three different companies. They relate the receipt of useful knowledge (as reported by employee) to levels of trust and tie strength indicated in the same questionnaire. They find that after controlling for two levels of trustworthiness weak ties exert a stronger effect on successful knowledge receipt than strong ties. These studies all provide evidence in favour of important cultural and social factors in the diffusion of knowledge underlying industrial clusters. However, they fail to point out the characteristics that shape an environment conducive to learning and knowledge transmission. In other words, what turns an industrial cluster into a learning region? In order to answer this

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question a macro-level approach has to be taken. Contemporary measures on Social Capital provide empirical indicators for analyses on a national or regional scale.

The operationalisation of Social Capital is arguably complicated by its multi-faceted nature: "It is not a single entity but a variety of different entities, with two elements in common: they all consist of some aspect of social structures, and they facilitate certain actions of actors – whether persons or corporate actors – within the structure" (COLEMAN, 2000, p. 16). The most prominent empirical works are found in the growth literature. KNACK and KEEFER (1997) and ZAK and KNACK (2001) estimate the impact of Social Capital proxied by results from the World Values Surveys on national economic growth. They both find that trust exerts a positive and significant impact on growth rates. KNACK and KEEFER also find a significant impact of norms of civic cooperation, whereas they fail to illustrate an effect of associational activity on economic growth[6].

In our empirical analysis we combine the methodical approach of innovation economics with the concept of Social Capital from the growth literature. This approach serves to test the hypothesis that a region that displays a high density of social interaction in networks[6] and cultural dispositions inclined towards knowledge acquisition provides superior conditions for innovative production. For a sample of European Regions we estimate a knowledge production function with indicators from the European Values Survey as independent variables.

3 Data

As units of investigation we choose regions from countries in the European Union. In order to ensure spatial consistency and compatibility with related work such as BOTTAZZI and PERI (2003) and BEUGELSDIJK and SCHAIK (2001) we select the territorial units ranked as NUTS1 by Eurostat. The overall set comprises 51 observations from Germany (16), France (8), Great Britain (11), Spain (7), Italy (5), and the Netherlands (4). The results of BOTTAZZI and PERI (2003) that knowledge spillovers are limited to a range of 300km suggest that the regional NUTS1 dimension is appropriate for an analysis of sources of innovation. We additionally investigate the suitability of NUTS1 regions regarding the spatial limit of knowledge spillovers with an analysis of spatial autocorrelation in the error terms.

Four types of data are combined to shed light on fundamental factors in innovation processes: patent applications as measures of new knowledge, expenses for R&D as financial input, Human Capital and Social Capital as intangible input factors.

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3.1 Patent applications and R&D expenses

Patent statistics and expenses for R&D are the most common ingredients in knowledge production function. The merits and downsides of patents as proxies for innovation output are widely discussed (see GRILICHES, 1990). However, they constitute the most adequate available proxy for new economic knowledge for a large-scale analysis. The expenses for R&D are surveyed from private sector, government, higher education, and private non profit institutions. The summary statistics for the selected data are reported in the Appendix A. We standardised the patent and investment statistics with the number of inhabitants in order to eliminate population dimension as possible cause of distortion.

3.2 Human Capital

In addition to data on patent applications and R&D investments Eurostat also provides statistics on the stock of Human Capital in a region in the form of Human Resources in Science and Technology (HRST). A person is defined to be a member of HRST if she either has a successfully completed education at the third level in an S&T (science & technology) field of study or is employed in an S&T occupation for which the former qualifications are normally required. Statistics with respect to HRST are integrated in two forms: one variable is the percentage of overall HRST in total population, the other variable consists of the percentage of HRST employed in total high and medium high technology manufacturing sectors and knowledge intensive high-technology services (as defined in the NACE rev. 1.1). This distinction is made to obtain a general indicator for Human Capital and one more specific representative for the role of technicians and engineers in innovation processes. Even though there is a strong connection between the two variables, both were selected in order to capture their combined impact. In order to comprehensively preserve the potential explanatory power offered by each we integrate both variables in the model without further analysis of the single influences.

