# The bright side of Social Capital: How ’bridging’ makes Italian provinces more innovative

Riccardo Crescenzi
Department of Geography and Environment & SERC
London School of Economics
r.crescenzi@lse.ac.uk

Luisa Gagliardi
Research Area of Economic and Institutional Change
IMT- Lucca
l.gagliardi@imtlucca.it

Marco Percoco
Department of Public Policy and Management and CERTeT
Università Bocconi
marco.percoco@unibocconi.it

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**Abstract**

*Social capital has remained relatively underexplored in the innovation literature. Existing studies have failed to reach a consensus on its impact on local innovative performance: some empirical analyses emphasize a positive effect, others warned against the ‘dark side’ of social capital. This paper aims to fill this gap by shedding new light on the differential role of ‘bonding’ and ‘bridging’ social capital. The quantitative analysis of the innovative performance of the Italian provinces shows that social capital is an important predictor for innovative performance after controlling for the ‘traditional’ knowledge inputs (R&D investments and human capital endowment) and other characteristics of the local economy. However, only ‘bridging’ social capital – based on weak ties – can be identified as the key driver of the process of innovation while ‘bonding’ social capital is shown to be negative for innovation. The instrumental variable analysis makes it possible to identify a clear causal link from bridging (positive) and bonding (negative) social capital to innovation.*

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## 1. Introduction

The concept of social capital has been extensively applied by economists and other social scientists to the analysis of a wide range of phenomena: from economic growth (Knack and Keefer, 1997) and development trap (Woolcock, 1998) to political participation (Di Pasquale and Glaeser, 1999), institutional performance (La Porta et al, 1997) and the spread of secondary education (Goldin and Katz, 2001). However, the analysis of the link between social capital and the generation of innovation has remained relatively under-explored in 'mainstream' economics literature. Economists of innovation and economic geographers have recently tried to fill this gap but they have failed to reach a clear consensus on the impact of social capital on innovative performance and on the underlying transmission mechanisms (Cohen and Field, 2000; Hauser, et al. 2007; Kallio et al., 2010; Laursen and Masciarelli, 2007; Patton and Kenney, 2003; Sabatini, 2009; Tura and Harmakorpi 2005).

The existing literature on the social capital-innovation nexus adopts a broad definition of social capital encompassing all its dimensions simultaneously (associational activities, political participation, institutional thickness and trust). This broad definition has made it difficult on the one hand to empirically operationalise the concept and, on the other hand, to account for the contradictory evidence on its impact on innovative performance (positive in some studies – e.g. Akcomak and ter Weel, 2008 - negative in others - e.g. Florida 2002).

How can Social Capital be operationalised in order to deal with innovative performance? How can its 'bright' and 'dark' sides be reconciled in the analysis of the generation of innovation? This paper aims to answer these questions by disentangling both conceptually and empirically the different role of strong and weak ties (Guiso et al., 2010) as the foundations of 'bonding' (based on trust and links between like-minded people in close groups) and 'bridging' (based on trust and networking between heterogeneous groups) social capital (Putnam 2000; Rodriguez-Pose and Storper 2006).

In other words, the paper will test the hypothesis that it is not the 'quantity' of social capital per se that matters for innovation but its nature in terms of 'bonding' vs. 'bridging' capabilities: innovation is faster in open societies with a large stock of bridging social capital while bonding social capital is more likely to lead to the generation of close networks based on the exchange of redundant knowledge, lock-in and cognitive stagnation. In this perspective both the intensity and typology of network relations among innovative actors matter for innovation. The characteristics of such networks shape the way in which valuable knowledge is exchanged and re-combined linking together individuals, groups and regions (Audretsch and Feldman, 2004), stimulating relational proximity and preventing stagnation and lock-in (Boschma, 2005). In this framework the impact of social capital on innovation does not depend only on the density of the network and on the intensity of the contacts between knowledgeable individuals but on the extension of their "radius of trust" (Fukuyama, 1995). The wider the radius of trust in the network of knowledgeable individuals the greater is the likelihood of exchanging complementary knowledge (Knack, 2001).

In order to single out the distinctive role of 'bridging' and 'bonding' social capital this paper will build on the existing literature in a number of innovative ways. First of all the paper develops an operational definition of social capital (centred on its network dimension) and a clear conceptualisation of the mechanisms linking social capital and innovation by cross-fertilising the literature on the socio-institutional determinants of innovation with the literature on ‘bridging’ and ‘bonding’ social capital. Second, while the large majority of the existing analyses on the impact of social capital on regional innovation are based on qualitative methods, this paper adopts a quantitative approach, covering the many different ways in which ‘bonding’ and ‘bridging’ can be combined in reality and testing the generality of their impact on innovation. Third the empirical analysis will also explore the causal nature of these links by explicitly addressing potential endogeneity bias through a robust identification strategy based on a time lag instrumental variable approach.

The empirical analysis looks at the Italian provinces, one of the most exemplary case studies in the literature on social capital (Guiso et al, 2004; Ichino and Maggi, 2000; Putnam, 1993) but – to the best of our knowledge – still underexplored in terms of the link between social capital and innovation. Recent studies on the Italian case are largely qualitative (Ramella and Trigilia, 2009) while those adopting a quantitative approach have focused on selected geographic areas (e.g. industrial districts as in Cainelli et al., 2005) or have adopted a firm based perspective in order to address the impact of social capital on their propensity to innovate and their willingness to invest financial resources in innovative activities (Arrighetti and Lasagni, 2010; Laursen and Masciarelli, 2007) thus failing to develop a more general analysis on the effect of social capital on innovation at meso and macro level. Conversely, this paper covers all Italian provinces for a eight-year period and develops two separate measures for bonding and bridging social capital respectively. These measures will be regressed against the innovative activity of Italian provinces and OLS and IV estimates will be presented, fully addressing any endogeneity bias affecting previous studies. The results show that only bridging social capital exerts a positive impact on innovation, whereas bonding social capital is either non significant and negatively associated with innovation. This result suggests that social capital is a fundamental driver of innovation if and only if it operates as a channel for the exchange of non-redundant and complementary knowledge.

The paper is organized as follows: the second section provides an overview of the literature on the link between innovation and social capital, developing an operational definition of the concept and highlighting the transmission mechanisms from Bonding and Bridging social capital to innovation. Section three discusses the estimation strategy and the data while fourth section presents some key descriptive statistics and the main results discussing their economic implications. Finally some conclusions are drawn underlining the fundamental role of social capital as a determinant of local innovative performance.

