Social capital and the innovative performance of Italian provinces

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Abstract

Social capital has remained relatively underexplored in innovation literature due to the lack of consensus on the most suitable operationalisation for the analysis of innovative dynamics. This paper aims to fill this gap by looking at social capital as propensity towards civicness and pro-social behaviour that facilitates the circulation of non-redundant knowledge among otherwise disconnected groups. The quantitative analysis of the innovative performance of Italian provinces shows that social capital – proxied by blood donations and participation into voluntary associations - is an important predictor of innovative performance after controlling for 'traditional' knowledge inputs (R&D and human capital). In addition, instrumental variable analysis makes it possible to identify clear causal links between social capital and innovation, suggesting that social norms play an important role in shaping the incentives for knowledge generation, circulation and accumulation.

JEL CLASSIFICATION: O31, O33, R15
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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 traps (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, 1999). However, the analysis of the link between social capital and the genesis 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 no clear consensus has emerged on the impact of social capital on innovative performance and on the underlying transmission mechanisms (Cohen and Fields, 2000; Hauser, et al. 2007; Kallio et al., 2009; Laursen and Masciarelli, 2007; Patton and Kenney, 2003; Sabatini, 2009; Tura and Harmakorpi 2005).

Existing literature on the social capital-innovation nexus adopts a broad definition of social capital that simultaneously encompasses all its dimensions (associational activities, political participation, institutional thickness and trust). This broad definition has made it difficult not only to empirically operationalise the concept but also to account for the contradictory evidence on its impact on innovative performance: positive in some studies (e.g. Akcomak and ter Weel, 2009) and negative in others (e.g. Florida 2002).

This paper looks at the local endowment of social capital in terms of attitude towards civicness and pro-social behaviour. In this perspective local trust, reciprocity and even altruism, by lowering transaction costs, are fundamental components of an environment

congenial for (high-risk) innovation investments that benefit from ties based on trust and cooperation (Dettori et al. 2010; Hauser et al., 2007). Trust and cooperation shape the networks through which valuable knowledge is exchanged and re-combined (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 depends simultaneously on the density of the network linking knowledgeable individuals and on the extension of their "radius of trust" (Fukuyama, 1995). The wider the radius of trust in the network of knowledgeable individuals the greater the likelihood that complementary knowledge will be exchanged (Knack, 2001) with a positive impact on innovative performance.

In order to study the impact of social capital on innovation, this paper builds upon existing literature in a number of innovative ways. First, the paper develops an operational definition of social capital and a clear conceptualisation of its impact on innovation by cross-fertilising the literature on the socio-institutional determinants of innovation with the literature on 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. Third, the empirical analysis also explores the causal nature of the social capital-innovation nexus by explicitly addressing the potential endogeneity bias through a robust identification strategy based on a time lag instrumental variable approach.

The analysis looks at the Italian provinces, an exemplary case study in the literature on social capital (Guiso et al, 2004; Ichino and Maggi, 2000; Putnam, 1993) although – to the best of our knowledge – the link between social capital and innovation has not been explored in depth. Recent studies on social capital in Italy are largely qualitative (Ramella and Trigilia, 2009), those based on a quantitative approach focused on

selected geographical areas (e.g. industrial districts as in Cainelli et al., 2005) or adopted a firm-based perspective in order to address the impact of social capital on the firms' propensity to innovate and their willingness to invest financial resources in innovative activities (Arrighetti and Lasagni, 2010; Laursen and Masciarelli, 2007).

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 at play. Section three discusses the estimation strategy and the data, while the fourth section presents some key 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 social capital shapes local innovative performance

A growing body of literature suggests that innovation is a social process embedded in the local socio-institutional environment that, in its turn, 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 (Rodríguez-Pose, 1999), social filters (Rodríguez-Pose and Crescenzi 2008), innovative milieux (Breschi and Lissoni, 2001; Camagni, 1995), learning regions (Florida, 1995; Morgan, 1997) and regional systems of innovation (Cooke et al, 1997). In this context, social capital – together with other 'intangible' territorial assets – plays a very important role for the understanding of differential innovative performance at the territorial level (Dettori et al. 2010). However, the analysis of the impact of social capital on innovation has suffered from the lack of consensus on its definition and from the complexity of its operationalisation and measurement (Guiso et al., 2010). While Coleman (1988) argued

that it coincides with the social structure of a society that facilitated the actions of individuals, Putnam (1993) identified social capital in terms of trust-based relations and groups and Fukuyama (1995) suggested that social capital has to be intended in terms of trust, civicness and network relations.