3.3 Social Capital

Proxies for Social Capital are obtained from the European Values Study (EVS). This large scale longitudinal survey is conducted by several national institutions in a collaborative endeavour. Its objective is to investigate fundamental value patterns among European people with regard to religion/morality, politics, work/leisure, and primary relations. The data in the analysis are obtained from the third wave of research[8] conducted in 32 countries in Western, Central and Eastern Europe in 1999. The sample size in the six countries under investigation

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amounts to 8808 observations representative for the entire adult population (i.e. all persons older than 18 years) on a national level. The EVS provides a large sample of homogeneous data that allow for a regional analysis of the selected countries. However, the size of the regional sample differs for some countries (in particular large ones such as Germany and United Kingdom) as the study does not use a regionally stratified random sampling design. For the majority of the regions under investigation the size is acceptable (see Appendix C). The EVS primarily tries to survey individual attitudes and values rather than forms of behaviour. Yet it has become a standard source of data relative to social capital used in the growth literature.

Questions that serve as indicators for acquisition and diffusion of knowledge are selected based on qualitative criteria. They either display a connection to Social Capital in the form of trust or social networking, or they provide indication on the individual's willingness to absorb information. The latter clearly represents an extension that goes beyond a narrow conceptualisation of Social Capital, but should not be neglected in the analysis of learning processes rooted in local culture. The questions on trust refer to a general declaration if people can be trusted or if one cannot be too careful in dealing with other people (question 8), an indication how many immoral acts presumably almost all or many compatriots commit (question 66) and how many groups of people one would rather not want to have as neighbours (question 7). A high score on all of these variables reflects a rather distrustful attitude towards other persons. The questions on social networking regard importance attached on a four-point Likert scale to friends and acquaintances (question 1C), amount of time spent with friends (question 6A), colleagues from workplace (question 6B), in clubs and associations (question 6D), and an indication of how many groups one is a member of (question 7). The individual's willingness to absorb information and to interact with external stimuli ("openmindedness") is captured by a range of questions about interest in politics (questions 1E, 2, 77) and importance attached to technological as well as self-development (questions 57 C and D). A table with a detailed description of questions and codification can be found in the Appendix B[9].

All original questions are coded so that low values indicate a large stock of Social Capital and high values a small stock of Social Capital (e.g. the indication of which groups of people one would not want to have as neighbours that relates higher values to lower trust). For readability of the tables question 7 was recoded accordingly to the other variables relative to social interaction (hence, all variables are coded in a homogeneous fashion). The codification will have to be reconsidered in the interpretation of regression results in Table 4.

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4 Methods

The selected questions from the EVS all provide indication on aspects of Social Capital. In contrast to the growth literature (notably KNACK and KEEFER, 1997; BEUGELSDIJK and SCHAIK, 2001) we do not proceed with single or combinations of questions as proxies for different forms of Social Capital. In order to account for the abstract and latent nature of this concept, we conduct a preselection of questions with reference to social interaction and information processing. Subsequently a factorial analysis is performed. The resulting factors are interpreted with reference to their theoretical substance. The statistical procedure returns quantitative information on the number of independent dimensions as well as qualitative information provided that the factors can be interpreted in a consistent and meaningful fashion. The ultimate objective of the analysis is to identify important factors in the learning climate of a region and to relate it to patenting activity with the aid of a knowledge production function.

In its basic form the knowledge production function as pioneered by GRILICHES (1979) relates inputs into the R&D process to outputs. Traditional indicators for outputs are patent applications (*PA*), inputs are predominantly represented by R&D investments (*RD*) and Human Capital (*HC*). In order to account for the interactive nature of innovative processes the factorial values of the Social Capital variables (*SC*) are integrated into the function to test their impact on innovative production. The function is estimated in a log-linearised Cobb-Douglas format. Its particular form with the unit of observation denoted by subscript *i* being the NUTS1 region is given in equation (1).