## 2. How 'bridging' and 'bonding' social capital shapes local innovative performance

The analysis of the impact of social capital on innovation has suffered from the lack of consensus on its definition, often reflected in a substantial vagueness in operationalisation and measurement (Guiso et al., 2010). Coleman (1988) argued that it coincides with the social structure of a society facilitating the actions of individuals. Putnam (1993) identified social capital in terms of trust-based relations and groups. Fukuyama (1995) suggested that social capital has to be intended in terms of trust, civicness and network relations. However, these definitions are difficult to operationalise and do not allow to shed light on the debate on the “dark side” of social capital and to overcome the “impasse” on its optimal endowment for innovation. In addition, from the methodological perspective, several issues are still unresolved. As Solow (1999) pointed out in his critique to Fukuyama (1995), if social capital is something more than a fuzzy concept it has to be somehow measurable. However we are still far from dealing with a universal measure of social capital. Different aspects of social capital were alternatively emphasized and different measures proposed: from civic cooperation to collective action, from trust to political participation, groups and networking.

The recent evolution of the analysis of the socio-institutional determinants of innovation offers a fertile ground for the development of a suitable working definition of ‘social capital’ and for the conceptualisation of its links with innovative performance. A growing body of literature has suggested that innovation is a social process embedded in the local social environment and it is systematically affected by the strength and intensity of social ties. The emphasis on the social dimension of innovation led to the definition of innovation prone and innovation averse regions (Rodriguez Pose, 1999), social filters (Rodriguez-Pose and Crescenzi 2008), innovative milieux (Breschi and Lissoni, 2001; Camagni, 1995), learning regions (Florida, 1995; Morgan, 2007) and regional systems of innovation (Cooke et al, 1997). In all these perspectives the analysis is focused on the network dimension of the innovation process: networks foster innovative capabilities by facilitating the diffusion of valuable and non-redundant knowledge and preventing stagnation and lock-in (Boschma, 2005).

In line with this literature the link between social capital and innovation can be indentified in the concepts of networking and embeddedness (Granovetter, 1985). Relational networks connecting individuals, groups, firms, industries with different knowledge bases are a critical precondition for knowledge generation and transfer. In this context innovation emerges from a cumulative process embedded in the social context and systematically affected by processes of interactive learning stimulating the exchange and re-combination of knowledge (Asheim, 1999; Lundvall, 1992).

Social capital is then a crucial pre-condition for innovation since it stimulates inter-personal interactions, the formation of networks and the circulation of valuable knowledge (Tura and Harmaakorpi, 2005).

The focus on "relations as central units of analysis" (Boggs and Rantisi, 2003) for innovative performance sheds light on a number of channels through which social capital exerts its influence on innovation. Capello and Faggian (2005) emphasized the role of relational capital for the generation and diffusion of innovation by looking at knowledge spillovers as crucial transmission channels accounting for the effect of networking and social relations on innovative performance. Kallio et al. (2008) suggested that the link between the social dimension and the emergence of an innovative outcome lies in the local absorptive capacity enabling the diffusion of knowledge within the regional system of innovation. Other authors argued that social capital has only a second order effect and that it is mediated by the increasing returns of the investments in human (Bourdieu, 1986, Gradstein and Justman, 2000, Dakhli and De Clercq, 2004) or physical capital (Becker and Diez, 2004, Fritsch and Franke, 2004, Cainelli et al., 2005).

However, how can these mechanisms explain the 'dark' side of social capital? The potentially detrimental effects of social capital (Akerlof, 1976; Olson, 1982) and its 'optimal' endowment (i.e. the optimal strength and intensity of the relations between individuals) remain unexplained. As Florida (2002) pointed out places with strong social capital are often the areas with the worst innovative performance. In this context social capital, based on strong relations between individuals, becomes the reason behind the closure of the network and the insulation from external information and challenges.

By looking at social capital as a fundamental component of the socio-institutional environment shaping the process of innovation, this paper contends that differences in the nature of social networks rather than the density of their linkages offer a potential explanation for the non-linear relation between social capital and innovation (Hauser et al., 2007).

The so called "weak ties hypothesis" proposed by Granovetter (1973) is crucial in this context. Relationships between people can be characterized by either frequent contacts and deep emotional involvement or sporadic interactions with low emotional commitment. The former category is generally identified as 'strong ties' - such as the relationships within families or close friends - while the latter is associated with the definition of 'weak ties' linking individuals characterized by loose acquaintances. Contextualising Granovetter's argument into the analysis of innovation, 'weak ties' can be seen at the source of novel information and responsible for the diffusion of ideas (Granovetter, 1982; Rogers, 1995), while 'strong ties' increase the risk of exchanging redundant knowledge simply because they connect knowledge seekers with other individuals that are more likely to deal with ‘known’/familiar information and knowledge (Levin and Cross, 2004).

In other words weak ties are fundamental in spreading information because they operate as bridge between otherwise disconnected social groups (Ruef, 2002). Weak ties serve as a bridging mechanism between communities within the same society, while strong ties function as a bonding device within homogeneous groups potentially hampering the degree of sociability outside restricted social circles (Beugelsdijk and Smulders, 2003).

‘If knowledge stays too much inside […] bounded communities—when communities mistrust each other— then knowledge will have a limited and uneven spread. Bridging between communities gives the more knowledgeable communities confidence that their knowledge will be used by members of other communities to their mutual benefit.’ (Rodriguez-Pose and Storper, 2006, p.8).

Following this line of reasoning it is possible to identify the distinctive influence on innovation exerted by social networks of different nature: ‘connections between heterogeneous groups’ whose density and intensity constitute the ‘bridging social capital’ of a territory vs. ‘the links between like-minded people, or the reinforcement of homogeneity’ whose density and intensity forms the regional endowment of ‘bonding social capital’ (Schuller et al., 2000)

Bridging social capital, by lowering transaction costs, may contribute to the building of an environment congenial for innovation investment, which is a high risky activity, hence benefitting from ties based on trust and cooperation (Hauser et al., 2007). Conversely, bonding social capital is likely to affect negatively innovation because it may work in favour of small groups lobbying for preferential policies and protection of the *status quo,* hampering risky innovative activities (Dakhli and De Clercq, 2004; Knack and Keefer, 1997; Portes and Landolt, 1996). In this perspective the 'dark side of social capital' lies in the typology of the ties and in the radius of trust of the network rather then in the total intensity of the relationships among knowledgeable individuals: we need to look for the 'right' typology, rather than for the optimal 'quantity' of social capital if we are aimed at enhancing local innovative performance.

The case of Italy is a particularly appropriate 'laboratory' to test these hypotheses. Putnam (1993) has suggested that one of the main reasons for the persisting differences in development between the North and South of Italy is due to institutional quality and social capital. Arrighetti and Lasagni (2010) analyse the effect of these social conditions on the propensity to innovate of Italian firms finding that innovative firms tends to cluster in those provinces characterized by higher level of "positive social capital", interpreted as civicness and high social interactions, and lower level of "negative social capital", generally associated with opportunistic behaviours due to the coexistence of groups lobbying for specific interests. On the same line of argument, but focusing on case studies as the Emilia Romagna industrial districts, Cainelli et al.(2005) argue that the extensive horizontal relationships among local economic actors generate positive network externalities favouring the exchange of valuable knowledge and fostering the innovative performance of local firms.

