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EFFECTS OF DIFFERENT DIMENSIONS OF SOCIAL CAPITAL ON INNOVATION: EVIDENCE FROM EUROPE AT THE REGIONAL LEVEL

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EFFECTS OF DIFFERENT DIMENSIONS OF SOCIAL CAPITAL ON INNOVATION: EVIDENCE FROM EUROPE AT THE REGIONAL LEVEL

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Abstract

This paper investigates how different dimensions of social capital influence innovation output. The novelty of the paper lies in the fact that for measuring social capital, instead of one overall index, six factors are constructed of 20 indicators using principal components analysis. Then, human capital and R&D are also included in the analysis as factors of innovation. Unlike many previous studies, this one uses the structural equation modelling approach instead of regression analysis in order to take into account the relationships between the factors of innovation. Regional-level data from Eurostat Regio and the European Social Survey are analysed. Compared to preceding studies, a larger number of observations is used. The findings provide strong support for the argument that social capital indeed influences innovative activity and furthermore, that different dimensions of social capital have dissimilar effects on innovation.

Keywords: innovation, social capital, human capital, R&D

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1. INTRODUCTION

It is commonly accepted that innovation plays an important role in economic development and growth. Hence, there is no doubt that investments in research and development (R&D) as a main catalyst of innovation are needed. However, the same expenditures on R&D in different countries or regions fail to yield similar results and success in innovation, for example, a comparable number of new patent applications. This is so because the innovation process is additionally influenced by many other factors. One of the factors that has received much attention in the literature is the overall level of human capital of a particular country or region. Another very important factor is the social environment, i.e. networks, norms, trust, etc., which can be jointly referred to as social capital.

Social capital as a relevant factor of innovation has been actively dealt with in the literature over the last few years. Notwithstanding, there are as yet very few empirical tests assessing the effect of social capital on innovation. It can be assumed that one possible reason for this lies in the problems with the measurement of social capital. First, the concept of social capital has many dimensions that have to be taken into account when discussing social capital and its influences. Due to the heterogeneous character of social capital, no unique indicator of social capital can be used and therefore measurement methods using many indicators have to be applied. Second, these indicators cannot be found among the usual indicators published by statistical offices. Hence, special surveys have to be conducted in order to get appropriate data. As the concept of social capital itself is quite new, not many surveys offering data about social capital are available yet.

The purpose of this article is to examine the effect of social capital on innovation in Europe at the regional level. Analysing European regions has an advantage of a relatively homogeneous sample, where the possible unobserved factors of innovation are less influential (Ackomak and ter Weel, 2005). The regional level was chosen for two reasons. First, prior research has shown significant within-country differences in the levels of innovative activities, human and social capital (see, for instance, Daklhi and de Clercq (2004) for a review). Second, considering the number of possible variables in the model, for the sake of getting reliable results, a larger sample than the number of European countries is necessary. The current study uses data from the European Social Survey and Eurostat. Although previous studies have examined analogical data, their number of observations has been smaller.

To measure social capital, many previous studies have used an overall index, one variable or one latent construct (see, for instance, Subramaniam and Youndt, 2005; Ackomak and ter Weel, 2005; Ackomak and ter Weel, 2006). However, it can be assumed that different dimensions of social capital may have dissimilar impacts on innovation. Therefore, this paper tests the influence of social capital on innovation by separate dimensions. In addition, the number of different dimensions of social capital included in the present analysis is higher than in previous studies analysing more than one dimension (Tsai and Ghoshal, 1998; Landry *et al*. 2002; Daklhi and de Clercq, 2004).

To take account of other main factors of innovation, the current analysis includes human capital and R&D as factors of innovation. With regard to methodology, the previous studies using regression analysis have failed to take into account the relationships between the factors of innovation themselves. To overcome this problem, this study uses the structural equation modelling approach.

The paper is structured as follows. Section 2 presents the conceptual background. Section 3 discusses the causal relationships between innovation, social capital, and other factors of innovation − R&D and human capital. Section 4 introduces the data analysed. Section 5 deals with the measurement and Section 6 presents the results of the structural model estimation. Section 7 comprises the discussion, while Section 8 points out the limitations and makes recommendations for future research. Section 9 concludes.

2. CONCEPTUAL BACKGROUND

Innovation is usually understood as the introduction of something new or significantly improved, be they products (goods or services) or processes. The involvement of a country or a region in innovative activity has two aspects: inputs and outputs (see, for instance, Nasierowski and Arcelus, 1999). The inputs include, for example, expenditures on R&D and employment in R&D, both in the government and business sector. The results of innovative activity such as patent applications, publications, and the growth of the high-technology sector are understood as the outputs of innovation. It is important to distinguish between inputs and outputs when constructing a theoretical model and testing it empirically. Hereinafter, when innovation is mentioned, the outputs of innovative activity are actually borne in mind, while the inputs of innovation activity will be considered as an influencing factor of innovation.

One important factor of innovation is human capital – an individual's knowledge, skills and abilities that can be improved with education – both regular education and lifelong learning. Human capital can be firm-specific, industry-specific or individual-specific (Daklhi and de Clercq, 2004). The last type can also be understood as the general level of human capital in a country or region. The general level of human capital is more connected with regular education, while lifelong learning contributes more often to the industry- or firm-specific human capital. Therefore, this regional-level analysis focusses on the general level of human capital usually measured with the population's average number of years of schooling, or with the percentage of population with different levels of education attained.

Next, social capital can be considered as a factor of innovation. There are many definitions of social capital. Adler and Kwon (2002) and Tamaschke (2003) provide exhaustive overviews of different definitions. Social capital has been analysed at different levels (see, for example, Leana and van Buren, 1999): it can be considered as an asset of an individual, but it can also be viewed at the community or firm level. The third approach advocated by

Robert Putnam is to study social capital as an attribute of a country or a region (Portes, 1998). According to Putnam (1995) social capital "refers to features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit." The definitions covering networks, norms and trust have often been used when analysing the impact of social capital on economic growth or, more specifically, on innovation (see, for instance, Knack and Keefer, 1997; Fountain, 1998; Landry *et al*. 2002 and Daklhi and de Clercq, 2004 for further references).

Social capital is often divided into two forms or types: structural and cognitive social capital (Hjerppe, 2003; Chou, 2006). Cognitive social capital encompasses norms and trust, while structural social capital includes social networks: both formal and informal.

Norms can be viewed as a social contract or unwritten rules, for example, the norms of helping and good citizenship – cooperation and subordination of self-interest to that of the society (Daklhi and de Clercq, 2004). Trust can be described as confidence in the reliability of others. The trust that people have in other people in general can be referred to as generalised or general trust. In addition, often also the trust in different institutions like police, government, church, banks, media, etc. – also referred to as institutional trust, is studied. Trust and norms are strongly related: civic norms guiding people's behaviour can be viewed as trustworthiness that increases trust in other people. Also, the norm that voting is a civic duty may increase political participation and improve governmental performance and hence also the trust in government (Knack and Keefer, 1997). On the other hand, one important norm is reciprocity (Fountain, 1998): people act for the benefit of others and expect to get help in return when it is needed. Therefore, in case of high trust, the expectations that others will reciprocate are high and people tend to really follow the civic norms in their actions (Knack and Keefer, 1997).

Informal networks are formed by the interpersonal relationships between friends, relatives, colleagues, neighbours, etc. Formal networks refer to participation in the associations and voluntary organisations: professional, religious, cultural, etc. In contrast to the informal networks, in case of formal networks, the boundaries can be drawn on the basis of membership in these organisations. Both formal and informal networks provide support and communication channels for information exchange. Activity in voluntary organisations is often also considered as social participation (Harper and Kelly, 2003; Franke, 2005). In addition, civic participation is considered as a dimension of social capital, being expressed, for example, by voting activity (*ibid*.). While cognitive social capital is a rather subjective concept usually measured with the help of surveys, networks and participation are more objective, although also measured by surveys alongside the objective measures of memberships in organisations or voting activity.

As can be seen, social capital is a complex concept with many dimensions. In the next section, the influences of different factors on innovation will be discussed. For reasons of space, the review is intended as illustrative, not exhaustive.

3. THE FRAMEWORK OF CAUSAL RELATIONSHIPS

As noted before, R&D as an input of innovation is unquestionably a key factor of innovation. Also, the general level of human capital of a region or a country is commonly supposed to positively influence innovation. An overview of theoretical reasoning and empirical results can be found, for instance, in Daklhi and de Clercq (2004) or Subramaniam and Youndt (2005). The general level of human capital determines the quality of the labour force which is employed or can potentially be employed in R&D. In addition to the direct positive influence on innovation, a higher educational level of the labour force in R&D demands lower extra expenditures on additional training, leaving more finances for other innovative activities. Daklhi and de Clercq (2004), for example, have found that human capital has a significant positive influence on R&D expenditures.