$$\ln PA_i = \alpha + \beta \ln RD_i + \sum_{k=1}^{2} \gamma_k \ln HC_{ki} + \sum_{j=1}^{N} \delta_j \ln SC_{ji} + \varepsilon_i , \qquad (1)$$

where

$\alpha, \beta, \gamma_k, \delta_j$	Parameters to be estimated
PA_i	Patent applications per million inhabitants in region *i*
RD_i	Per capita expenses on research and development in region *i*
HC_{1i}	Percentage of (general) HRST in total population of region *i*
HC_{2i}	Percentage of HRST in sectors with high and medium technology content in total population of region *i*
SC_{ji}	Average factorial value of factor *j* in region *i*
N	Number of factors extracted by factorial analysis
ε_i	Disturbance term in region *i*

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The coefficients represent the elasticities of the dependent variable with respect to the independent variables. An increase of one percent in the variable R&D results in an increase in Patent Applications of β percent. Estimation of the function with the indicated data will provide information on size and significance of the individual coefficients.

5 Results

5.1 Identification of dimensions

A total of 14 variables are processed with factorial analysis. The correlation matrix in association with respective test statistics provides indication if the data are appropriate for performance of factorial analysis. The Bartlett test of sphericity is highly significant and the Kaiser-Mayer-Olkin criterion exhibits a test statistic of 0.766. In order to facilitate interpretation we perform factorial analysis with a varimax-rotation which does not alter communalities and provides uncorrelated factors. Following the Kaiser-criterion factorial analysis extracts five factors with eigenvalues greater than one. Overall explained variance of these factors amounts to 57.2%. This is an acceptable result given the nature of data that are derived from individual respondents inquired about subjective attitudes. Considering that personal opinions are influenced by a certain extent of fatigue and vagueness the structures obtained from such indications can hardly assert comprehensive explanatory power. The communalities reported in Table 1 denote what percentage of the variance of one variable is explained and indicate which questions are reflected well by the elaborated factors. The results differ for individual questions but on the whole are quite satisfactory.

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Table 1: Communalities of variables condensed in factorial analysis

Variables	Extraction
How important in your life: politics (Q1E)	0.64
How often discuss politics with friends (Q2)	0.63
How often do you follow politics in media (Q77)	0.52
How interested are you in politics (Q51a)	0.77
How important in your life: friends and acquaintances (Q1C)	0.40
How often spend time with friends (Q6A)	0.59
How often spend time with colleagues (Q6B)	0.43
How often spend time in clubs+voluntary associations (Q6D)	0.64
Group membership (5A-O)	0.68
People can be trusted/can't be too careful (Q8)	0.43
Sum neighbours (7A-N)	0.65
ActsCompatriots (66A-H)	0.48
More emphasis technology (57C)	0.58
More emphasis Individual (57D)	0.59

The extracted factors are illustrated in Table 2 based on the correlations of the individual variables with the factors (factor loadings). Clearly each variable just correlates with one factor, which is denoted by the high correlations from 0.546 to 0.862. Factor 1 for example consists of the first four variables listed in Table 2 with factor loadings from 0.711 to 0.862. These variables are coded in the same direction with the consequence that high values of the variables produce high values of the factor. This indicates that if the political interest is low (measured by an original high value on the Likert scale), factor 1 is high.

Table 2: Matrix of factor loadings. The gray background indicates which variable corresponds to which factor.

	Factors				
Variables	1	2	3	4	5
How important in your life: politics (Q1E)	.788	.106	.086	.010	.021
How often discuss politics with friends (Q2)	.776	.144	.078	.024	.014
How interested are you in politics (Q51a)	.862	.060	.136	.051	.027
How often do you follow politics in media (Q77)	.711	-.065	.035	.082	.045
How important in your life: friends and acquaintances (Q1C)	.112	.616	.071	-.006	.080
How often spend time with friends (Q6A)	-.024	.755	.130	.020	.033
How often spend time with colleagues (Q6B)	.072	.634	.090	.113	-.057
How often spend time in clubs+voluntary associations (Q6D)	.095	.293	.732	-.009	.061
Group Membership (5A-O)	.201	.083	.777	.148	-.052
People can be trusted/cant be too careful (Q8)	.143	.103	.204	.593	.035
Sum neighbours (7A-N)	.034	.220	-.264	.725	.011
Acts Compatriots (66A-H)	-.056	-.302	.294	.546	-.057
More emphasis technology (57C)	-.011	.084	-.016	-.121	.748
More emphasis Individual (57D)	.088	-.031	.016	.131	.748