## 3. Model of empirical investigation

In order to assess the impact of social capital on the innovative performance of the Italian provinces, the empirical analysis relies on a 'modified' Knowledge Production

Function (KPF) approach. The analysis is based on the KPF (formalised by Griliches, 1979; 1986; and Jaffe, 1986) but adopts a place-based perspective with Italian provinces (NUTS3 level) as units of observation. This specification of the KPF is customary in the literature on regional innovation (Audretsch, 2003; Audretsch and Feldman 1996; Crescenzi et al., 2007; Feldman, 1994; Fritsch, 2002; Moreno et al. 2005; OOhuallachain and Leslie, 2007; Ponds et al, 2010; Varga, 1998) and allows us to focus upon the territorial dynamics of innovation introducing both total social capital endowment and its bonding and bridging components as determinants of regional innovative performance. The Regional Knowledge Production Function takes the following form:

$$Patents\_growth_{i,(t-T)\rightarrow t} = \beta_0 + \beta_1 Patent_{i,t-T} + \beta_2 SocCap_{i,t-T} + \\ + \beta_3 Grad_{i,t-T} + \beta_4 privR\&D_{i,t-T} + \beta_5 X_{i,t-T} + \delta_i + \varepsilon_i$$

*(Equation 1)*

Where $Patents\_growth_{i,(t-T)\rightarrow t} = \frac{1}{T}\ln(\frac{Patents_{i,t}}{Patents_{i,t-T}})$ is the logarithmic transformation of the ratio of patent applications in province *i* at the two extremes of the period of analysis (t-T,t). Among the independent variables $soccap_{i,t-T}$ is our variable of interest and represents the measure(s) of social capital (Total, Bonding and Bridging) in each province *i* at time (t-T); $patents_{i,t-T}$ is the log of the level of patent applications per million inhabitants at the beginning of the period of analysis (t-T); $privrd_{i,t-T}$ is private expenditure in R&D as percentage of regional GDP at (t-T); $grad_{i,t-T}$ is the number of graduates as a percentage of regional population at time (t-T); $X_{i,t-T}$ is the matrix of additional controls (i.e. regional sectoral composition, population density and female unemployment) at (t-T); Finally, $\delta_i$ represents macro-regional dummies for southern, central and northern Italy and $\varepsilon_i$ is the error term. A detailed description of the variables is included in Table A-1 in Appendix A.

**Regional Innovative Performance –** OECD Patent data are used as a proxy for innovation. The generation of innovation is proxied by the logarithmic approximation of the growth rate of patents over the 2001-2007[1] period. Patent statistics are generally regarded as a reliable measure of innovative output providing comparable information on inventions across different regions and a broad range of technological sectors (OECD, 2001; Sedgley and Elmslie, 2004). Conversely, patent-based innovation indicators fail to account for both the differentiated degree of novelty of patented products (not all patented products are equally 'new' and/or valuable) and the non patentability of many inventions (in particular as far as process innovation is concerned). In addition different sectors show an intrinsically differentiated propensity to patent (Crescenzi et al., 2007). In order to minimise any potential bias in our analysis: a) we control for the initial patent intensity of each region, accounting for its initial global propensity to patent; b) we control for the sector structure of the economy. In addition, the specification of the dependent variable in terms of growth rate is an attempt to overcome lack of panel data and provide some evidence on the dynamic

[1] Patent data at the NUTS3 level are in principle available for a longer time series; however data on social capital and other control variables at the provincial level are impossible to recover before 2001. The empirical analysis is forced to rely on 2001 Census data and some additional specialized data sources for social capital-related variables (Cartocci, 2007) for the computation of the independent variables. In order to capture the dynamic effect of social capital on innovation the dependent variable is computed by covering the time interval between 2001 and the latest available year in the OECD PatStat database (i.e. 2007). Even though still relatively limited, the coverage of an eight year period is a significant improvement on the existent quantitative literature on the link between social capital and innovation in the Italian provinces. All existing studies cover a shorter time span. For example Cainelli et al. (2005) looking at the Emilia Romagna Industrial districts cover the 2002-2007 period; Laursen and Masciarelli (2007), whose analysis is focused on larger geographical units (NUTS2 Regions), still cover a shorter time interval (2001-2003).

effect of social capital on innovation (Crescenzi et al, 2007): after controlling for the effect of initial conditions in terms of innovative performance (initial level of patenting) social capital and its bonding and bridging components are tested as predictors of the regional capability to develop upon the existing technological infrastructure and improve its innovative performance (patent growth rate).

**Initial patent intensity -** The initial patent intensity in each province is used as a proxy for the existing technological capabilities and the distance from the technological frontier. It also controls for differences in the patenting propensity often related to pre-existent differences in sector specialization as discussed above.

**Social Capital -** Coherently with the conceptual framework outlined above, the analysis looks at both the total regional endowment of social capital and at its constituent components in terms of 'bonding' and 'bridging' social capital. The focus of the empirical analysis is on the networking dimension of social capital, with the aim to capture its effect on the circulation of knowledge. As previously mentioned this implies a crucial distinction between networks based on weak ties, or bridging social capital, and networks based on strong ties, or bonding social capital.

The analysis relies on data on family characteristics as a proxy for bonding social capital based on strong ties (Beugelsdijk and Smulders 2003; Levin and Cross, 2004; Ruef, 2002) and data on voluntary associations as a proxy for bridging social capital based on weak ties operating as forms of horizontal relations fostering networks of civic engagement (Arrighetti and Lasagni, 2010; Beugelsdijk and Schaik, 2004).

As far as bonding social capital is concerned, in order to capture the strength of family ties, the analysis relies on two key indicators: ‘the number of families having lunch at least once per week with relatives and close friends (per 100 households)’ and ‘the number of young adult individuals living with parents (per 100 young adults)’. Strong family ties imply geographical proximity of adult children: young adults tend to stay longer with their parents and relationships within families are particularly strong and based on repeated interactions (Alesina and Giuliano, 2010).

Family characteristics are at the heart of the existing analyses of social capital in Italy since the seminal work by Banfield (1958) who proposed the idea that low propensity to cooperate is generally associated to, among other things, the strength of family ties. In particular, Banfield (1958) pointed out the negative impact on economic development of the low propensity to cooperate which, in its turn, implies high transaction costs. This ‘development trap’ is the outcome of strong family ties (the so-called “a-moral familism”), high uncertainty and a highly unequal distribution of income and wealth. So far, there is no conclusive empirical evidence supporting Banfield’s hypothesis, however, some recent research provides support to this view. Alesina and Giuliano (2010) find that strong family ties are associated to low levels of generalized trust. Similarly, Giavazzi et al. (2010) relate family types to female labor market participation rate in European regions, whereas Duranton et al. (2009) relate past family structures to a number of contemporary outcomes: they all concur in suggesting the existence of a strong link between ‘close’ family ties and the outward-looking orientation/networking of local societies.