The influence of social capital on innovation can be described as forming the innovative milieu (Daklhi and de Clercq, 2004). A good overview on the development of theories concerning social capital as a factor of innovation can be found in Landry *et al*. (2002). Next, the impact and the influence mechanisms of social capital on innovation will be discussed, distinguishing between different dimensions of social capital.

It is generally accepted that firms do not innovate in isolation but need interaction with their environment. Hence, the structural dimension of social capital − both formal and informal networks − can be thought to be paramount for several reasons. First, innovation significantly depends on the spread of information, especially in high-technological fields, where information is very specific (Fukuyama, 2000). Further specialisation and more complex technologies demand more cooperation. Networks consist of ties between individuals and through them also between firms. These ties enable, help and speed information exchange and also lower the costs of information search. It has been said that access to know-how can be gained with the help of know-who, that is, information about who knows what (Gregersen and Johnson, 2001; Lundvall, 2006). Often, networks may help to avoid duplication of the costly research. Second, networks have a synergy effect, bringing together complementary ideas, skills and also finance. Connecting different creative ideas and thoughts can lead to unusual combinations and radical breakthroughs (Subramaniam and Youndt, 2005). In addition, networks not only facilitate the innovations themselves, but also help and speed the diffusion of innovations (Abrahamson and Rosenkopf, 1997). However, the information exchange via networks cannot work without trust (see also Tsai and Ghoshal, 1998).

Next, the cognitive dimensions of social capital are considered as the factors of innovation. Trust can influence innovation through many mechanisms. First, the higher the general trust, the lower the monitoring costs of possible malfeasance or non-compliance by partners and the smaller the need for written contracts (Knack and Keefer, 1997; Tamaschke, 2003). Hence, higher trust enables firms to spend more time and finances on other purposes, innovative activity being one of them. Second, the higher the general trust in a society, the less risk averse are its members, including investors. It is commonly known that innovation is closely associated with risk and venture capital markets are critical for innovation − higher trust encourages investors to invest more in R&D projects (Ackomak and ter Weel, 2006). Third, in case of higher general trust, when workers are selected, their human capital is more important and their acquaintances are less important (Knack and Keefer, 1997). Thus, the labour force employed in R&D probably has higher skills and education that are needed for innovative activity. Fourth, as it was noted before, cooperation needs trust. Therefore, trust between firms developed by repeated cooperation may lead to riskier and more radical innovative cooperation projects (Ackomak and ter Weel, 2006). The trust in institutions like the government and legal system is also substantial. In case of a reliable legal system and effective patent registration, the motivation to innovate is higher: the innovators feel that the results of their activity and R&D expenditures are protected and they can expect their activity to pay off (Dakhli and de Clercq, 2004; Tabellini, 2006).

Although norms are strongly related to trust, norms themselves have received less attention in the previous literature about the impacts of social capital on innovation. Dakhli and de Clercq (2004) argue that the higher the norms of civic behaviour, for instance, the norm of helping others, the higher the country's level of innovation. Reciprocity can be one important factor to encourage the diffusion of resources: for example, the amounts of information given to each other at a given point of time do not have to be equal – the information is expected to be returned in the future. The norm that prefers society's interests to self-interest also supports the diffusion of information. In addition, the shared norms help to avoid misunderstandings and facilitate cooperation.

Although the literature on the impact of social capital on innovation has been proliferating in the last decade, to date there are only a few studies that have empirically tested this impact. Landry *et al*. (2002) analysed the effects of networks and trust on the likelihood and on the radicalness of innovation at the firm level. They found confirmation for the innovation-increasing effect of networks, but trust turned out to be insignificant in determining both likelihood and radicalness of innovation. Dakhli and de

Clercq (2004) analysed the impact of networks, trust and norms on different indicators of innovation at the country level. It turned out that none of these three dimensions of social capital influence the number of patents, that higher institutional trust increases high-tech export, and unexpectedly for the authors, that higher norms of civic behaviour appear to decrease high-tech export. The authors supposed that the norms of being a good citizen are contradictory to the intentions to think differently and create new ideas.

There are also studies with more optimistic results. For example, Tsai and Ghoshal (1998) found in their firm-level analysis that both social interactions and trustworthiness increase the number of innovations via resource exchange and combination. The firm-level study by Subramaniam and Youndt (2005) showed that the overall social capital influenced positively both incremental and radical innovative capabilities. Ackomak and ter Weel (2006) analysed European regional-level data, finding that trust has a positive influence on the number of patent applications.

The relationship between human and social capital has also been the subject of discussion. First, it is often argued that social capital has a positive impact on education and human capital. However, by that it is usually meant that surrounding social capital helps to create the human capital of a child or young person (see Chou, 2006 for an overview). Hence, the influence of the present level of social capital will become evident in a longer perspective. Therefore, when analysing social and human capital concurrently, this influence cannot be expected to emerge. Second, there are many proponents of a view that a higher level of education means higher social capital. Norms, and cooperation and social participation skills can be viewed as by-products of education. Further, more educated people are usually more informed and able to make evaluations of social and political issues, hence their civic participation is also higher (see Denny, 2003 and Dee, 2004 for a more exhaustive overview). Dee (2004) provided empirical evidence that educational attainment largely affects both attitudes and civic engagement. Denny (2003) found that education has a significant, but rather small impact on social participation. Thus, in the context of the current study the direction of causal relationship from human capital to social capital can be presumed.

In summary, it can be assumed that besides R&D and human capital, social capital also influences innovative activity. Moreover, considering the heterogeneous character of social capital, it can be supposed that different dimensions of social capital have dissimilar impacts on innovation. In addition, the indirect influences of social capital and human capital on innovation have to be tested: social capital via R&D, and human capital via social capital and R&D. Next, the data used for testing these propositions will be introduced.

4. DATA

The data used in this study were drawn from two databases. The measures of R&D, innovation, and one indicator of human capital came from the Eurostat's Regio database (Eurostat, 2007) while the measures of social capital and the other indicators of human capital were taken from the database of the European Social Survey (ESS) (Jowell *et al*., 2003; Norwegian…, 2007). Data were available for 20 countries[2] at the regional level. Although the author's intention was to include all countries at the NUTS2 level (European …, 2007), the data in ESS were available only at the NUTS1, NUTS2 or NUTS3 level[3] for each country. Therefore, the data available at the NUTS3 level were aggregated to the NUTS2 level. For the aggregation the raw data were used, ensuring that the data aggregated to the NUTS2 level were completely comparable to the data already presented at the NUTS2 level. For Belgium,

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[2] The countries included in the analysis are: Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovenia, Spain, Sweden, and the United Kingdom. In case of Switzerland, the innovation data were not available; hence Switzerland was not included in the analysis.

[3] The NUTS (Nomenclature of Territorial Units for Statistics) is established by Eurostat. This hierarchical classification subdivides each country into a number of NUTS1 regions, each of which is in turn subdivided into a number of NUTS2 regions and so on (see European ..., 2007 for further information).

France, Germany and the United Kingdom, the data were available at the NUTS1 level and these countries had thus to be included in the analysis at this level. To ensure that the data drawn from ESS would be representative of the demographic structure of a region, weighted data were chosen. Six regions, where the number of respondents in ESS was below 25, were omitted. The final number of observations used is 162. Analogical data were used in the studies by Ackomack and ter Weel (2005; 2006), but they analysed only 11 countries (divided into 87 regions) (2005) or 14 countries (102 regions) (2006), respectively. It has to be mentioned that the data in the two databases used differ in their nature: while the ESS data were obtained from a survey where the number of respondents was quite small in some regions, the data in Eurostat Regio gained from the national statistical offices are of a more general character. However, because of the complex character of the concept of social capital, surveys are the best option available for measuring social capital. Although not all-including, the weighted ESS data are the best proxy for different dimensions of social capital in European regions at present.