The factorial analysis performed with the EVS questions provides a clear loadings structure and allows to discern important social orientations toward knowledge acquisition and diffusion. The three variables about trusting other people are mainly contained in factor 4 that is termed "Basic Trust". This attitude is the most prominent indicator for empirical measurement of Social Capital (though mostly measured by a single question) and serves as the foundation of open-minded interaction and mutual dialogue. Whereas factors 1 and 5 reflect direct attitudes promoting information processing, factors 2 and 3 indicate the integration of respondents into networks. The four variables about interest in politics and political engagement all display a high loading on factor 1. This factor is termed "Political Interest" and characterizes the interest and engagement of the population in public affairs. This factor shows the best performance regarding the explained variance and the communalities of the single variables. The two variables concerning disposition towards

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technological and self-improvement represent factor 5 that emphasises efforts towards ongoing education and personal growth. Whereas factor "Political Interest" can be supposed to favour the acquisition of general knowledge (proxied by knowledge of current political events), the factor "Technological and Self-Improvement" is pointed at specific knowledge in technological or other scientific areas. The capacity of local culture to establish social systems and interpersonal networks can be located in factors 2 and 3. These two factors capture networking activities of respondents: factor 2 ("Friendship Ties") consists of interaction with friends and colleagues from the work place, whereas factor 3 ("Associational Activity") relates to activity in formal groups and associations. The composition and interpretation of all factors is summarised in Table 3. In the terminology of GRANOVETTER (1973) the relations with close friends are "strong ties" because they predominantly consist of overlapping and cohesive groups of people, whereas activities in clubs and associations are mostly performed with people that are loose acquaintances and hence "weak ties". According to the theoretical work of TURA and HARMAAKORPI (2005, p. 1118) it is important "to focus on both the bridging- and bonding-type indicators of social capital".

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Table 3: Definition and interpretation of elaborated factors with indication of relevance for knowledge diffusion

Factorial analysis	Questions	Definition	Interpretation	Relation to knowledge diffusion and acquisition
Factor 1	How important in your life: politics (Q1E) How often discuss politics with friends (Q2) How interested are you in politics (Q51a) How often do you follow politics in media (Q77)	Political Interest	Interest in public affairs and participation in political decision making processes	Promotes acquisition of general knowledge
Factor 2	How important in your life: friends and acquaintances (Q1C) How often spend time with friends (Q6A) How often spend time with colleagues (Q6B)	Friendship Ties	Integration in informal networks with friends and colleagues	Presence of strong ties
Factor 3	How often spend time in clubs+voluntary associations (Q6D) Group Membership (5A-O)	Associational Activity	Integration in formal networks and associations	Presence of weak ties
Factor 4	People can be trusted/cant be too careful (Q8) Sum neighbours (7A-N) Acts Compatriots (66A-H)	Basic Trust	Prerequisite for mutual dialogue and open-minded interaction	Willingness to engage in interaction and information exchange
Factor 5	More emphasis technology (57C) More emphasis Individual (57D)	Technological and Self Improvement	Efforts towards continuous learning	Promotes acquisition of specific knowledge

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Subsequent to factorial analysis the factorial values for each observation are computed. Aggregation on a regional level is achieved by taking the averages of the individual values in the regions under scrutiny. These values are required for the analysis of the relationship between learning orientations and regional innovation.

5.2 Estimation of knowledge production function

Before computation of regional averages the factorial values were normalised to the interval [0,1]. This procedure allows for logarithmic transformation of all standardised variables and a subsequent linear estimation of the Cobb-Douglas function. The knowledge production function is estimated at an annual base for three years with OLS. Considering the hypothesis by MASKELL (2000) that Social Capital accumulation requires time consuming reiteration it seems reasonable to assume that the regional stock of Social Capital does not change significantly in three years. Therefore the identical factorial values (elaborated from data for 1999) are integrated in the estimation of the model in every year.