Bridging social capital based on weak ties is, instead, measured by means of two ‘traditional’ indicators widely used in the economic literature. ‘Blood donations’ (Blood donations per 1000 residents) and ‘participation in voluntary associations’ (number of voluntary associations per Kmq) proxy the participation of individual in activities with positive social externalities and are an indicator of their altruism (Cartocci, 2007).

The ‘number of families having lunch at least once per week with relatives’[2] and the ‘number of young adults living with parents’[3] are used to define a composite indicator of bonding social capital while the ‘number of blood donations’ and ‘number of voluntary associations’ are combined in the composite indicator for bridging social capital. An additional measure of ‘total’ social capital encompassing both its bonding and bridging dimension is also computed in order to detect the overall effect of social capital on innovation.

Our social capital variables are computed in line with the indicators for technological capabilities (ArCo) by Archibugi and Coco (2004). The ‘Total Social Capital’ indicator combines both ‘bonding’ and ‘bridging’ social capital variables with equal weights:

$$Socialcapital = \sum_{i=1}^{2} \lambda_i I_i$$

Where $I_i$ represents each of the two components of social capital (bonding and bridging) and $\lambda_i$ is the constant equal to ½. The indexes $I_i$ for each component are, in their turn, calculated with the same procedure using the simple mean of the corresponding social capital variables normalised to vary from 0 to 1 as follows:

$$I_i = \frac{Observed\_value - Minimum\_observed\_value}{Maximum\_observed\_value - Minimum\_observed\_value}$$

Social capital variables cover all Italian Provinces (NUTS3 level)[4] and are available from ISTAT (Italian National Statistical Office)[5].

[2] Per 100 households
[3] Per 100 young adults
[4] 103 observations

**Innovation input-** 'Private R&D as a share of GDP' and the number of graduates over the total population are used as proxies for the key inputs of the 'standard' regional Knowledge Production Function (Crescenzi et al., 2007; Moreno et al., 2005; OOhuallachain and Leslie, 2007; Ponds et al., 2010; Varga, 1998). Due to data availability our R&D measure is available only at regional level (NUTS 2) while the number of graduates is available for each province (NUTS3).

**Controls -** Our specification of the knowledge production function includes controls for population density at the provincial level, labour market characteristics in terms of female unemployment rate, and sector structure as measured by the Herfindhal Index.

The Herfindhal Index is calculated using data on employment for three sectors: agriculture, industry and services and is interpreted as a measure of specialization. All controls are available at the provincial level (NUTS3) from ISTAT.

The analysis includes additional controls in order to minimise the impact of the spatial autocorrelation in the error term. In particular it includes the spatial lag of population density as a measure of accessibility and macro-regional dummies (north, south and centre) in order to control for time invariant area characteristics and other unobserved sources of spatial autocorrelation (Armstrong, 1995; Rodriguez Pose, 1999).

Let us now discuss our identification strategy. The identification of the link between innovation and social capital is challenged by the potential endogeneity of social capital due to both reverse causality and omitted variable bias.

The key research hypothesis in this paper is that social capital can be treated as a determinant of innovation by leading to the development of networks between

[5] See Table A1 for further detail.

knowledgeable individuals, stimulating knowledge circulation and diffusion and favouring the re-combination of valuable information. In addition the effect of social capital on innovation is supposed to depend on the extension of the radius of trust of such networks: weak ties, bridging members of different epistemological communities, are more efficient than strong ties within the same group as a stimulus for innovation.

Even if grounded into a large body of literature and supported by robust qualitative evidence, this argument may overlook the possibility that causality runs in the opposite direction: more innovative provinces might be able to generate, through higher economic incentives to create valuable networks, a virtuous cycle based on cooperation and trust, stimulating civicness and sense of community. In addition, an omitted variables problem may also bias the estimation of the model. The measures of social capital are potentially correlated with local characteristics that cannot be fully controlled for. This is particularly problematic when considering neighbouring effects and spatial correlation: the omitted variable bias may depends on both local characteristics and neighbouring areas features affecting local innovative performance.

In other to minimize the impact of these problems, the model controls for spatial correlation by including the spatial lag of social capital and a set of macro-regional dummies. Furthermore, the potential endogeneity of social capital is dealt with by adopting an instrumental variable approach (2SLS). In particular the level of bonding and bridging social capital in each province are instrumented with the 'number of non profit organizations in 1911' and the 'average political participation in referenda[6]'

[6] The measure is constructed as the average political participation in the following referenda: 1946 (Monarchy vs. Republic), 1974 (divorce), 1978 and 1981 (abortion), 1985 ("*scala mobile*") and 1987 (nuclear power). The average measure is used in order to limit the potential bias coming from peculiar ideological positions in different regions in respect to particular questions.

respectively. For both instruments the analysis relies on regional-level[7] data due to the lack of historical data at the provincial level.

The rationale for using those instruments can be found into the path dependence characterizing the stock of social capital. In fact, Putnam (1993) suggested that the current stock of social capital in Italian regions is influenced by past (unobserved) quantity of trust and past (observed) institutional quality. Along this line, Tabellini (2010) has proposed an analysis of the link between trust and development, where the former was instrumented with historical variables. Our instruments - ‘number of not-for-profit organizations in 1911’ and ‘voter turnout in selected referenda’ - are both meant to proxy past social capital stock. In particular, the first instrument is expected to be negatively correlated with bonding social capital in line Banfield’s hypothesis of a negative correlation between family ties and cooperative behaviour (in this case proxied by the number of not-for-profit organizations). The political participation to referenda is, instead, assumed to be positively correlated to bridging social capital because it can be considered a proxy of civic participation and civic engagement**.**

[7] Available in Nuzzo (2006), see Table A-1 for further detail.

## 4. Empirical results

Table 1 shows some descriptive statistics on the link between the innovative performance of Italian provinces and the characteristics of their social capital environment: the growth in the level of patenting, the composite measure of social capital and its two sub-components (bonding and bridging). The variation in the mean value of the composite measure of total social capital among different macro-areas (North, Centre, South) is not particularly relevant casting doubts on the explanatory power of total social capital for differential in innovative performance.

*[Insert Table 1]*

A more accurate understanding of this preliminary evidence comes from the mean value of the proxies for bonding and bridging social capital. Table 1 shows that the macro-area with the best innovative performance (North) is characterized by the highest level of bridging social capital and the lowest level of bonding social capital. Conversely, southern regions show the opposite pattern. Furthermore the heterogeneity in terms of bonding and bridging social capital among different macro-areas is particularly large: bonding social capital is significantly higher in southern regions while the highest levels of bridging social capital seems to be concentrated in the northern part of the country.

The preliminary analysis of these indicators offers some interesting insights: more than the total amount of social capital (measured as the combination of bonding plus bridging social capital) what seems to vary in line with the innovative performance of different macro-areas is the magnitude of the bonding and bridging components: bonding social capital is negatively correlated to innovation while bridging social capital shows a positive correlation with innovative performance.