It makes sense to assume that the innovation process takes time and thus a time lag should be considered between the observations of the factors of innovation and the observations of innovation. Daklhi and de Clercq (2004) and Subramaniam and Youndt (2005), for instance, use innovation data observed three years later than the factors of innovation. Yet, many studies do not use the time lag (Tsai and Ghoshal, 1998; Nasierowski and Arcelus, 1999; Landry *et al*. 2002) or use innovation data observed even earlier than the factors of innovation (Ackomack and ter Weel, 2005; Ackomack and ter Weel 2006). As the stock of social or human capital does not change rapidly, it is possible that the results are not drastically influenced by the chosen time lag. Still, whenever feasible, it is reasonable to use such data about the factors of innovation which are observed before the innovation data. In this study, all the indicators of social capital and one indicator of human capital were drawn from the ESS, which has had two rounds: 2002 and 2004. As the latest innovation data in the Eurostat Regio database pertained to 2003, the first round of ESS (2002) was chosen. Hence, considering the data, the best choice is a one-year time lag: the innovation data for 2003 and the data measuring factors of innovation for 2002. The only exception is that in case of R&D the missing data for Germany, Greece, Italy, Luxembourg and Sweden in 2002 were replaced with the observations for 2003. As the correlations between the data for 2002 and 2003 ranged between 0.976 and 0.991, the replacements presumably do not decrease the reliability of the analysis.

Next, the indicators included in the analysis will be briefly introduced. The exact descriptions of the indicators included in the analysis are presented in Appendix A.

Innovation is measured by the number of patent applications to the European Patent Office (EPO). However, the reliability of this measure can be questioned, as it covers only one aspect of innovative activity, excluding, for example, process innovations or product modifications (see Daklhi and de Clercq (2004) for a more in-depth discussion). Yet, this is the only way at the moment to proxy innovation outputs at the regional level in Europe and it captures the main patterns of innovative results (Daklhi and de Clercq, 2004; Ackomack and ter Weel, 2006). Three indicators: the numbers of all patent applications, high-tech and biotechnology patent applications were included in the analysis. As the number of ICT patent applications, which was also available, was highly correlated (0.94) with the number of high-tech patent applications, it was not included in the analysis to balance the set of innovation indicators.

Innovation inputs, i.e. R&D, are described by four indicators: the R&D expenditures and the employment in R&D both in the business and government sector. Two indicators are used to measure human capital. First, the average number of school years was taken from ESS. Since the number of respondents to ESS is quite small in some regions, this measure should be compared and complemented with some more reliable indicator. Therefore, and in order to capture another aspect of human capital, the percentage of labour force with tertiary education was drawn from Eurostat Regio.

Regarding social capital, it is assumed that different dimensions of social capital can influence innovation in dissimilar ways. Therefore, for describing social capital, an overall index, one variable or one latent construct cannot be used. This idea is supported by the argument pointed out by Franke (2005) that grouping several dimensions of social capital into one index may eliminate the substance of the concept and its explanatory power may be lost in an analysis. In this study, first informal networks are described by the frequency of meeting friends, relatives or colleagues and the importance of friends in life. Here and hereafter the scales are chosen so that larger values reflect a larger stock of social capital. Formal networks, which can also be referred to as social participation, are measured by the average number of memberships in various voluntary organisations as a more objective measure and by the importance of organisations in life as a more subjective measure. Civil participation is described by voting activity.

Three indicators used to measure general trust are the answers to three questions about whether most people can be trusted, whether most people are fair, and whether most people are helpful. Institutional trust is measured by four indicators: trust in the legal system and politicians, and satisfaction with the government and the way democracy works. When attempting to describe and analyse norms, one has to bear in mind that the claimed norms can noticeably differ from actual behaviour. However, even the indicators of actual behaviour, if drawn from surveys, are subjective, because the respondents are likely to be reluctant to admit bad behaviour (Knack and Keefer, 1997). In this paper, norms are described by eight indicators. At the same time, the norm of activity in organisations can also be viewed as an indicator of social participation and the norm of duty to vote as an indicator of civic participation. The other six indicators are the norms of helping, loyalty, supporting, following rules, behaving properly and obeying the laws.

Concerning data normality, the outlier values were omitted. In order to preserve as much valuable information as possible, instead of deleting whole observations, each variable was considered separately and values more than three standard deviations away from the mean of a particular indicator (Kline, 1998, p. 79) were deleted. After this, the data satisfy the normality assumption with absolute values of skewness ranging from 0.041 to 1.317 (should be less than 3 (Kline, 1998, p. 82)) and of kurtosis from 0.032 to 1.247 (less than 8 or 10 (*ibid.*)). The numbers of usable observations are presented in Appendix B. For the data analysis here and hereafter SPSS for Windows 11.5 and Amos 4.0 were used. Next, the measurement of latent variables will be introduced.

5. MEASUREMENT OF LATENT VARIABLES

As mentioned before, this paper aims to analyse the effects of different dimensions of social capital on innovation separately. This is a complicated task, as collinearity problems can be expected if different dimensions are separately included in the model (Ackomak and ter Weel, 2005). Therefore, first multicollinearity diagnostics were inspected. The condition index (if only the indicators of social capital are included) is 185.74, which is larger than both limit values suggested in the literature: 30 and 100 (Maruyama, 1998, p.64). Hence, there exists multicollinearity between the variables describing social capital. This is supported by the variance inflations factors (VIF) ranging from 1.98 to 11.492, as it is commonly accepted that VIF greater than 10 indicates multicollinearity (Kline, 1998, p.78).

One possible way to overcome this problem is to use confirmatory factor analysis[4] as a part of the structural equation modelling (SEM)[5] methodology to generate latent variables describing different dimensions of social capital (trust, norms, informal and formal networks, civic participation), human capital, R&D and innovation. However, when this method was applied on the data, the results showed persisting multicollinearity problems. Some standardised regression coefficients describing the influence of different latent factors on innovation were significantly higher than one (reaching even values over 100 or below -100 in case of some

[4] While in case of exploratory factor analysis any indicator may be associated with any factor, in case of confirmatory factor analysis the indicators describing a particular latent factor are predetermined on the basis of theoretical considerations (see, for instance, Maruyama, 1998).

[5] See, for instance, Maruyama (1998) or Kline (1998) for an overview of SEM as a method.

specifications) and very unstable, which is a sign of multicollinearity (Maruyama, 1998, p. 63).

This is presumably caused by the problems with attaining convergent and discriminant validity. Many of the indicators of different constructs are quite strongly correlated, for example, correlations between the indicators of general trust and membership in voluntary organisations, or frequency of meeting (see Appendix B for correlations). At the same time, some correlations between the indicators describing the same construct are quite small − often the correlations between indicators that reflect different constructs are smaller than within-construct correlations. Also, it is possible that some indicators simultaneously reflect different latent constructs. Thus, it can be supposed that it is more reasonable to group the indicators of social capital in some other way which is more consistent with the data structure. This supposition can be tested by exploratory factor analysis, which also solves multicollinearity problems resulting in variables describing social capital and not correlating with each other.

Thus, an exploratory factor analysis was conducted using the principal components method with equamax[6] rotation. In order to test for stability of the results, other extraction methods (maximum likelihood, generalised least squares) and other rotation methods (varimax, quartimax) were implemented, but the pattern of loadings of indicators into factors remained the same. To decide the number of factors, the Kaiser criterion was used: only the factors with eigenvalue greater than 1 were retained (Statsoft, 2003). The factor loadings and percentages of total variance explained by the factors are presented in Table 1. For reasons of simplicity and clarity, the coefficients with absolute values less than 0.4 are suppressed. The extracted six factors explain altogether 82.04% of the total variance of indicators included in the analysis.

[6] Equamax is chosen, because it is a combination of varimax, which minimises the number of variables that have high loadings on each factor, and quartimax, which minimises the number of factors needed to explain each variable (SPSS, 2005).

Table 1. Rotated component matrix of social capital indicators and % of total variance explained

Indicators	Factors					
	1	2	3	4	5	6
Importance of friends	0.77					
Trust in fairness	0.76		–0.41			
General trust	0.69	0.43				
Trust in helpfulness	0.67					
Membership in voluntary organisations	0.67					
Frequency of meeting socially	0.55			0.49		
Satisfaction with the government		0.87				
Satisfaction with the democracy		0.79				
Trust in politicians		0.75				
Norm of loyalty and devotion			0.84			
Norm of helping and care			0.80			
Norm of behaving properly	–0.47		0.56		0.45	
Norm of activity in organisations				0.90		
Importance of voluntary organisations				0.86		
Norm of supporting				0.68		
Norm of obeying laws					0.86	
Norm of following rules			0.45		0.72	
Voting						0.78
Norm of duty to vote					0.48	0.76
Trust in the legal system		0.53				0.66
Variance explained (%)	17.01	14.43	14.26	12.74	11.85	11.75
Cumulative variance explained (%)	17.01	31.44	45.70	58.44	70.29	82.04

The first factor can be interpreted as 'general trust and networks' as it covers all three indicators of general trust but also both indicators of informal networks and the objective measure of formal networks. It is interesting that this factor is negatively related to the norm of behaving properly – this can be caused by the contradiction mentioned before between the norms and actual behaviour. The second factor represents institutional trust, including all four indicators of institutional trust. This factor is also positively related to general trust, which is quite logical. The third factor can be referred to as the norms of helping and decency. It has high loadings of the norm of helping and loyalty and somewhat lower but still significant loadings of the norms of behaving properly and following rules. The negative relationship with trust in fairness can again be explained by the contradiction between norms and behaviour: behaviour does not favour trust in fairness.