When looking at social capital from the perspective of the literature on the socio-institutional determinants of innovation it is immediately apparent that both the 'network' and 'civic-engagement' dimensions of social capital are relevant to innovation dynamics. Innovation is simultaneously influenced by the extent, density and shape of the networks through which knowledge is channelled (Breschi and Lissoni, 2001) and by the 'rush and motivation' for the development (and maintenance) of these linkages used for the exchange of 'economically valuable' knowledge (Storper and Venables, 2004). Both dimensions play a crucial role in knowledge exchange, re-combination and generation (Dettori et al. 2010).

The shape and density of networks matters for innovation given that 'bridging' networks – i.e. 'open' connections between heterogeneous groups - foster innovative capabilities by facilitating the diffusion of valuable and non-redundant knowledge and preventing stagnation and lock-in (Boschma, 2005; Dettori 2010). 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 mechanisms of interactive learning stimulating the exchange and re-combination of knowledge (Asheim, 1999; Lundvall, 1992).

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

and Harmaakorpi, 2005; Capello and Faggian 2005)[1]. 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 with deep emotional involvement or by 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. When contextualising Granovetter's argument into the analysis of innovation, 'weak ties' can be seen as a 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 in a context of generalized trust gives each communities confidence that their knowledge will be used by members of other communities to their

[1] Kallio et al. (2009) suggested that the link between the social dimension and the emergence of an innovative outcome lies in local absorptive capacity that promoted 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 increasing returns on 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).

mutual benefit.' (Rodríguez-Pose and Storper, 2006, p.8). As a consequence social capital - in terms of trust, reciprocity and even altruism - by lowering transaction costs (Diani, 2004), generates the incentives ('rush and motivation' as in Storper and Venables 2001) for 'bridging' ties to be generated, maintained over time and actively used for valuable knowledge exchange, contributing to an environment congenial for (high-risk) innovation investment that benefit from 'open' ties based on trust and cooperation (Hauser et al., 2007). In other words, social capital also influences innovation by means of reciprocity (motivation for knowledge exchange) in small groups or networks. This type of pro-social behaviour is often motivated by forms of expectations about the behaviour of other individuals and this, in its turn - as argued by Dodgson and Gann (2010) - results in a more efficient sharing of information and knowledge. Furthermore it is worth noticing that pro-social behaviour, in its purest form, can also be motivated by altruism, i.e. a situation in which intrinsic motivation is overwhelmingly dominant with respect to extrinsic motivation (Benabou and Tirole, 2003). A wide range of human actions can be driven by altruism[2] or by the willingness to contribute to social welfare with no reward in exchange. In this regard, Dogson and Gann (2010) argue that collaborative efforts in developing freeware software is a 'special' case of pro-social behaviour largely driven by intrinsic motivation. However, in the case of formal product innovation this situation is practically very rare: even in the particular case of 'purely' academic research, the extrinsic motivation of scientists in the form of career concerns remains crucial. When innovation is captured by means of patents (as in the standard quantitative literature based on the Knowledge Production Function) these forms of collaborative (altruistic) innovation are necessarily excluded from the analysis. Coherently with this framework – and under the significant

[2] We would like to thank one of the anonymous referees for raising this point

constraints in term of data availability that a priori prevent the inclusion of direct proxies for the structure of local network relations - the empirical analysis will proxy social capital by means of data on blood donations and participation into voluntary associations. In light of the conceptualisation and measure of innovation adopted in this paper, these proxies will be interpreted as signs of attitudes for pro-social behaviour, 'civicness' or civic values (as in Putnam, 1993) promoting simultaneously the production of public goods, the incentives for knowledge-sharing and acting as a pre-condition for its diffusion through 'bridging' networks.