This preliminary evidence seems to support the main hypothesis of our analysis: social capital seems to have a beneficial effect on local innovative performance when it is based on weak ties between otherwise disconnected communities. Symmetrically a strong predominance of bonding social capital is associated with weaker innovative performance. The double-sided effect of social capital on innovation is further confirmed by the correlation matrix in Table 2. Bridging social capital is positively associated with higher innovative performance while this correlation is negative for bonding social capital. Moreover the correlation between the two dimensions of social capital is highly negative suggesting that the geography of social capital in Italy is characterized by a strong divide between high bonding and high bridging areas.

*[Insert Table 2]*

Figure 1 shows the distribution of the composite measure of total social capital at the provincial level. Areas with a high level of social capital are fairly equally distributed in the whole country with peaks in both southern and northern regions, confirming the provincial level (NUTS3) as the relevant spatial unit for the analysis of social capital. Figures 2 and 3 show the distribution of bridging and bonding social capital respectively. Bridging social capital seems to be systematically higher in Northern Italy and in part of the Central regions while Southern provinces are characterized by a strong predominance of bonding social capital. This is the result of the different historical trajectories of these areas: areas where independent city-states (the so-called *Repubbliche Comunali*) were concentrated now benefit from higher levels of trust and government effectiveness, lower reliance on 'family' networks and higher 'bridging' social capital (Guiso et al. 2008, Percoco 2010a and 2010b have provided empirical support to this idea).

*[Insert Figures 1,2,3 and 4]*

In line with the descriptive statistics, the spatial distribution of innovation (Figure 4)[8] doesn't show any obvious association with the geography total social capital. Areas characterized by a stronger innovative performance - such as provinces in Veneto, Trentino Alto Adige, Friuli Venezia Giulia and part of Piedmont - show a lower level of social capital while traditionally low-innovation areas (such as those in Sicily and Apulia) are characterized by a relatively stronger total social capital endowment. Conversely the percentile map of bridging social capital shows a much better spatial matching with the distribution of innovation, supporting the crucial role of weak ties as a precondition for innovation at the provincial level.

*[Insert Table 3]*

Table 3 reports the estimation results for the Regional Knowledge Production Function specified in Equation 1. In the basic specification only the 'traditional' inputs of the KPF (R&D Expenditure and Human Capital) are included in the model together with the initial level of patenting in each region (Tab.3, Col.1). The initial number of patents per million inhabitants is statistically significant at 1% level and negatively associated with the dependent variable. This suggests a (weak) convergence in innovative performance in line with existing regional-level research on Europe and the United States (Crescenzi et al 2007; Moreno et al. 2005b), reflecting a weak trend in (conditional) technological convergence in advanced economies. In the Italian case this trend reflects the crisis of traditionally successful innovative areas (such as the industrial districts) and the emergence of some new successful players. The 'core' long-established areas of the "Made in Italy" - such as the industrial districts specialized in

[8] The percentile map of innovation is based on the level of patenting in 2001 in order to provide a static picture of the spatial pattern of the variables of interest at the same point in time.

the production of leather goods and shoes - mainly in Tuscany and Marches- experienced a negative dynamic in productivity, while other areas - in particular those specialised in chemistry and oil (spatially concentrated in Tuscany and Sicily) and metallurgic (Tuscany and Sardinia) or the industrial districts specialized in clothing (Veneto and Apulia) and eyewear (Veneto, Emilia-Romagna and Friuli-Venezia Giulia) - showed an economic performance significantly above the national average (ISTAT Annual Report, 2007/2008).

Regional Investment in R&D is highly significant and positively associated with innovative performance while, in this specification of the model, there is no evidence of any human capital endowment effect on innovation. Investments in R&D are generally weak in Italy (1.2% of GDP in 2010, the lowest rate in the EU-15) in sharp contrast with the above EU-average intensity of the leading provinces in Lombardy and Emilia-Romagna generating a highly localised geography of innovative efforts.

Subsequently, controls for population density, labour market characteristics, sector structure and the spatial lag of population density (as a proxy for accessibility) are introduced into the model (Table 3, column 2). Neither the level of female unemployment (proxy for the efficiency of the local labour market), nor the Herfindhal Index (measure of sector specialisation) are statistically significant. The highly regulated Italian labour market does not exert any influence on local-level innovative performance. The same is true for regional specialisation patterns heavily constrained by low factor mobility and by the lack of critical mass in average firm-size. What matters for innovation – and this result remains robust in subsequent specifications of the model – are agglomeration economies: population density is positively associated with innovation at the 5% significance level while the spatial lag of population density shows a statistically significant negative effect on innovative performance. The most innovative provinces are those where density is higher (major urban areas with their functional hinterland) and are surrounded by less dense provinces from which they absorb labour force commuting into their functional borders. Once the underlying geography of Italian innovation is fully controlled for (by means of the proxies discussed above) the impact of regional human capital endowment becomes positive and statistically significant. This would put Italy in line with other EU countries and with the US where local human capital is a key driver of innovative performance (Crescenzi et al. 2007). However, as will be discussed below, the impact of regional human capital is not robust to the inclusion in the model of controls for the North-South divide, clearly reflecting the fundamental mismatch between (Southern) graduates' skill profile and their occupations (Iammarino and Marinelli, 2011)

In column 3, total social capital is introduced into the model showing a positive and significant (5% significance level) impact on innovation. In column 4 neighbourhood effects and spatial autocorrelation are controlled for by introducing the spatially lagged value of total social capital endowment together with the macro-regional dummies[9]. The measure of social capital remains positively associated with innovation with a significance level of 5%. After fully controlling for the North-South divide and other spatial effects social capital emerges as the most important predictor for innovative performance together with our proxy for agglomeration economies. Highly agglomerated provinces – where face-to-face contacts maximise the exchange of knowledge – with a high level of cooperation and associational activities (high total

[9] The Moran's I over the residuals is calculated in order to test for spatial correlation. After controlling for the spatial lag of population density and social capital and adding macro'regional dummies the coefficient of the Moran's I becomes statistically insignificant. The p-value further confirms the rejection of the null hypothesis of spatial autocorrelation in the residuals. The spatial autocorrelation tests on the residuals are available on request and confirm the robustness of our results (Gibbons and Overman 2010).

social capital) show the best innovative performance. This result provides quantitative confirmation for the qualitative evidence of some existing studies on innovation and social capital (Biagiotti, 2008; Ramella and Trigilia, 2009; Ramella and Trigilia, 2010). However the empirical strategy adopted in this paper makes it possible to test the differential impact of different 'qualities' of social capital and to isolate the effect of the two fundamental components of social capital: bonding social capital based on strong ties, and bridging social capital, based on weak ties. For this purpose the measure of total social capital is split into two separate indicators (Table 3, column 5) one for bonding and the other for bridging social capital. The regression results show that the bridging component is statistically significant at the 1% level and positively associated with innovation while bonding social capital is not significant and negatively associated with innovative performance. Bridging social capital alone remains the single most important predictor for innovative performance. This evidence suggests that the positive and significant effect of social capital on innovation is largely based on weak ties rather than strong ties. Weak ties allow access to non-redundant information, favouring the transfer and re-combination of valuable knowledge.