The dependent variable is patents per capita for each of the three years in 51 (2001 with n = 35) NUTS1 regions and the estimated coefficients for each of the three years in combination with the two sided p-value are indicated in Table 4.

Table 4: Estimation results for 1997, 1999 and 2001. The 'ln' in brackets denotes logarithmic transformation of original variables.

Variable	**Coefficient 1997**	***p*-value**	**Coefficient 1999**	***p*-value**	**Coefficient 2001**	***p*-value**
Constant	1.96	0.4424	0.91	0.7159	4.98	0.0641
RD (ln)	0.59	0.0021	0.59	0.0025	0.81	0.0028
HC_1 (ln)	-1.41	0.0020	-1.22	0.0087	-1.33	0.1055
HC_2 (ln)	1.28	0.0000	1.13	0.0000	0.74	0.0316
Political Interest (ln)	-0.86	0.0822	-1.58	0.0016	-1.28	0.1244
Friendship Ties (ln)	-0.36	0.5064	-0.65	0.2040	1.38	0.1305
Associational Activity (ln)	-3.52	0.0014	-2.38	0.0187	-4.29	0.0057
Basic Trust (ln)	-0.47	0.3908	0.25	0.6321	1.02	0.3222
Technological and Self Improvement (ln)	-0.10	0.7421	-0.23	0.4158	-0.86	0.0454
R-squared	0.9		0.9		0.89	
Sample size	51		51		35	

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Regarding for example "Associational Activity" a regression coefficient of -3.52 represents the elasticity of the dependent variable with respect to the independent: a 1% increase in the variable "Associational Activity" will lead to a decrease of 3.52% in patenting activity. Bearing in mind that "Associational Activity" is inversely coded, higher activity in social interaction will bring about more innovation. The same interpretation also applies to the other factors.

Even though the estimation is performed only for annual intervals (which is rather short for the supposed long term relationship between R&D and patenting) the results are in harmony with the observation of GRILICHES (1990) that in cross sectional data the relationship between R&D investments and patents is rather strong. "The median R-squared is on the order of 0.9, indicating that patents may indeed be a good indicator of inventive output, at least in this dimension" (GRILICHES, 1990, p. 1673). In fact, the goodness of fit is about 0.9 in every year. The model is highly significant and the results with regard to individual coefficients are similar for each year.

To see whether we capture all spillovers, we also estimate a spatial autoregressive model in the error term (ANSELIN, 1988) and compute the Moran *I* statistic (KELEJIAN and PRUCHA, 2001). Both tests do not give any evidence of spatial dependence in the disturbances. This result is concordant with the findings of BOTTAZZI and PERI (2003) that spillovers are spatially limited within a range of 300km. This extent covers our analyzed NUTS1 regions.

Due to multicollinearity[10] between the investment variable and both human capital indicators the size of the single coefficients has to be interpreted with caution. However, the result concerning their combined impact is still valid and has to be taken into consideration (BELSLEY, 1991). R&D investments display a highly significant and positive coefficient in every year. It is the strongest single variable in the model that alone accounts for around 80% of the variance of patenting activity.

We also estimated the model with the averages of the economic variables in order to investigate the robustness of the results in a longer term (based on 51 observations). Average patent applications per capita over three years regressed on average investments per capita provides an R-squared of 0.76. Adding the two Human Capital variables increases the R-squared to 0.82.

The consideration of the five factors representing Social Capital additionally increases the R-squared in the estimation based on averages to 0.9. A closer inspection of the individual coefficients reveals that only "Political Interest" and "Associational Activity" provide

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significant explanatory power. "Associational Activity" exhibits the largest coefficient of all factors with significant probability for every year. The factor "Associational Activity" displays a larger impact than "Political Interest" (-2.5 vs. -1.6).

With respect to the estimation based on annual values "Political Interest" is significant in 1999 and almost so in 1997 (if one accepts the 10% threshold significance also holds in that year). Probably due to the reduction in sample size the *p*-value in 2001 exceeds 10%. In 2001 also the factor "Technological and Self-Improvement" is significant. But considering that the 2001 sample is the smallest of all and that this factor falls short of significance by a wide margin in the previous years and in the estimation based on averages it is supposed to be of minor importance. The factors "Friendship Ties" and "Basic Trust" do never exhibit significant coefficients.