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 perpetuation of developmental differences between the North and the South of Italy is to be ascribed to the quality of the institutions and social capital. Arrighetti and Lasagni (2010) analysed the effect of these social conditions on the propensity to innovate of Italian firms and concluded that innovative firms tend to cluster in those provinces characterized by higher levels of 'positive social capital', defined as civicness and high social interactions, and lower levels of 'negative social capital', generally associated with opportunistic behaviour caused by the existence of groups lobbying for partisan interests. Following the same line of argument, but focusing on case studies such as the Emilia Romagna industrial districts, Cainelli et al. (2005) argued that 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 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 and Rodriguez-Pose, 2011; Crescenzi et al., 2007 and 2012; Feldman, 1994; Fritsch, 2002; Moreno et al. 2005a; O'hUallachain and Leslie, 2007; Ponds et al, 2010; Varga, 1998) and it allows us to focus upon the territorial dynamics of innovation by taking account of our measure of social capital as determinant of regional innovative performance. The Regional Knowledge Production Function takes the following form:

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

(Equation 1)

Where $Patents\_growth_{i,(t-T)\to t} = \frac{1}{T}\ln(\frac{Patents_{i,t}}{Patents_{i,t-T}})$ 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 of social capital 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, δ_i represents macro-regional dummies for southern, central and northern Italy and ε_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 period 2001-2007[3]. 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 either the differentiated degree of novelty of patented products (not all patented products are equally 'new' and/or valuable) or the non-patentability of many inventions (in particular as regards process innovation or 'open source' innovation as discussed above). In addition, different sectors appear to have intrinsically different propensities to patent inventions. In order to minimise any potential bias in our analysis: a) there are controls for the initial patent intensity of each region; b) there are also controls for the economic sectoral structure. The specification of the dependent variable in terms of growth rate is an attempt to overcome the lack of

[3] 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 prior to 2001 are unavailable. 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 shorter time spans. 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).

panel data and provide some evidence on the dynamic 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 is tested as predictor of a given region's capability to develop based upon existing technological infrastructure and hence 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 their distance from the technological cutting edge. 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 the concept of social capital as propensity towards pro-social behaviour in terms of attitude for cooperation with anonymous others, participation in groups and associations and civicness. The rationale for the adoption of this definition is that 'positive' social behaviour tends to be generally associated with more successful economic outcomes (De Blasio and Nuzzo, 2010) and that a greater level of civic engagement and cooperation may, in its turn, facilitate the exchange of economically valuable (often non-codified or tacit) knowledge in 'open' networks. From this perspective we refer to the idea proposed by Burt (1992: 32) that "people who do better are somehow better connected" and that those people "connected to certain others, trusting certain others, devoted to support certain others" can be identified as structural holes connecting different segments of the society. The concept of social capital interpreted in terms of civic virtues and propensity to cooperate has been

operationalized through a composite indicator based on two key variables: 'blood donations per 100 residents' and 'voluntary associations per Sq-Km'[4].

Both variables are interpreted as measures for altruism reflecting the attitude to develop horizontal relations fostering networks of civic engagement (Arrighetti and Lasagni, 2010; Beugelsdijk and Schaik, 2005, De Blasio and Nuzzo, 2012) and are considered customary proxies for the participation of individuals in activities with positive social externalities (Cartocci, 2007) and pro-social behaviour (Putnam, 1993, Guiso et al., 2004, Nannicini et al., 2010).

The reliability of these variables as proxies for social capital is also reinforced by some specificities of the Italian case. First of all, it should be borne in mind that blood donations are completely free in Italy and national regulations do not allow for any form of monetary compensation for donors. In addition AVIS (Italian National Association of Blood Donors) data confirm that blood donations clinics are equally accessible and evenly distributed across provinces and regions in the entire country[5].

Second, empirical evidence also makes it possible to rule out the possibility that the density of voluntary associations could be considered also as a proxy for urbanization economies: when the composite indicator for social capital is regressed on the 'number of firms per Sq-Km' there is no evidence of any significant correlation[6].