The robustness of these results is tested against a potential endogeneity bias by means of an instrumental variable (IV) approach: 2SLS results are shown in Table 3, Column 6. The IV results strongly support the existence of a causal link between bridging social capital and innovation (positive coefficient and statistically significant at 1% level), while bonding social capital remains not statistically significant and negatively associated with innovation. Once the potential endogeneity of social capital is fully accounted for the significance of bridging social capital increases substantially, making it the most important predictor of innovative performance. First stage regressions (shown in Table 4) confirm the validity of this instrumental strategy. Both instruments – non-for-profit organizations in 1901 and referendum turnout - are highly correlated with the instrumented variables – bonding and bridging social capital respectively - showing the expected signs and confirming the rational for their selection.

*[Insert Table 4]*

In addition the econometric literature on instrument validity suggests that it is possible to incur in the problem of weak instruments even with an unproblematic first stage regression (Greiger and Stock, 1997; Stock and Yogo, 2005). In order to rule out the risk of weak instruments we refer to both the rule of thumb applied by Greiger and Stock (1997) and to the Stock and Yogo's (2005) threshold values. The F statistics in the first stage is strongly above the critical value and close to the value of 10 for the bridging and bonding instruments respectively and it is generally above the threshold values reported by Stock and Yogo (2005)[10] (as shown in Table 5). Consequently, our instrumental variables strategy is robust and not affected by any potential weak instrument bias.

*[Insert Table 5]*

*Further robustness checks*

To confirm the robustness of the statistical findings discussed above, a number of additional robustness checks have been implemented. In Table 6 the key specifications of the model of empirical analysis are re-estimated with the dependent variable in level (rather then in growth rates). When compared to the initial specification, where the patents growth rate was used as dependent variable while controlling for the initial patent intensity in each province, this additional specification is aimed at analysing the

[10] The F statistic is above all the Stock and Yogo (2003) threshold values for the instrument for bridging social capital and above the 15% critical value for the instrument adopted for bonding social capital.

dynamic effect of social capital on innovation in a complementary way. The measure of social capital is regressed against the innovative performance of Italian provinces in subsequent years in order to test for a path-dependency associated to the social capital dimension.

*[Insert Table 6]*

Columns 1, 2 and 3 in Table 6 report the estimation results using respectively the number of patents per million of inhabitants in 2002, 2005 and 2007 as dependent variables[11], controlling for the potential endogeneity of social capital by means of the instrumental variables approach. These additional results confirm the robustness of the relation between bridging social capital and innovation and show that it becomes stronger over time, highlighting a path-dependency/cumulative effect of social capital on innovation. In addition, it is important to notice that bonding social capital is now not only strongly negative but also statistically significant (in 2002 and 2007), further reinforcing the contrast between the two components of social capital.

As a final robustness check the instrumental variable regressions are re-estimated by progressively eliminating all control variables (Table 7). This shows that the effect of bridging and bonding social capital remains consistent in all specifications of the model independently from the inclusion of additional regressors. This suggests that social capital has an independent effect on innovation above and beyond its potential second order effect on physical and human capital.

*[Insert Table 7]*

[11] Note that the number of observation is changing in 2002 because the dependent variable is available for 97 provinces out of 103 only.

## 6. Conclusions

A large body of literature has looked at the very different ways in which social capital influences economic and social activities. However, the analysis of its impact on innovation has remained relatively underexplored. While some contributions emphasized a positive effect others warned against the 'dark side' of social capital when it comes to innovation. The analysis of innovation has suffered from the lack of a suitable working definition of social capital as also from the difficulties in operationalising its linkages with innovation dynamics. This paper contributes to fill this gap by looking at social capital as a networking and associational activity between knowledgeable individuals so as to become a fundamental determinant of innovation by acting as a mechanism for the diffusion and circulation of valuable knowledge. In this perspective, the effect of social capital on innovation is shaped by its capability to facilitate the exchange of complementary knowledge between individuals belonging to different epistemic communities (bridging social capital) - rather than within homogeneous like-minded groups (bonding social capital) - making it possible to access non redundant information and preventing cognitive lock-in. This paper has empirically tested these hypotheses by means of a quantitative analysis of the innovative performance of the Italian provinces. Notwithstanding the significant data limitations affecting all quantitative research on social capital and its effect, the results are clear-cut and robust.

Social capital is an important predictor for innovative performance after controlling for the 'traditional' knowledge inputs (R&D investments and human capital endowment) and for other characteristics of the local economy. However, 'bridging' social capital – based on weak ties – can be isolated as the key driver of the process of innovation while 'bonding' social capital is generally negative for innovation. This evidence suggests that – when dealing with innovation – it is crucially important to look at the nature of the networks generated and supported by social capital. It is the radius of trust of network relations that matters rather then their density or intensity. The empirical analysis has devoted special attention to the potential endogeneity of social capital that might bias the estimation of its impact on innovation. The instrumental variable approach has made it possible to identify a clear causal link between bridging (positive) and bonding (negative) social capital and innovation. The identification of these links suggests that the networking dimension of social capital can be considered as a viable innovation policy target. If changes in the local endowment of social capital are certainly hard to promote by means of public policies, carefully designed innovation policies can contribute to change the local balance between bonding and bridging social capital. Policies based on the mobility of 'knowledgeable individuals' and cooperative research projects can contribute to reinforce the external projection of existing networks between innovative agents. In addition, policies targeting the university system (largely public and heavily 'localistic' in Italy) in order to design recruiting mechanisms for research students and staff more open to 'outsiders' would also facilitate the development of 'bridging' social capital. Further exploration of these policy options remains in our agenda for future research but this paper has contributed to open the way to a more systematic quantitative exploration of the link between innovation and social capital as an important pre-condition for policy analysis.

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## Appendix A – Variables included in the analysis