The estimations provide highly significant explanatory power and robust results for annual intervals as well as the three-year period. These statistics illustrate the potential of the selected input variables to explain regional innovation rates and provide evidence in favour of the hypotheses proposed by relational economic geography.

6 Discussion and conclusion

The starting point of our analysis is the hypothesis that Social Capital plays an important role in the diffusion of knowledge and regional innovative capacity. This hypothesis is tested in two steps. The first consists in an identification of potential dimensions of Social Capital based on results from the European Values Study. The five obtained factors are "Political Interest", "Friendship Ties", "Associational Activity", "Basic Trust", and "Technological and Self-Improvement". The integration of the five factors into the knowledge production function significantly enhances the explanatory power of the model. The explained variance is increased by 8%.

The empirical results indicate that Social Capital is distinguished into several dimensions that are independent from each other (or in a more technical terminology the dimensions are uncorrelated). The heterogeneity of the concept constitutes an important finding that has to be considered in future studies with respect to effects of Social Capital. Analyses have to be conducted in a more differentiated and focused fashion.

Of the five elaborated factors two display a direct connection to innovative production. Whereas the factor "Political Interest" exhibits a somewhat weaker relationship in the three years under investigation, the factor "Associational Activity" represents a robust influence on patenting activity in all time periods. This finding is in line with the proposition of

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Granovetter about the strength of weak ties. "Close friends know the same people you do, whereas acquaintances are better bridges to new contacts and nonredundant information" (GRANOVETTER *et al.*, 2000, p. 220). Hence, new knowledge is more easily disseminated through loose contacts than close friendships and consequently activity in clubs and associations leads to innovation. Individuals that form the strong ties of factor 2 are more likely to be similar to each other and therefore cannot provide access to sources of new information.

In contrast to papers from the growth literature we could not find a significant effect of trust towards other people. Trust may have a more robust impact on economic growth on a national level, whereas connectedness of people is more important for innovation in industrialised countries. That would be another indication of the multi-dimensionality of the concept: different dimensions have different effects on economic variables such as growth rates or innovation rates. A closer look at the composition of this factor reveals that questions are formulated in negative way (e.g. indication of groups of people that one would not want to have as neighbours) and hence are rather a measure of mistrust. The respondents may relate the questions to persons that do not belong to their networks but to the general public. Therefore trust is possibly measured with respect to persons one does not interact with and accordingly results may be distorted. Technically, 'Basic Trust' is the factor with the lowest loadings of the variables and the quality of the data as indicators for trust may be limited.

In addition to conventional inputs like Financial and Human Capital also Social Capital exerts a considerable impact on production of economic knowledge. The size of the explanatory power is about equal to the one contributed by Human Capital. Neglecting Social Capital in regional innovation models of a knowledge based economy is thus a severe shortcoming. This is an interesting finding given the nature of the innovation output indicator. Patent applications are usually presented by large firms which seem rather less dependent on Social Capital than SME's. Our results indicate that embeddedness in the local environment also includes large firms and is not confined to SME'S with limited resources. The specific effects of the various components of Social Capital on large firms and SME's is not resolved by our analysis and represents scope for further research.

The obtained results indicate the following conclusions:

- Social Capital is not an appropriate term for empirical analyses, because it consists of multiple independent dimensions. Scientific hypotheses should be formulated with respect to specific dimensions rather than the too general notion of Social Capital.

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- According to our operationalisation the independent components of Social Capital have a joint significant impact on innovation measured by patent applications that corresponds to the influence of Human Capital.
- Robust empirical evidence has been provided for the significant role of weak ties in social interaction and innovation on a regional scale.