The fourth factor represents the norms of active social participation as it includes both subjective indicators related to organisational activity, and the norm of supporting, and is positively related to the activity of meeting other people. The fifth factor describes the norms of orderliness. It has high loadings of the norms of obeying laws and following rules, and somewhat lower loadings of the norms of behaving properly and the duty to vote. The sixth factor can be interpreted as civic participation, including both the norm and practice of voting. It is logical that this factor is also positively related to trust in the legal system.

The results show that different dimensions of social capital are indeed strongly related. In case of social participation, it is possible to separately consider the norms and actual behaviour, but this may rather reflect the problems connected with the subjective character of data.

Before estimating the structural model, also the latent variables of human capital, R&D and innovation, or more precisely patenting intensity[7], were constructed. Principal components analysis of parti-

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[7] As innovation is measured by patent applications, here and hereafter, when presenting the results of the analysis, under innovation the activity of submitting patent applications, that is, patenting intensity,

cular indicators was conducted to capture the information into one variable. An analogical method has been used earlier by Whiteley (2000) to create one variable describing social capital. The results are presented in Table 2. The percentages of total variance explained are quite large, considering that only one factor was extracted.

Table 2. Factors of human capital, R&D and innovation: factor loadings and % of variance explained

Latent variable/factor	Indicator	Factor loadings	Variance explained (%)
Human capital	Labour force with tertiary education	0.88	77.21
	Years of education completed	0.88	
R&D	R&D expenditure in the business sector	0.82	59.40
	R&D personnel in the business sector	0.82	
	R&D expenditure in the government sector	0.77	
	R&D personnel in the government sector	0.66	
Innovation (patenting intensity)	High-tech patent applications	0.91	74.97
	Patent applications	0.90	
	Biotechnology patent applications	0.78	

The factor scores of all latent variables discussed so far were saved as variables and entered into the structural model presented in the next section.

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is meant and the term innovation is used rather for reasons of concision than generalisation.

6. RESULTS OF THE STRUCTURAL MODEL ESTIMATION

Next, the structural equation modelling (SEM) approach was used to analyse how different factors influence innovation. First of all, the model includes the direct effects of R&D, human capital and six factors describing social capital on innovation. According to the literature and theoretical considerations discussed before, the direct effects of human capital on all social capital factors and R&D are also presumed and tested. This enables capturing the indirect effect of human capital on innovation through social capital and R&D. In addition, it can be supposed that some dimensions of social capital, especially those connected with trust, influence innovation not only directly but also through R&D. To test these influences, the direct effects of social capital factors on R&D were also included in the initial model. As the factors describing social capital are uncorrelated because of the specificity of principal component analysis, different dimensions of social capital are assumed to have no causal relationships to each other. All the direct effects (which also form the indirect effects) tested are presented in Figure 1.

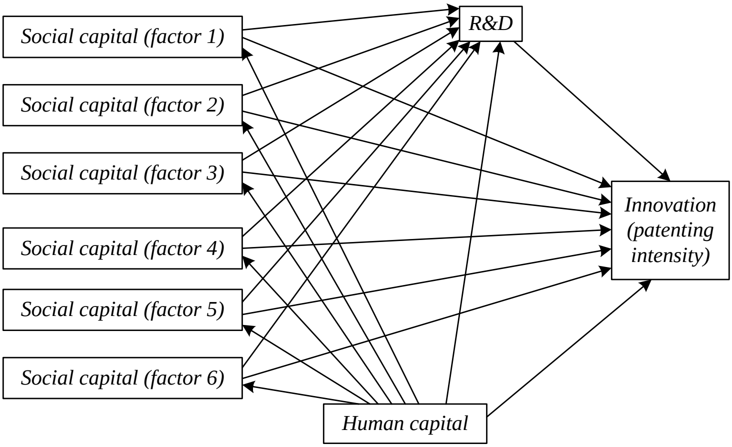

Figure 1. Structural model.

As mentioned before, the indicators measuring human capital were drawn from different sources and the reliability of the indicator of the average years of education completed (hereafter referred to as ‘the years of education’) can be more questionable than that of the indicator of labour force with tertiary education (hereafter referred to as ‘tertiary education’). Also, they capture different aspects of human capital: the former indicates overall educational level of the population, while the latter focuses on the spread of tertiary education among labour force. Therefore, three model specifications were tested: models using the latent construct including both indicators and both indicators alone as a measure of human capital.

The full information maximum likelihood (FIML) method was used for estimation. This method enables utilising all the information available in case of missing data because in case of every observation it takes into account only variables with available data for this observation (Enders and Bandalos, 2001). All the variables were standardised before the analysis to ensure comparability of the relative fit indices calculated by AMOS. The standardised regression coefficients, squared multiple correlations and fit measures of the initial models are displayed in Appendix D.

According to the squared multiple correlations, 72–74% of variance in innovation, or more precisely, patenting intensity is explained by the initial models described before. The overall model fit has been assessed in terms of five measures. The χ^2/df ratio (discrepancy / degrees of freedom) indicates the best fit (2.46) if tertiary education is used as a measure of human capital, followed by the model with the latent construct (2.86) and the years of education (2.90). Whereas commonly the values less than 3 are considered as favourable (Kline, 1998, p. 131), all three models are acceptable. The RMSEA (root mean square error approximation) values range from 0.09 to 0.10. These values lie on the borderline of model acceptance (Arbuckle and Wothke, 1999). With regard to the relative fit indices, those indices that are less sensitive to the sample size (according to Hu and Bentler 1999, pp.89-91) were chosen because of the relatively small sample size in this study. Still, the indices used have also been reported to undervalue the models if the sample size is smaller than

250 (*ibid*.). The values of normed fit indices (NFI) are ranging from 0.82 to 0.85, incremental fit indices (IFI) from 0.87 to 0.90, and comparative fit indices (CFI) from 0.85 to 0.89. Usually the values higher than 0.9 (Kline, 1998, p. 131; Hu and Bentler 1999, pp.89-91), but also those higher than 0.8 (Tsai and Ghoshal, 1998) have been considered as indicators of a good fit. Hence, the initial models, especially the model including tertiary education, can be viewed as acceptable, but the differences in fit measures are too small to decide that one model is better than the others.

As can be seen from Appendix D, the fit measures can be significantly improved by deleting the insignificant paths one by one (backward method), but the variance of patenting intensity explained and the statistically significant regression coefficients do not change significantly. It can be assumed that in calculating the indirect and total effects[8], the insignificant regression coefficients have very little influence, if any. As the insignificant regression coefficients are mostly close to 0, the indirect effect through the particular insignificant path will also be close to 0 and it does not change the total effect significantly. This can be seen from Table 3. Therefore, the implications can be drawn on the basis of the results of the initial models. In addition, the specifications without the effects of human capital on social capital or the effects of social capital on R&D were tested. The results are not presented in this paper for reasons of space, but the patterns of regression coefficients, the variance explained and the fit measures did not change significantly.

As expected, R&D has a statistically significant large[9] positive effect on patenting intensity in the case of tertiary education as a measure of human capital (0.52), and it is slightly smaller in the models including the latent construct (0.46) and the years of education (0.42). Contrary to expectations, only the direct effect of

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[8] See, for example, Maruyama (1998) for principles of calculating indirect and total effects.

[9] Here and hereafter the interpretation bases on the recommendations that the standardised regression coefficients with absolute values of 0.5 or more can be interpreted as large, coefficients with absolute values around 0.3 as medium, and coefficients with absolute values less than 0.1 as small effects (Kline 1998, pp. 149–150).

the years of education on patenting intensity turned out to be statistically significant, although rather small (0.19). The other measures of human capital had no statistically significant direct effect on patenting intensity. However, human capital influences patenting intensity also through other variables. Mainly because of a large direct effect on R&D, but also because of direct effects on different dimensions of social capital (see Appendix D), the indirect effect compensates the missing direct effect. Hence, the total effect of human capital on patenting intensity turned out to be a large positive effect (coefficients between 0.51 and 0.57, see Table 3) in all the models. It is interesting to note that human capital has a rather positive direct effect on institutional and general trust, networks and civic participation, but a rather negative direct effect on all factors describing norms.