[4] The two social capital indicators ('number of voluntary associations' and 'blood donations') are only made available with different standardization methods ('per sq. Kilometres' and 'per 1000 residents' respectively). However, the rationale for the focus on the spatial density of voluntary associations is that this proxy aims to capture the density of pro-social actions in terms of their spatial intensity, in line with the focus of the paper on the spatial/territorial dimension of social capital.

[5] Blood donations clinics are generally present in each municipality with a standard deviation in the density of blood donations clinics per Kmq of just 0.010. The table with descriptive statistics on the geography of blood donation clinics in Italy is not included in the paper but is available from the authors upon request.

[6] This regression includes controls for additional covariates such as population density, spatial lag of population density, female unemployment, employment in agriculture and services and macro regional dummies. All these regressors will also be included in the main specification of the KPF. Table with the results of this additional robustness check is available upon request.

Our composite indicator for social capital is computed in line with the indicators of technological capabilities (ArCo) by Archibugi and Coco (2005). The Social Capital indicator combines both variables with equal weights:

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

Where I_i represents each of the two variables adopted as proxy for social capital (Blood donations and Voluntary Associations) and λ_i is the constant equal to ½. The index is then 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)[7] and are available from ISTAT (Italian National Statistical Office)[8]. The use of a composite indicator as proxy for social capital endowment is customary in the literature and reflects the multifaceted nature of this concept. In addition, the use of composite indicators is crucial for the identification strategy discussed below: given the significant constraints in terms of historical data availability at the sub-national level it would be impossible to identify suitable instruments for each social capital variable separately.

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., 2005b; O'hUallachain and Leslie, 2007; Ponds et al., 2010; Varga, 1998). On account of limited 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).

[7] 103 observations
[8] See Table A1 for further detail.

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 measured by the share of employment in agriculture and services[9].

The sectoral composition is controlled for by 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 to minimise the impact of spatial autocorrelation in the error term. In particular, it includes the spatial lag of population density[10] 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).

Identification strategy - The next question is how to identify the link between innovation and social capital given the potential endogeneity of social capital on account of both reverse causality and omitted variable bias as well as the relevant risk of measurement errors implicitly associated to the adoption of proxies to measure the key variable of interest.

The main research hypothesis in this paper is that social capital can be treated as a determinant of innovation as it facilitates, through the promotion of cooperation and civic engagement, the development of networks between knowledgeable individuals and

[9] Additional controls on sector structure (such as the Herfindal Index) were also included in the model with no statistically significant effect. In order to keep our specification as simple as possible (parsimony) these variables were excluded from the final specification of the model presented in the paper but additional regression tables are available on request.

[10] Computed by means of a .first order 'queen contiguity' spatial matrix as customary in the literature.

the circulation and diffusion of knowledge. Even if grounded in 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 economic incentives sufficiently high as to create valuable networks - a virtuous cycle based on cooperation and trust, stimulating civicness and a sense of community and providing greater incentives toward pro-social behaviours. In addition, an omitted-variable problem may also bias the estimation of the model. The measures of social capital are potentially correlated to local characteristics that cannot be fully controlled for. This is particularly problematic when considering neighbouring effects and spatial correlation: the omitted variable bias may depend on both local characteristics and neighbouring areas features affecting local innovative performance.

Finally, the adoption of proxies and the construction of a composite indicator of social capital may potentially exacerbate the measurements errors in our variable of interest.

In order to minimize the impact of all these problems, the model controls for spatial correlation by including the spatial lag of social capital[11] 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 social capital in each province is instrumented with the 'voter turnout in selected historical referenda'[12]. For the instrument the analysis relies on regional-level[13] data due to the lack of historical quantitative information at the provincial level.

[11] Computed – as for other spatially lagged variables – by means of a first order rook contiguity matrix.
[12] The measure is constructed as the average political participation in the following referenda (voting is not mandatory): 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 with respect to particular questions.