### Table A-1: Variables List

| VARIABLES | DESCRIPTION | SOURCE | YEAR |
|---|---|---|---|
| Patents Growth | Logarithmic transformation of the ratio of patent applications per million inhabitants in region *i* at the two extremes of the period of analysis (t-T,t) | OECD RegPat database | 2001-2007 |
| Patents (Level in 2001) | Logarithm of the level of patent applications per million inhabitants at the beginning of the period of analysis (t-T) | OECD RegPat database | 2001 |
| Private R&D | Logarithm of private expenditure in R&D as percentage of regional GDP at (t-T) | ISTAT Indicatori Ricerca e Innovazione | 2001 |
| Graduates | Logarithm of the number of graduates in over 24 population at time (t-T) | EUROSTAT Regional Database | 2001 |
| Female Unemployment | Logarithm of the number of unemployed women in total female labour force | OECD Regional Database - Regional Labour Market TL3 database | 2001 |
| Herfindal Index | Sum of the square of the ratio sector employment/total employment defined for agriculture, industry and services | OECD – Regional Database - Regional Labour Market TL3 dataset | 2001 |
| Population density | Logarithm of the population in respect to local surface | OECD Regional Database - Demographic Statistics TL3 dataset | 2001 |
| Social Capital | Blood donations (Number of blood donations per 100 residents) | Cartocci (2007) | 2001 |
| | Voluntary Associations (Number of voluntary associations per Kmq) | Cartocci (2007) | 2001 |
| | Weekly Lunch (Number of families having lunch at least once per week with relatives and close friends per 100 households) | ISTAT Rilevazione "Parentela e Reti di solidarietà" | 2001 |
| | Adult Children (Number of young adult individuals living with parents per 100 young adults) | ISTAT Rilevazione "Parentela e Reti di solidarietà" | 2001 |
| Non Profit 1911 | Number of non profit organizations per 100 inhabitants | Nuzzo (2006) | 1911 |
| Referendum | Logarithm of the average political participation to the following referenda: 1946 (Monarchy vs. Republic), 1974 (divorce), 1978 and 1981 (abortion), 1985 ("scala mobile") and 1987 (nuclear power) | Nuzzo (2006) | 1946-1974-1978-1981-1985-1987 (Mean value) |

**Fig.1: Social Capital (Total)**

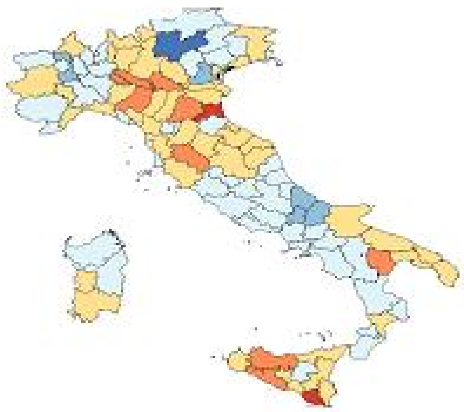
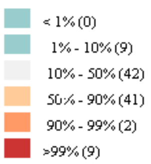


**Fig 2: Bridging Social Capital**

**Fig.3: Bonding Social Capital**

**Fig.4: Innovation**

Legenda:




Note: Figures 1,2,3 and 4 report the percentile map for the level of patents in 2001, the composite measure of social capital in 2001, the measure for bonding and bridging social capital in 2001 respectively.

## Table 1: Descriptive Statistics

| Macroregion | Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| **NORTH** | Patents Growth | 45 | 0.0601 | 0.0633 | -0.1137 | 0.2377 |
| | TOTAL Social Capital | 46 | 0.3443 | 0.1718 | 0 | 0.8528 |
| | Bonding Social Capital | 46 | 0.2467 | 0.1091 | 0 | 0.5100 |
| | Bridging Social Capital | 46 | 0.4922 | 0.1679 | 0.1867 | 1 |
| **CENTRE** | Patents Growth | 24 | 0.0581 | 0.0680 | -0.0724 | 0.2002 |
| | TOTAL Social Capital | 25 | 0.3112 | 0.1383 | 0.1101 | 0.6568 |
| | Bonding Social Capital | 25 | 0.4759 | 0.0339 | 0.4322 | 0.5377 |
| | Bridging Social Capital | 25 | 0.3344 | 0.1262 | 0.1620 | 0.6667 |
| **SOUTH** | Patents Growth | 28 | 0.0388 | 0.1415 | -0.2073 | 0.3393 |
| | TOTAL Social Capital | 32 | 0.3611 | 0.1905 | 0.0735 | 1 |
| | Bonding Social Capital | 32 | 0.8463 | 0.1424 | 0.4271 | 1 |
| | Bridging Social Capital | 32 | 0.1801 | 0.1649 | 0 | 0.7196 |

## Table 2: Correlation Matrix

| | Patents Growth | Social Capital | Bonding | Bridging |
|---|---|---|---|---|
| Patents Growth | 1.0000 | | | |
| TOTAL Social Capital | 0.2408 | 1.0000 | | |
| Bonding Social Capital | -0.0143 | 0.1649 | 1.0000 | |
| Bridging Social Capital | 0.1936 | 0.6812 | -0.6097 | 1.0000 |

**Table 3: Estimation of the Empirical Model: Regional Knowledge Production Function with Total, Bonding and Bridging Social Capital: Annual growth rate of regional patenting (2001-2007)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Dep.Var: Patent Growth | OLS | OLS | OLS | OLS | OLS | OLS | 2SLS |
| Patents (Level in 2001) | -0.0407*** | -0.0396*** | -0.0379*** | -0.0380*** | -0.0750*** | -0.0793*** | -0.0876*** |
| | (0.0104) | (0.0107) | (0.0109) | (0.0110) | (0.0118) | (0.0116) | (0.0115) |
| Private R&D | 0.0373*** | 0.0376*** | 0.0352*** | 0.0351*** | -0.0057 | 0.0015 | 0.00415 |
| | (0.0099) | (0.0104) | (0.0089) | (0.0090) | (0.0109) | (0.0115) | (0.0150) |
| Graduates | 0.0766 | 0.107* | 0.0940* | 0.0945 | 0.0306 | 0.0268 | -0.0088 |
| | (0.0488) | (0.0528) | (0.0540) | (0.0547) | (0.0555) | (0.0555) | (0.0522) |
| Female Unemployment | | 0.0140 | 0.0111 | 0.0112 | 0.0075 | 0.0066 | 0.0005 |
| | | (0.0137) | (0.0140) | (0.0147) | (0.0126) | (0.0122) | (0.0124) |
| Herfindal Index | | -0.00216 | -0.0026 | -0.0027 | -0.0014 | -0.0014 | -0.0021 |
| | | (0.0021) | (0.0019) | (0.0018) | (0.0019) | (0.0019) | (0.0021) |
| Population density | | 0.0311** | 0.0319** | 0.0318** | 0.0371*** | 0.0401*** | 0.0465*** |
| | | (0.0146) | (0.0135) | (0.0134) | (0.0106) | (0.0105) | (0.0077) |
| Spatial lag of Population | | -0.0385* | -0.0395* | -0.0389** | -0.0260 | -0.0257 | -0.0225 |
| density | | (0.0212) | (0.0215) | (0.0183) | (0.0177) | (0.0176) | (0.0141) |
| TOTAL Social capital | | | 0.112** | 0.115 | 0.145** | | |
| Endowment | | | (0.0525) | (0.0701) | (0.0655) | | |
| Spatial lag of Social Capital | | | | -0.0114 | -0.0230 | | |
| | | | | (0.128) | (0.114) | | |
| Bonding Social Capital | | | | | | -0.0181 | -0.0603 |
| | | | | | | (0.106) | (0.0932) |
| Bridging Social Capital | | | | | | 0.161*** | 0.395*** |
| | | | | | | (0.0516) | (0.0631) |
| North (Dummy) | | | | | 0.180*** | 0.112 | 0.0219 |
| | | | | | (0.0365) | (0.0779) | (0.0740) |
| Centre (Dummy) | | | | | 0.141*** | 0.101* | 0.0565 |
| | | | | | (0.0289) | (0.0499) | (0.0504) |
| Constant | 0.428** | 0.599** | 0.518** | 0.520* | 0.173 | 0.198 | 0.0633 |
| | (0.165) | (0.229) | (0.241) | (0.250) | (0.223) | (0.232) | (0.216) |
| Observations | 97 | 97 | 97 | 97 | 97 | 97 | 97 |
| R-squared | 0.181 | 0.253 | 0.288 | 0.288 | 0.420 | 0.428 | 0.298 |