As regards social capital, a statistically significant positive influence is exerted on patenting intensity by general trust and networks, institutional trust, and civic participation. Among them, civic participation has the largest effect. In models with the latent construct of human capital and the years of education, the total effect (0.33 and 0.29, respectively) mainly comprises the direct effect, while in the model with tertiary education, the somewhat smaller direct effect is compensated by the positive indirect effect through R&D, resulting in an analogical total effect (0.36). Both general trust and networks, and institutional trust have a rather small but statistically significant positive impact on patenting intensity (coefficients ranging from 0.19 to 0.24 and from 0.18 to 0.26, respectively). These are mainly direct effects, except the effect of general trust and networks, which has a small positive indirect effect on patenting intensity through R&D in the model with the years of education as a measure of human capital. The norms of orderliness turn out to have a significant negative total effect of medium size: coefficients ranging from –0.33 to –0.39, which consists mainly of the statistically significant direct effect. The norms of helping and decency, and the norms of active social participation have no statistically significant effect on patenting intensity.

Table 3. Standardised total effects of factors on innovation (patenting intensity)[10]

Measure of human capital	Latent construct		Tertiary education		Years of education	
Model	initial	(modified)	initial	(modified)	initial	(modified)
R&D	0.46	(0.52)	0.52	(0.50)	0.42	(0.43)
Human capital	0.57	(0.53)	0.51	(0.52)	0.55	(0.52)
General trust and networks	0.19	(0.15)	0.24	(0.16)	0.21	(0.23)
Institutional trust	0.21	(0.21)	0.18	(0.20)	0.26	(0.22)
Norms of helping and decency	–0.02		–0.06		–0.02	
Norms of active social participation	–0.03		–0.10		0.03	
Norms of orderliness	–0.33	(–0.31)	–0.32	(–0.28)	–0.39	(–0.40)
Civic participation	0.33	(0.31)	0.36	(0.43)	0.29	(0.26)

[10] Unfortunately, it was not possible to obtain any indicators about the statistical significance of the total effects in AMOS. However, according to the results concerning the direct effects, it can be assumed that the border value for significance at the 0.01 level is around 0.19 and for significance at the 0.10 level around 0.13. Therefore, except for the two factors of social capital left out from modified models, all other total effects can be considered as statistically significant.

7. DISCUSSION AND IMPLICATIONS

The results of this paper provide significant support for the argument that social capital indeed influences innovative activity. Also, the findings indicate that different dimensions of social capital affect innovation in dissimilar ways. As expected, institutional trust, general trust and networks have a positive, although rather small, impact on innovation measured by patenting intensity. These findings provide regional-level support to the results of the firm-level study by Tsai and Ghoshal (1998). The results support the idea that higher trust allows spending more time on innovative activity (Knack and Keefer, 1997; Tamaschke, 2003). Although it can be expected that higher trust also enables firms to spend more finances on innovative activity, in two models out of three, the effect of the factor including general trust on R&D turned out to be statistically insignificant. This can be explained by the fact that this factor also includes networks, which are not explicitly expected to affect R&D expenditures. With regard to networks, the results support the argument that both formal and informal networks contribute to innovation. The results also show that among the dimensions of social capital, civic participation has the strongest positive effect on innovation measured by patenting intensity. The positive effect of both institutional trust and civic participation provide support for the argument that a reliable legal system is accompanied by effective protection for the results of innovative activity, which in turn stimulates innovative activity (Dakhli and de Clercq, 2004; Tabellini, 2006). Until today, the impact of civic participation has not received much attention in the literature as a factor of innovation. This can be put down to the fact that many of the studies published so far are firm-level studies, while civic participation is rather a country-level concept. However, civic participation can also be viewed as an indicator of participation activity, which can be expected to influence innovation at the firm level, too. Hence, in future research this dimension of social capital should get more attention as a factor of innovative activity.

The norms of orderliness appeared to have a negative medium effect on innovation measured by patenting intensity. This result provides support to the findings of Dakhli and de Clercq (2004) and confirms the idea that the norms of being a good citizen are contradictory to creativity and thinking differently. The other factors describing the norms of helping, decency, and active social participation turned out to have no significant influence on patenting intensity. Here, two implications can be pointed out. First, it is rather the actual behaviour that matters, and not the norms, whereas the norms may but need not guide the actual behaviour. Second, the insignificance of some norms as factors of patenting intensity can explain the little attention they have received in the literature about the effect of social capital on innovative activity. However, as some norms turned out to have a significant negative influence, the effects of different norms on innovation need to be analysed more thoroughly in the future.

Thus, different dimensions of social capital seem to influence innovation in differing ways: although the impact is mostly positive, some dimensions can have a negative impact. Therefore, the positive impact of some dimensions can be counteracted by the negative impact of other dimensions, and if only the impact of overall social capital is studied, the impact can seem relatively small. Thus, the analyses that do not distinguish between the dimensions of social capital may undervalue the impact of social capital. These results provide support to Franke's (2005) argument about the risk of losing the explanatory power when grouping all the dimensions of social capital together into one index.

With regard to policy implications, if only one measure of social capital is used, the conclusion may easily be that there are no possibilities to encourage innovation through social capital. However, if different dimensions of social capital are distinguished, there may be some dimensions that have a strong impact on innovation. Focussing on these dimensions, for example, on civic participation or intentions to increase trust in institutions, may help foster innovative activity. Consequently, it is not appropriate to test the impact of social capital on innovation using one overall measure comprising all the dimensions of social capital.

As expected, R&D turned out to have a large positive effect on innovation measured by patenting intensity. The results with respect to the direct effect of human capital are mixed. Human capital appeared to have a significant positive direct effect on patenting intensity only if measured by the average number of years of education completed. If the percentage of labour force with tertiary education or a latent construct including both indicators were used, the direct effect turned out to be insignificant. There are several possible interpretations to that. First, the different results can be caused by the different aspects captured by the two indicators of human capital: it is likely that in the context of innovative activity the overall educational level of the population is more important than the spread of tertiary education. Second, the differences can be put down to the possible unreliability of the indicator of the years of education, since it is drawn from a survey with quite a low number of respondents in some regions. Hence, one may rather trust the results of the model including only the indicator of tertiary education. Unfortunately, no analogical studies are available to enable comparison of the results. However, two aspects should be pointed out. First, regardless of the different results concerning the direct effect, in case of all model specifications, the total effect of human capital appears to be the same – positive and large as expected. Second, the differences discussed do not significantly affect the results with respect to the influence of social capital on patenting intensity. Hence, the confusion with human capital and its measures should not be considered as decreasing the reliability of the findings about the influence of different dimensions of social capital on innovation.

8. LIMITATIONS AND FUTURE RESEARCH

Several limitations should be recognised with respect to this study. Although the sample size of this study was larger than that of analogical previous studies, it was still relatively small. Also, while most of the countries were represented at the NUTS2 level, four countries had to be included into the analysis at the NUTS1 level because of data unavailability. It is possible that this imbalance in representation may have caused some bias in the results. Thus, the future availability of data for all countries at the NUTS2 or NUTS3 level would be very useful. Also, there are many missing data in the data set compiled for this study. Here, new surveys and better cooperation between the national statistical offices and some central statistical institution are needed.

There are also some problems with respect to measurement. First, measuring innovation is problematic. The number of patent applications as a measure of innovation focusses only on one aspect of innovation, failing to capture process innovations, product modifications, or radicalness of innovation. It can be assumed that social capital can have an even stronger impact on the diffusion and adaptation of innovations. The current study is not the only one suffering from this shortcoming. Hence, there exists a strong motivation to develop and collect indicators capturing other aspects of innovation, too, both at the national and regional level. Also, the reliability of the measure of the overall educational level of the population used in this study is questionable. The indicator of the average years of education completed was calculated on the basis of the European Social Survey, where the number of respondents has been quite small in some regions. Although the weights were used to ensure that the data would be representative according to the demographic structure of regions, this indicator may still by unreliable. Therefore, the question remains if the differences in results concerning the direct effect of human capital are due to the unreliable indicator or the fact that different aspects of human capital have dissimilar impacts on innovation. Hence, if a regional-level indicator based on the whole population in Europe becomes available about the average years of education, it would be interesting to rerun the analysis.

As noted before, although the results of this study refer to a strong positive effect of civic participation on innovation, this influence has not received much attention in the empirical research so far. Hence, future research should lay more emphasis on this influence and re-examine it. In addition, one more aspect that certainly deserves further attention is the influence of different norms on innovation. In the current study, the norms of orderliness appeared to have a negative impact on patenting intensity, while the other norms had no influence on it. However, if data describing more different norms will become available, future studies could supplement the findings and improve the understanding of the influence of different norms on innovative activity.