In order to understand the rationale behind our identification strategy it is important to consider that in the case of social capital the selection of an appropriate instrument is constrained by two major factors. First, as discussed above there is still no consensus on a single definition of social capital and its measure (Guiso et al., 2010). This implies that the search for an appropriate instrument cannot build on the micro-foundations of the concept. Second, there are major problems in recovering reliable time series for the key social capital proxies, especially when the analysis is performed for sub-national geographical units. This also explains why it was impossible to use a panel structure for the empirical analysis and why it was also impossible to make use of the standard Instrumental Variables time lag approach based on the lagged values of the variables of interest (Putnam, 1993).

In order to overcome both shortfalls the existent empirical literature on the economics of institutions and culture in general and on social capital in particular has made extensive use of alternative historical proxies as instruments.

The existing literature on the impact of social capital, by building on both the theoretical framework of the overlapping-generations model and the multidimensionality of social capital (Guiso et al., 2008), has suggested that inter-generationally transmitted priors and social structures (measurable by means of different but correlated variables) affect individual decisions regarding whether to trust other members of the society or alternatively just the member of a restricted group (Tabellini 2010). As a consequence, in line with the existing literature, the identification strategy is not based on the causal link between 'referenda turnout' and social capital indicators. On the contrary, the

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

proposed instrumental variable - in absence of reliable historical data on the social capital indicators at the beginning of the 20th century - is considered as alternative proxy for past stocks of social capital and adopted as time lag instrument (Tabellini, 2010; Putnam, 1993; Tomassini, 1999).

The instrument - 'voter turnout in selected historical referenda' - is expected to be positively_correlated with social capital as it is considered in the literature as an alternative proxy for civic participation and engagement and civic virtues (De Blasio and Nuzzo, 2012)**.**

More in depth the historical turnout in referenda of 'general' relevance can be interpreted – in line with a large body of literature - as a proxy for the propensity of people to participate in social life showing positive social behaviour. This choice is also supported by Putnam's (1993) view of participation in 'general interest' referenda as radically different from turnout in political elections. While all parties involved in political elections are largely motivated by self-interest (being elected for candidates, having their instances represented in the relevant institutional bodies for their electors), participants (promoters, campaigners and voters) in referendums are directly interested in promoting change at the level of the entire society and their self-interest (if any) remains very limited (Putnam 1993).

4. Empirical results

The cartographic representation of the key variables of interest (Figure 1 and 2) shows similarities between the spatial distribution of innovation and that of the composite measure of social capital. The geography of innovation is linked with social capital patterns and, although the fundamental North-South divide is apparent, the maps confirm the provincial level as the relevant spatial unit of analysis.

[Insert Figures 1 and 2]

In order to further investigate this preliminary descriptive evidence the Regional Knowledge Production Function specified in Equation 1 is estimated and results are presented in Table 1. The values of the R-squared and of the Moran's I test[14] for spatial autocorrelation in the regression residuals are reported for all specifications of the model confirming the robustness of our results.

[Insert Table 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 province (Tab. 1, 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 and Rodriguez-Pose, 2011; Crescenzi et al 2007; Moreno et al. 2005b), and reflects a weak trend in (conditional) technological convergence in advanced economies. In the Italian case this trend also reflects the crisis of traditionally successful innovative areas (such as 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 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 metallurgy (Tuscany and Sardinia) or the industrial districts specialized in clothing (Veneto and Apulia) and eyewear (Veneto, Emilia-Romagna and Friuli-Venezia Giulia)

[14] Calculated by means of a customary first order queen contiguity spatial matrix.

- 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. 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. However, in all specifications of the model there is no evidence of any impact of human capital endowment on innovation. This result highlights one of the specificities of the Italian case: differently from the rest of Europe or the US (Crescenzi et al. 2007) the local endowment of human capital does not exert a direct impact on local innovation due to the fundamental mismatch between (Southern) graduates' skill profile and their occupations (Iammarino and Marinelli, 2011).

Subsequently, our key variable of interest, namely social capital, is included in the regression (Table 1, Col. 2) showing a positive and highly significant correlation with the innovative performance of Italian provinces. The following specifications allow for the inclusions of additional regressors in order to check for the robustness of our preliminary findings. In column 3 the spatial lag of social capital[15] is introduced into the model without any significant evidence of spatial correlation in the sample[16]. Subsequently additional controls for labour market characteristics, sector structure, population density and its spatial lag (as a proxy for accessibility) are introduced into the model (Table 1, columns 4, 5 and 6 respectively). Neither the level of female

[15] Measured by means of a customary first order queen contiguity. Note that additional robustness tests using the rook version of the matrix were performed with no qualitative changes in the estimates.