Considering these promising results future studies should try to develop more precise measures of components of Social Capital. Surveys can be formulated to assess different types of social interaction and illustrate their respective connection to regional innovation more systematically. An investigation of the relationship of dimensions of Social Capital with relational capital mediated through labour markets and cooperation agreements between firms can potentially provide valuable insights in this respect. Apart from their significance for academic research such analyses may be instrumental in formulating regional development policies. Consequently the identification of best practice models and regional benchmarking can be based in part on indicators of Social Capital as proxies for innovative capacity. However, the obtained empirical results illustrate the importance of knowledge diffusion in social interaction enveloped in the "black box" of innovation.

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NOTES

1. For literature emphasising the importance of social and institutional relations for local innovative production and sustained development see STORPER (1997), AMIN and THRIFT (1995), MALECKI (1999), GERTLER (2003), BATHELT and GLÜCKLER (2003), COOKE and MORGAN (1998), COOKE *et al.* (1997).

2. The first category contains the works of JAFFE (1989), AUDRETSCH and FELDMAN (1996), ANSELIN *et al.* (1997), BOTTAZZI and PERI (1993), whereas JAFFE *et al.* (1993) and FRITSCH (2001) can be assigned to the second category.

3. CAPELLO and FAGGIAN (2005, p.78) define relational capital as "…the set of all relationships – market relationships, power relationships and cooperation – established between firms, institutions and people that stem from a strong sense of belonging and a highly developed capacity of cooperation typical of culturally similar people and institutions".

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4. For more information on the concept of Social Capital see PUTNAM (1993) and FUKUYAMA (1995).

5. For recent theoretical developments on the significance of weak ties see BURT 1992 on structural holes and PUTNAM 2000 on bridging and bonding relationships.

6. The variable trust is assessed with the percentage of persons answering yes to the question: "Generally speaking, would you say that most people can be trusted?" Norms of civic cooperation is assessed with indications on a 10-point Likert scale if behaviours like cheating on taxes or keeping found money can never be justified, always be justified or something in between. Density of associational activity is the average membership of groups cited per respondent in a list of 10 different and rather broad group categories.

7. The hypothesis is similar to the one stated by STORPER and VENABLES (2004): Informal face-to-face contacts are an efficient technology to communicate knowledge in today's economy. Cities or locations with a high frequency of theses contacts display a high degree of "buzz".

8. For a more detailed exposition of methodology and results of the third wave of the European Values Study see HALMAN (2001).

9. The selection of the question is mainly overlapping with the questions on social trust, group involvement and informal social interactions by IYER *et al.* (2005).

10. As a measure of multicollinearity tolerance was used which is defined as 1 – determination coefficient of variable *i* regressed on the remaining independent variables. A value lower than 0.1 indicates severe multicollinearity. However, we obtained for the logarithmic variables RD, HC1 and HC2 the values 0.155, 0.130 and 0.162 respectively. Hence we refrain from interpreting the single coefficients.

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Appendix A

Summary statistics of Eurostat variables of the selected regions for the years 1997, 1999 and 2001. Std. dev. denotes the standard deviation.

Variables	Year	Mean	Std. dev.	Minimum	Maximum
Area in km^2		38640	40217	404	215025
Total Population (in 1000 of inhabitants)	1997	5999.4	3775.1	676.1	17961.1
	1999	5948.7	3804.8	665.8	17987.7
	2001	5977.1	3836.1	660.3	18027.0
Patents per million inhabitants	1997	102.6	95.7	5.5	411.9
	1999	126.6	114.7	6.1	497.6
	2001	151.0	139.6	6.1	641.1
Investments in R&D per million inhabitants (in millions of Euro/Ecu)	1997	336.8	240.2	51.5	1121.3
	1999	375.7	261.9	58.2	1224.7
	2001	434.5	296.5	73.8	1278.1
Percentage HRST of total population	1997	15.1%	4.2%	7.8%	25.5%
	1999	15.9%	4.0%	8.3%	25.2%
	2001	16.7%	3.9%	9.2%	25.5%
Percentage HRST in sectors with medium and high technology content of total population	1997	1.6%	0.8%	0.2%	3.7%
	1999	1.7%	0.8%	0.3%	3.9%
	2001	1.9%	0.9%	0.4%	4.2%

Source: Eurostat, NewCronos database

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Appendix B

The following questions are processed with factorial analysis after deleting the observations with answers "don't know" or "no answer". The codification given is the original scale asked in the European Values Study. A high score of these variables reflects a low degree of social interaction, trust or information processing (the variable group membership was calculated by subtracting the number of indicated groups from 15 which codes the variable in the same direction like the other questions). The questions 5A-O, 7A-N, 66A-H are asked for each entry individually in a yes-no fashion, the three variables processed with factorial analysis are obtained by summing up all "yes" answers.