9. CONCLUSIONS

In summary, this paper attempted to examine the impact of different dimensions of social capital on innovation, including also human capital and R&D in the analysis as the factors of innovation. It was assumed that different dimensions of social capital might influence innovation in dissimilar ways. Therefore, instead of one overall index, six factors were constructed of 20 indicators of social capital. Because of multicollinearity, principal components analysis had to be used instead of confirmatory factor analysis. After constructing the latent variables measuring social and human capital, R&D and innovation measured by patenting intensity, structural equation modelling was used to examine the influences of social and human capital and R&D on innovation. Besides the direct effects, the possible relationships between the factors of innovation themselves were taken into account. Hence, the conclusions are drawn on the basis of the total effects on innovation.

The findings provide strong support for the argument that social capital influences innovative activity. The results also show that different dimensions of social capital have dissimilar effects on patenting intensity. Among the dimensions of social capital, civic participation, which has not received much attention in the literature so far, appeared to have the strongest positive effect on innovation measured by patenting intensity. Institutional trust, general trust and networks turned out to have a positive, although rather small, impact on patenting intensity. In keeping with the author's assumptions and previous results, the norms of orderliness appeared to have a negative medium effect on patenting intensity. The other factors describing the norms of helping, decency, and active social participation turned out to have no significant influence on patenting intensity. As the positive impact of some dimensions of social capital can be compensated by the negative impact of others, the analyses using only one overall index for social capital are likely to undervalue the influence of social capital on innovation. As expected, R&D turned out to have a large positive effect on innovation. The results with respect to the direct effect of human capital were mixed, but the total effect of human capital appeared to be positive and large as expected.

This study has some limitations. Its sample size is relatively small and has missing data. Also, the patent data capture only one aspect of innovation. However, despite these deficiencies, this study indicates that social capital has a significant impact on innovation and that it is important to analyse this impact, distinguishing between different dimensions of social capital. In the future, especially the norms and civic participation will need further study as factors of innovative activity.

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KOKKUVÕTE

Erinevate sotsiaalkapitali dimensioonide mõju innovatsioonile: analüüs regionaalsel tasemel Euroopas

Käesolevas artiklis analüüsitakse sotsiaalkapitali erinevate dimensioonide mõju innovatsioonile, kaasates analüüsi ka uurimis- ja arendustegevuse ning inimkapitali eeldatava mõju innovatsioonile. Sotsiaalkapitali mõju innovatsioonile on viimase kümnendi jooksul pälvinud teaduskirjanduses järjest enam tähelepanu. Siiski on sellealaseid empiirilisi uurimusi veel küllalt vähe. Üheks oluliseks põhjuseks on arvatavasti sotsiaalkapitali mõõtmise keerukus. Esiteks, kuna sotsiaalkapitali kontseptsioon sisaldab palju erinevaid dimensioone, ei ole seda võimalik mõõta vaid ühe näitajaga. Teiseks tuleb sotsiaalkapitali mõõtmiseks läbi viia eraldi uuringuid, mida pole seni sotsiaalkapital mõiste uudsuse tõttu veel kuigi palju tehtud. Käesolevas artiklis kasutatakse andmebaase *ESS* (*European Social Survey*) ja *Eurostat Regio*. Seejuures kasutatakse võrreldes varasemate analoogiliste uurimustega rohkem vaatlusi ja sobivamat ajalist nihet innovatsiooni ja selle mõjurite näitajate vahel. Erinevalt paljudest varasematest, regressioonanalüüsi kasutanud uurimustest, võetakse käesolevas uurimuses tänu struktuurse modelleerimise (*structural equation modelling*) kasutamisele arvesse ka erinevate innovatsiooni mõjurite omavahelised mõjud.

Sotsiaalkapitali mõõtmiseks tuli multikollineaarsuse tõttu kinnitava faktoranalüüsi asemel kasutada peakomponentide meetodit. Selle tulemusena moodustus 20 sotsiaalkapitali näitaja alusel kuus faktorit: üldine usaldus ja võrgustikud, institutsionaalne usaldus, kodanikuosalus, abistamise ja lojaalsusega, aktiivse osalusega ning korralikkusega seostuvad normid. Samuti on peakomponentide meetodil moodustatud innovatsiooni (täpsemalt patenteerimisintensiivsust), uurimis- ja arendustegevust ning inimkapitali kirjeldavad muutujad.

Struktuurse mudeli hindamise tulemused kinnitavad esiteks, et sotsiaalkapital mõjutab innovatsiooni, ja teiseks, et sotsiaalkapitali erinevatel dimensioonidel on innovatsioonile erinev mõju. Kodanikuosalus, mis ei ole seni kirjanduses eriti tähelepanu pälvinud, osutus kõige rohkem innovatsiooni, täpsemalt patenteerimisintensiivsust positiivselt mõjutavaks sotsiaalkapitali dimensiooniks. Institutsionaalsel ja üldisel usaldusel ning võrgustikel ilmnes samuti olevat positiivne, kuid nõrgem mõju patenteerimisintensiivsusele. Kooskõlas varasemate uurimuste ja teoreetiliste oletustega ilmnes, et korralikkusega seostuvad normid avaldavad patenteerimisintensiivsusele negatiivset mõju. Teiste norme kirjeldavate faktorite mõju patenteerimisintensiivsusele osutus statistiliselt ebaoluliseks. Lisaks näitasid tulemused, et uurimis- ja arendustegevus avaldab patenteerimisintensiivsusele oodatult tugevat positiivset mõju. Inimkapitali otsene mõju patenteerimisintensiivsusele osutus erinevaks sõltuvalt kasutatud inimkapitali näitajast, kuid kogumõju osutus tugevaks positiivseks mõjuks kõigi inimkapitali näitajate korral. Mainitud erinevused ei mõjutanud tulemusi sotsiaalkapitali mõju osas innovatsioonile.

Kuna ühtede sotsiaalkapitali dimensioonide positiivset mõju innovatsioonile vähendab teiste dimensioonide negatiivne mõju, võib juhtuda, et kui kasutada vaid üht üldist sotsiaalkapitali kirjeldavat indeksit, siis alahindavad tulemused sotsiaalkapitali tegelikku mõju innovatsioonile. Seepärast tuleks edaspidises uurimistöös kindlasti analüüsida erinevate sotsiaalkapitali dimensioonide mõju eraldi.

Appendix A. Indicators measuring innovation inputs and outputs, human and social capital.

Construct	Indicator	The exact name of indicator according to the source	Source
Innovation	Patent applications	Patent applications to the EPO by priority year, per million labour force	Eurostat
	High-tech patent applications	High-tech patent applications to the EPO by priority year, per million labour force	Eurostat
	Biotechnology patent applications	Biotechnology patent applications to the EPO by priority year, per million labour force	Eurostat
R&D (innovation inputs)	R&D expenditure in the business sector	Total intramural R&D expenditure (GERD), business enterprise sector, percentage of GDP	Eurostat
	R&D expenditure in the government sector	Total intramural R&D expenditure (GERD), government sector, percentage of GDP	Eurostat
	R&D personnel in the business sector	Total R&D personnel, business enterprise sector, percentage of total employment	Eurostat
	R&D personnel in the government sector	Total R&D personnel, government sector, percentage of total employment	Eurostat
Human capital	Labour force with tertiary education	Tertiary education – levels 5–6 (ISCED 1997), percentage of population aged 15 and over	Eurostat
	Years of education completed	Years of full-time education completed, average	ESS
Informal networks	Frequency of meeting socially	How often socially meet with friends, relatives or colleagues, percentage at least once a week	ESS
	Importance of friends	Important in life: friends, average on scale 0–10	ESS
Formal networks/ social participation	Membership in voluntary organisations	Various[11] voluntary organisations, last 12 months: member, average number of memberships per person	ESS
	Importance of voluntary organisations	Important in life: voluntary organisations, average on scale 0–10	ESS

[11] Trade unions, business/professional/farmers' organisations, political parties, sports/outdoor activity clubs, cultural/hobby activity organisations, religious/church organisations, consumer/automobile organisations, humanitarian organisations etc., environmental/ peace/animal organisations, science/education/teacher organisations, social clubs etc., other voluntary organisations.