*** p<0.01, ** p<0.05, * p<0.1 - Clustered - robust standard errors in parentheses

## Table 4: First stage regressions

| | (1)<br>Bonding Social Capital | (2)<br>Bridging Social Capital |
|---|---|---|
| Patents (Level in | -0.0220 | 0.00202 |
| 2001) | (0.0207) | (0.0249) |
| Private R&D | 0.0632** | -0.0103 |
| | (0.0288) | (0.0221) |
| Graduates | 0.0211 | 0.122 |
| | (0.0194) | (0.0743) |
| Female | -0.00163 | 0.0261* |
| Unemployment | (0.00907) | (0.0136) |
| Herfindal Index | -0.000429 | 0.00381 |
| | (0.00160) | (0.00247) |
| Population density | 0.0258 | -0.0238 |
| | (0.0152) | (0.0157) |
| Spatial lag | 0.0280 | -0.00326 |
| Population density | (0.0240) | (0.0246) |
| North (Dummy) | -0.642*** | 0.0460 |
| | (0.0743) | (0.0860) |
| Center (Dummy) | -0.397*** | -0.0752 |
| | (0.0585) | (0.0759) |
| Referendum | -0.247 | 1.417*** |
| | (0.271) | (0.258) |
| Non profit 1911 | 0.000840*** | -0.000102 |
| | (0.000238) | (0.000204) |
| Constant | 1.839 | -5.692*** |
| | (1.185) | (1.270) |
| Observations | 97 | 97 |
| R-squared | 0.931 | 0.615 |

*** p<0.01, ** p<0.05, * p<0.1
Clustered - robust standard errors in parentheses

## Table 5: First stage statistics

| Variable | Shea Partial R2 | Partial R2 | F( 2, 19) | P-value |
|---|---|---|---|---|
| Bonding Social Capital | 0.2931 | 0.3274 | 6.54 | 0.0069 |
| Bridging Social Capital | 0.1754 | 0.1959 | 15.60 | 0.0001 |

**Table 6: Robustness Checks (1): Estimation of the Empirical Model: Regional Knowledge Production Function with Bonding and Bridging Social Capital: Level of Patents (2002, 2005, 2007)**

| | (1) | (2) | (3) |
|---|---|---|---|
| Dep. Var.: | Patents (Level in 2002) 2SLS | Patents (Level in 2005) 2SLS | Patents (Level in 2007) 2SLS |
| Bonding Social | -2.309** | -1.210 | -1.505* |
| Capital | (0.950) | (0.904) | (0.873) |
| Bridging Social | 2.150** | 2.977*** | 2.999*** |
| capital | (0.967) | (0.945) | (0.539) |
| Private R&D | -0.0500 | -0.0117 | 0.0490 |
| | (0.119) | (0.140) | (0.141) |
| Graduates | 0.505 | -0.491* | -0.145 |
| | (0.382) | (0.256) | (0.401) |
| Female | 0.0842 | -0.0797 | -0.0581 |
| Unemployment | (0.0696) | (0.0832) | (0.0967) |
| Herfindal index | -0.0119 | -0.0274 | -0.0154 |
| | (0.0275) | (0.0207) | (0.0190) |
| Population density | 0.307*** | 0.309*** | 0.427*** |
| | (0.0879) | (0.0787) | (0.0561) |
| Spatial lag | 0.105 | -0.161 | -0.115 |
| Population density | (0.204) | (0.135) | (0.110) |
| North (Dummy) | 0.116 | 0.414 | 0.184 |
| | (0.717) | (0.735) | (0.695) |
| Centre (Dummy) | 0.425 | 0.549 | 0.550 |
| | (0.495) | (0.516) | (0.482) |
| Constant | 2.697 | 0.530 | 0.900 |
| | (1.891) | (1.622) | (1.759) |
| Observations | 97 | 103 | 103 |
| R-squared | 0.697 | 0.672 | 0.709 |

*** p<0.01, ** p<0.05, * p<0.1

Clustered - robust standard errors in parentheses

**Table 7: Robustness Checks (2): Estimation of the Empirical Model: Regional Knowledge Production Function with Bonding and Bridging Social Capital: Annual growth rate of regional patenting (2001-2007)**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Dep. Var.: | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS |
| Patents Growth | | | | | |
| Bonding Social | -0.0603 | -0.0722 | -0.0718 | -0.0648 | -0.0417 |
| Capital | (0.0932) | (0.153) | (0.154) | (0.152) | (0.111) |
| Bridging Social | 0.395*** | 0.394*** | 0.398*** | 0.394*** | 0.410*** |
| Capital | (0.0631) | (0.0910) | (0.0906) | (0.0902) | (0.0874) |
| Patents (Level in | -0.0876*** | -0.0829*** | -0.0851*** | -0.0841*** | -0.0849*** |
| 2001) | (0.0115) | (0.0120) | (0.0126) | (0.0131) | (0.0134) |
| Private R&D | 0.0041 | 0.0147 | 0.0134 | 0.0144 | |
| | (0.0150) | (0.0241) | (0.0242) | (0.0241) | |
| Graduates | -0.0088 | -0.0059 | -0.0268 | | |
| | (0.0522) | (0.0599) | (0.0535) | | |
| Female | 0.0005 | 0.0007 | | | |
| Unemployment | (0.0124) | (0.0136) | | | |
| Herfindal Index | -0.0021 | -0.0025 | | | |
| | (0.0021) | (0.0024) | | | |
| Population density | 0.0465*** | | | | |
| | (0.0077) | | | | |
| Spatial lag | -0.0225 | | | | |
| Population density | (0.0141) | | | | |
| North (Dummy) | 0.0219 | -0.0059 | -0.0013 | -0.0018 | 0.0333 |
| | (0.0740) | (0.132) | (0.135) | (0.134) | (0.0794) |
| Center (Dummy) | 0.0565 | 0.0362 | 0.0422 | 0.0399 | 0.0634 |
| | (0.0504) | (0.0862) | (0.0878) | (0.0877) | (0.0528) |
| Constant | 0.0633 | 0.222 | 0.135 | 0.206 | 0.154 |
| | (0.216) | (0.276) | (0.241) | (0.184) | (0.105) |
| Observations | 97 | 97 | 97 | 97 | 97 |
| R-squared | 0.298 | 0.183 | 0.171 | 0.175 | 0.151 |

*** p<0.01, ** p<0.05, * p<0.1

Clustered - robust standard errors in parentheses