Nr.	Question	Codification
1C	How important in your life is: Friends and acquaintances	Very important: 1 Important: 2 Not important: 3 Not at all important:4
1E	How important in your life is: politics	
2	How often do you discuss political matters with your friends?	Frequently: 1 Occasionally: 2 Never: 3
5A-O	List of groups with indication which one is a member of (sum of group memberships, generated variable)	Min 0 Max 15
	Social welfare services, religious organisations, cultural organisations, trade unions, political groups, local community, third world development, conservations issues, professional organisations, youth work, sports activities, women's groups, peace groups, voluntary organisations concerned with health, other	
6A	How often do you perform activity: Spend time with friends	Every week: 1 Once or twice a month: 2 A few times a year: 3 Not at all: 4
6B	How often do you perform activity: Spend time with colleagues from work or your profession outside the workplace	
6D	How often do you perform activity: Spend time with people in clubs and voluntary associations (sport, culture, communal)	
7A-N	List of groups of people with indication which ones does one not want to have as neighbours (sum over all groups, generated variable)	Min: 0 Max: 14
	People with criminal record, people of a different race, left wing extremists, heavy drinkers, right	

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	wing extremists, large families, emotionally unstable people, muslims, immigrants, people with aids, drug addicts, homosexuals, jews, gypsies, hindus	
8	Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?	Most people be trusted: 1 Can't be too careful: 2
51a	How interested would you say are you in politics?	Very interested: 1 Somewhat interested: 2 Not very interested: 3 Not at all interested: 4
57C	More emphasis should be laid on development of technology	Good: 1 Don't mind: 2 Bad: 3
57D	More emphasis should be laid on development of individual	
66A-H	List of unlawful/immoral acts with indication which ones almost all or many compatriots commit (Sum over all groups, generated variable)	Min: 0 Max: 8
	Claiming state benefits to which they are not entitled, cheating on tax if they have the chance, paying cash for services to avoid taxes, taking the drug marijuana or hash, throwing away litter in a public place, speeding over the limit in built-up areas, driving under the influence of alcohol, having casual sex, avoiding a fare on public transport, lying in their own interest, accepting a bribe in the course of their duties	

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Appendix C

NUTS1 Regions	Sample size
FR Bassin Parisien	324
FR Centre Est	209
FR Est	100
FR Ile De france	299
FR Méditerranée	235
FR Nord	84
FR Ouest	201
FR Sud ouest	163
GB North East	56
GB North West	138
GB Yorks & Humbs	60
GB E. Mids	61
GB W. Mids	99
GB Eastern	46
GB London	90
GB South East	187
GB South West	79
GB Wales	59
GB Scotland	84
DE Schleswig-Holstein	23
DE Hamburg	20
DE Niedersachsen	126
DE Bremen	24
DE Nordrhein-Westfalen	289
DE Hessen	103
DE Rheinland-Pfalz	54
DE Baden-Württemberg	160
DE Bayern	181
DE Saarland	16
DE Berlin	135
DE Brandenburg	170
DE Mecklenburg-Vorpommern	115
DE Sachsen	290
DE Sachsen-Anhalt	175
DE Thüringen	155
IT NordOvest	538
IT NordEst	380
IT Centro	391
IT Sud	466
IT Isole	225
ES Noroeste	132
ES Noreste	123
ES Comunidad de Madrid	151
ES Centro	161
ES Este	330
ES Sur	254
ES Canarias	49
NL Noord-Nederland	100
NL Oost-Nederland	238
NL West-Nederland	475
NL Zuid-Nederland	185
Total	8808

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