Construct	Indicator	The exact name of indicator according to the source	Source
Civic participation	Voting	Voted last national election, percentage of eligible	ESS
General trust	General trust	Most people can be trusted or you can't be too careful, average on scale 0–10	ESS
	Trust in fairness	Most people try to take advantage of you, or try to be fair, average on scale 0–10	ESS
	Trust in helpfulness	Most of the time people helpful or mostly looking out for themselves, average on scale 0–10	ESS
Institutional trust	Trust in the legal system	Trust in the legal system, average on scale 0–10	ESS
	Trust in politicians	Trust in politicians, average on scale 0–10	ESS
	Satisfaction with the government	How satisfied with the national government, average on scale 0–10	ESS
	Satisfaction with the democracy	How satisfied with the way democracy works in country, average on scale 0–10	ESS
Norms of civic behaviour	Norm of helping and care	Important to help people and care for others' well-being, percentage very much like me/like me	ESS
	Norm of loyalty and devotion	Important to be loyal to friends and devote to people close, percentage very much like me/like me	ESS
	Norm of supporting	To be a good citizen: how important to support people worse off, average on scale 0–10	ESS
	Norm of following rules	Important to do what is told and follow rules, percentage very much like me/like me	ESS
	Norm of behaving properly	Important to behave properly, percentage very much like me/like me	ESS
	Norm of obeying laws	To be a good citizen: how important to always obey laws/regulations, average on scale 0–10	ESS
	Norm of activity in organisations	Good citizen: how important to be active in voluntary organisations, average on scale 0–10	ESS
	Norm of duty to vote	To be a good citizen: how important to vote in elections, average on scale 0–10	ESS

Appendix B. Correlations and numbers of observations of indicators included in the analysis[12]

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Patent applications	1	0.78	0.53	0.77	0.34	0.75	0.14	0.45	0.45	0.36	0.32	0.60	0.12	0.22	0.48
2. High-tech patent applications	0.78	1	0.55	0.68	0.26	0.65	0.14	0.35	0.48	0.27	0.21	0.53	0.02	0.17	0.37
3. Biotechnology patent applications	0.53	0.55	1	0.51	0.41	0.48	0.29	0.51	0.45	0.14	0.18	0.51	0.00	0.12	0.31
4. R&D expenditure in the business sector	0.77	0.68	0.51	1	0.40	0.87	0.16	0.45	0.40	0.20	0.31	0.55	–0.02	0.13	0.43
5. R&D expenditure in the government sector	0.34	0.26	0.41	0.40	1	0.31	0.72	0.45	0.33	–0.03	0.12	0.17	–0.06	–0.04	0.13
6. R&D personnel in the business sector	0.75	0.65	0.48	0.87	0.31	1	0.26	0.55	0.49	0.30	0.39	0.59	0.05	0.13	0.51
7. R&D personnel in the government sector	0.14	0.14	0.29	0.16	0.72	0.26	1	0.29	0.10	–0.19	0.04	0.03	0.03	0.08	–0.01
8. Labour force with tertiary education	0.45	0.35	0.51	0.45	0.45	0.55	0.29	1	0.54	0.42	0.46	0.62	0.03	0.00	0.60
9. Years of education completed	0.45	0.48	0.45	0.40	0.33	0.49	0.10	0.54	1	0.13	0.19	0.63	–0.31	–0.07	0.47
10. Meeting socially	0.36	0.27	0.14	0.20	–0.03	0.30	–0.19	0.42	0.13	1	0.46	0.55	0.46	0.16	0.68
11. Importance of friends	0.32	0.21	0.18	0.31	0.12	0.39	0.04	0.46	0.19	0.46	1	0.43	0.14	0.05	0.46
12. Membership in voluntary organisations	0.60	0.53	0.51	0.55	0.17	0.59	0.03	0.62	0.63	0.55	0.43	1	0.00	0.23	0.76
13. Importance of voluntary organisations	0.12	0.02	0.00	–0.02	–0.06	0.05	0.03	0.03	–0.31	0.46	0.14	0.00	1	0.36	0.17
14. Voting	0.22	0.17	0.12	0.13	–0.04	0.13	0.08	0.00	–0.07	0.16	0.05	0.23	0.36	1	0.17
15. General trust	0.48	0.37	0.31	0.43	0.13	0.51	–0.01	0.60	0.47	0.68	0.46	0.76	0.17	0.17	1
16. Trust in fairness	0.50	0.42	0.40	0.49	0.25	0.53	0.03	0.63	0.57	0.60	0.43	0.77	0.01	0.04	0.88
17. Trust in helpfulness	0.53	0.46	0.30	0.46	0.18	0.49	–0.06	0.58	0.54	0.60	0.44	0.82	0.02	0.17	0.88
18. Trust in the legal system	0.51	0.36	0.31	0.46	0.09	0.52	0.20	0.23	0.07	0.28	0.30	0.46	0.27	0.59	0.43
19. Trust in politicians	0.48	0.37	0.47	0.41	0.13	0.49	0.08	0.47	0.35	0.39	0.30	0.66	0.14	0.36	0.69
20. Satisfaction with the government	0.27	0.14	0.12	0.22	–0.04	0.31	–0.08	0.34	0.04	0.31	0.28	0.34	0.13	0.15	0.50
21. Satisfaction with the democracy	0.44	0.33	0.41	0.43	0.07	0.54	0.14	0.39	0.10	0.34	0.40	0.50	0.25	0.43	0.48
22. Norm of helping and care	–0.22	–0.17	–0.12	–0.17	–0.07	–0.09	0.13	–0.03	–0.39	–0.02	0.04	–0.32	0.44	0.24	–0.33
23. Norm of loyalty and devotion	–0.02	0.03	–0.02	0.03	0.02	0.09	0.17	–0.12	–0.20	–0.22	–0.02	–0.21	0.21	0.20	–0.35
24. Norm of supporting	0.02	–0.11	–0.06	–0.02	0.03	0.10	0.14	–0.01	–0.40	0.17	0.19	–0.11	0.49	0.33	0.01
25. Norm of following rules	–0.44	–0.42	–0.18	–0.28	–0.19	–0.22	0.05	–0.35	–0.37	–0.40	–0.14	–0.49	–0.05	–0.17	–0.45
26. Norm of behaving properly	–0.52	–0.47	–0.34	–0.42	–0.25	–0.38	0.03	–0.40	–0.46	–0.39	–0.30	–0.63	0.05	–0.01	–0.56
27. Norm of obeying laws	–0.15	–0.19	–0.04	–0.15	–0.11	–0.13	–0.09	–0.30	–0.08	–0.32	–0.26	–0.22	–0.18	0.00	–0.19
28. Norm of activity in organisations	–0.07	–0.10	–0.06	–0.10	–0.09	0.02	0.01	–0.14	–0.31	0.23	0.01	–0.12	0.69	0.19	0.01
29. Norm of duty to vote	0.28	0.16	0.18	0.20	0.08	0.23	0.03	0.01	0.11	–0.03	0.10	0.16	0.02	0.42	0.11
Number of observations	147	132	118	137	141	123	132	159	161	160	159	154	162	162	161

[12] Correlation coefficients with absolute values higher than or equal to 0.22 are significant at the 0.01 level; for significance at the 0.05 level and at the 0.10 level the border values are 0.17 and 0.14, respectively (two-tailed).

Appendix B (continued). Correlations and numbers of observations of indicators included in the analysis[13]

	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.
1. Patent applications	0.50	0.53	0.51	0.48	0.27	0.44	–0.22	–0.02	0.02	–0.44	–0.52	–0.15	–0.07	0.28
2. High-tech patent applications	0.42	0.46	0.36	0.37	0.14	0.33	–0.17	0.03	–0.11	–0.42	–0.47	–0.19	–0.10	0.16
3. Biotechnology patent applications	0.40	0.30	0.31	0.47	0.12	0.41	–0.12	–0.02	–0.06	–0.18	–0.34	–0.04	–0.06	0.18
4. R&D expenditure in the business sector	0.49	0.46	0.46	0.41	0.22	0.43	–0.17	0.03	–0.02	–0.28	–0.42	–0.15	–0.10	0.20
5. R&D expenditure in the government sector	0.25	0.18	0.09	0.13	–0.04	0.07	–0.07	0.02	0.03	–0.19	–0.25	–0.11	–0.09	0.08
6. R&D personnel in the business sector	0.53	0.49	0.52	0.49	0.31	0.54	–0.09	0.09	0.10	–0.22	–0.38	–0.13	0.02	0.23
7. R&D personnel in the government sector	0.03	–0.06	0.20	0.08	–0.08	0.14	0.13	0.17	0.14	0.05	0.03	–0.09	0.01	0.03
8. Labour force with tertiary education	0.63	0.58	0.23	0.47	0.34	0.39	–0.03	–0.12	–0.01	–0.35	–0.40	–0.30	–0.14	0.01
9. Years of education completed	0.57	0.54	0.07	0.35	0.04	0.10	–0.39	–0.20	–0.40	–0.37	–0.46	–0.08	–0.31	0.11
10. Meeting socially	0.60	0.60	0.28	0.39	0.31	0.34	–0.02	–0.22	0.17	–0.40	–0.39	–0.32	0.23	–0.03
11. Importance of friends	0.43	0.44	0.30	0.30	0.28	0.40	0.04	–0.02	0.19	–0.14	–0.30	–0.26	0.01	0.10
12. Membership in voluntary organisations	0.77	0.82	0.46	0.66	0.34	0.50	–0.32	–0.21	–0.11	–0.49	–0.63	–0.22	–0.12	0.16
13. Importance of voluntary organisations	0.01	0.02	0.27	0.14	0.13	0.25	0.44	0.21	0.49	–0.05	0.05	–0.18	0.69	0.02
14. Voting	0.04	0.17	0.59	0.36	0.15	0.43	0.24	0.20	0.33	–0.17	–0.01	0.00	0.19	0.42
15. General trust	0.88	0.88	0.43	0.69	0.50	0.48	–0.33	–0.35	0.01	–0.45	–0.56	–0.19	0.01	0.11
16. Trust in fairness	1	0.89	0.28	0.60	0.32	0.34	–0.38	–0.33	–0.11	–0.54	–0.70	–0.21	–0.18	0.10
17. Trust in helpfulness	0.89	1	0.41	0.63	0.42	0.40	–0.34	–0.38	–0.13	–0.62	–0.70	–0.22	–0.17	0.10
18. Trust in the legal system	0.28	0.41	1	0.64	0.42	0.72	0.05	0.06	0.35	–0.23	–0.21	0.05	0.16	0.44
19. Trust in politicians	0.60	0.63	0.64	1	0.69	0.70	–0.19	–0.28	0.05	–0.31	–0.40	0.09	0.00	0.30
20. Satisfaction with the government	0.32	0.42	0.42	0.69	1	0.61	–0.16	–0.26	–0.02	–0.24	–0.19	0.06	0.01	0.16
21. Satisfaction with the democracy	0.34	0.40	0.72	0.70	0.61	1	0.10	0.05	0.22	–0.17	–0.13	–0.06	0.09	0.21
22. Norm of helping and care	–0.38	–0.34	0.05	–0.19	–0.16	0.10	1	0.68	0.47	0.32	0.51	–0.10	0.34	–0.10
23. Norm of loyalty and devotion	–0.33	–0.38	0.06	–0.28	–0.26	0.05	0.68	1	0.34	0.40	0.50	0.02	0.23	0.07
24. Norm of supporting	–0.11	–0.13	0.35	0.05	–0.02	0.22	0.47	0.34	1	0.33	0.21	0.14	0.67	0.35
25. Norm of following rules	–0.54	–0.62	–0.23	–0.31	–0.24	–0.17	0.32	0.40	0.33	1	0.73	0.47	0.32	–0.01
26. Norm of behaving properly	–0.70	–0.70	–0.21	–0.40	–0.19	–0.13	0.51	0.50	0.21	0.73	1	0.35	0.31	–0.11
27. Norm of obeying laws	–0.21	–0.22	0.05	0.09	0.06	–0.06	–0.10	0.02	0.14	0.47	0.35	1	0.12	0.51
28. Norm of activity in organisations	–0.18	–0.17	0.16	0.00	0.01	0.09	0.34	0.23	0.67	0.32	0.31	0.12	1	0.19
29. Norm of duty to vote	0.10	0.10	0.44	0.30	0.16	0.21	–0.10	0.07	0.35	–0.01	–0.11	0.51	0.19	1
Number of observations	161	161	161	161	160	162	146	146	155	145	144	154	156	153

[13] Correlation coefficients with absolute values higher than or equal to 0.22 are significant at the 0.01 level; for significance at the 0.05 level and at the 0.10 level the border values are 0.17 and 0.14, respectively (two-tailed).

Appendix C. Correlations of variables included in the structural model[14]

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Innovation										
2. R&D	0.67 ***									
3. Human capital (latent construct)	0.49 ***	0.62 ***								
4. Years of education completed	0.53 ***	0.50 ***	0.88 ***							
5. Labour force with tertiary education	0.36 ***	0.54 ***	0.88 ***	0.54 ***						
6. General trust and networks	0.39 ***	0.40 ***	0.56 ***	0.43 ***	0.54 ***					
7. Institutional trust	0.13	0.16	0.18 **	0.01	0.35 ***	0.02				
8. Norms of helping and decency	–0.06	0.01	–0.31 ***	–0.35 ***	–0.16 *	–0.07	–0.02			
9. Norms of active social participation	–0.14	–0.08	–0.14	–0.38 ***	0.13	0.19 **	0.09	0.10		
10. Norms of orderliness	–0.26 **	–0.15	–0.25 ***	–0.13	–0.26 ***	–0.09	0.02	0.01	–0.07	
11. Civic participation	0.37 ***	0.33 ***	0.14	0.24 ***	0.01	0.10	0.06	0.01	–0.34 ***	–0.06

*** significant at the 0.01 level, ** significant at the 0.05 level, * significant at the 0.10 level (two-tailed).

[14] Although the principal component method enables avoiding the multicorrelation problem, the correlation coefficients between the factors of social capital are different from 0, because the pair-wise deletion method was used when performing principal components analysis.

Appendix D. Estimation results of the structural model (standardised regression coefficients): initial and modified[15] models

	Measure of human capital used:	Latent construct		Tertiary education		School years	
	Model:	Initial	Modified	Initial	Modified	Initial	Modified
Dependent variable	Influencing variable						
General trust and networks	Human capital	0.57 ***	0.58 ***	0.55 ***	0.56 ***	0.43 ***	0.42 ***
Institutional trust	Human capital	0.17 *	0.18 **	0.37 ***	0.36 ***	–0.01	
Norms of helping and decency	Human capital	–0.33 ***		–0.17 *		–0.36 ***	
Norms of active social participation	Human capital	–0.13		0.15 *		–0.39 ***	
Norms of orderliness	Human capital	–0.22 ***	–0.23 ***	–0.25 ***	–0.25 ***	–0.10	
Civic participation	Human capital	0.11		–0.02		0.23 ***	0.24 ***
R&D	Human capital	0.54 ***	0.64 ***	0.59 ***	0.58 ***	0.40 ***	0.43 ***
R&D	General trust and networks	0.11		0.09		0.24 **	0.24 **
R&D	Institutional trust	0.03		–0.11		0.14	
R&D	Norms of helping and decency	0.06		–0.01		0.04	
R&D	Norms of active social participation	0.00		–0.07		–0.01	
R&D	Norms of orderliness	–0.07		–0.04		–0.16 *	–0.16 *
R&D	Civic participation	0.15 *		0.26 ***	0.30 ***	0.07	
Innovation	R&D	0.46 ***	0.52 ***	0.52 ***	0.50 ***	0.42 ***	0.43 ***
Innovation	Human capital	0.07		–0.06		0.19 **	0.18 **
Innovation	General trust and networks	0.14 *	0.15 **	0.20 ***	0.16 **	0.11	0.13 *
Innovation	Institutional trust	0.19 ***	0.21 ***	0.24 ***	0.20 ***	0.20 ***	0.22 ***
Innovation	Norms of helping and decency	–0.05		–0.06		–0.04	
Innovation	Norms of active social participation	–0.03		–0.06		0.03	
Innovation	Norms of orderliness	–0.30 ***	–0.31 ***	–0.30 ***	–0.28 ***	–0.32 ***	–0.33 ***
Innovation	Civic participation	0.27 ***	0.31 ***	0.23 ***	0.28 ***	0.26 ***	0.26 ***

[15] When using the backward method, if all the paths beginning from a particular factor of social capital had been deleted, a path from human capital to this particular factor was also deleted

	Measure of human capital used:	Latent construct		Tertiary education		School years	
	Model:	Initial	Modified	Initial	Modified	Initial	Modified
Dependent variable	Influencing variable						
Squared multiple correlations of innovation		0.73	0.72	0.72	0.71	0.74	0.74
Fit measures:							
Discrepancy / df		2.86	0.65	2.46	1.39	2.90	0.39
Normed fit index		0.83	0.96	0.85	0.93	0.82	0.98
Incremental fit index		0.88	1.02	0.90	0.98	0.87	1.03
Comparative fit index		0.86	1.00	0.89	0.98	0.85	1.00
RMSEA		0.10	0.00	0.09	0.05	0.10	0.00
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$							