[16] This result is consistent with the Moran's I index of our dependent variable that shows a statistically non-significant spatial autocorrelation (I=-0.0521 ; P-value: 0.302) – Moran's I Scatter Plots available in the Online Appendix C.

unemployment (proxy for the efficiency of the local labour market), nor the measures of sector specialisation (the share of employment in agriculture and industry) 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, which are heavily constrained by low factor mobility and 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 with a 5% significance level while the spatial lag of population density is not statistically significant. The most innovative provinces seem to be those where density is higher: major urban areas with their functional hinterland. Finally, in order to minimize the persistence of additional omitted variables and residual neighbouring effects and spatial autocorrelation macro-regional dummies were introduced. Given that the Moran's I test (computed for each specification of the model) does not detect spatial autocorrelation in the residuals, the combination of macro-regional variables and spatially lagged explanatory variables are able to capture a significant part of the total spatial variability of the data.

The measure of social capital remains positively associated with innovation with a significance level of 1% in all the specifications. After fully controlling for the North-South divide and other spatial effects, social capital emerges as the most important predictor of innovative performance together with the proxy for agglomeration economies. Highly agglomerated provinces – where face-to-face contacts maximise the exchange of knowledge – with high levels of cooperation and associational activities 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), suggesting

that the positive and significant effect of social capital on innovation is largely based on evidence of pro-social behaviour stimulating generalized trust and cooperation between otherwise disconnected communities. Such cooperative attitude allows for the 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 1, Column 8. The IV results strongly support the existence of a causal link between social capital and innovation (positive coefficient and statistically significant at 1% level). The first stage regression (Table 2a) confirms the validity of this instrumental strategy. The instrument – referendum turnout - is highly correlated to the instrumented variable – social capital - showing the expected sign and confirming the rational for its selection.

[Insert Table 2a and 2b]

Being aware that the econometric literature on instrument validity suggests that it is possible to encounter the problem of weak instruments even with an unproblematic first stage regression (Staiger and Stock, 1997; Stock and Yogo, 2005) and in order to rule out any related risk the rule of thumb proposed by Staiger and Stock (1997) and the Stock and Yogo's (2005) threshold values are applied. The F-statistics in the first stage is consistent with both criteria [17] (Table 2b), confirming that the instrumental variables strategy is robust and unaffected by any potential weak instrument bias.

To support the robustness of the statistical findings discussed above, a number of additional robustness checks were implemented. In Table 3 the OLS specification is reported, substituting the composite indicator of social capital with its two components,

[17] The F statistic is above all the Stock and Yogo (2005) threshold values for the instrument for bridging social capital and above the 15% critical value for the instrument adopted for bonding social capital.

namely blood donations and voluntary associations. Both variables are positively correlated with innovation and statistically significant confirming their reliability as proxy for social capital interpreted in terms of pro-social behaviour. Further robustness checks on the specification of the model are included in the on-line Appendix B.

[Insert Table 3]

Finally, in order to provide further support for the reliability of the instrument it is necessary to check whether this variable is systematically correlated with alternative social capital proxies commonly adopted in the empirical literature. An extensive literature suggests that the multidimensionality of social capital has to be carefully taken into account when analysing its impact on any economic outcome. In particular, in the conceptual framework of this paper, substantially different effects may be produced by different extensions of the 'radius of trust' (Fukuyama, 1995). The extension of the cooperative networks in place and the typology of ties among the involved actors may affect the quality of information exchanged as well as its degree of novelty. Strong ties within closed groups are associated with the exchange of redundant knowledge and potential risk of lock in. This typology of networks and trust relations, commonly identified with the concept of bonding social capital, tends to be associated with intense relations among homogeneous individuals (Putnam, 2000, Beugelsdijk e Smulders, 2003) and often operationalized in terms of trust and relations with family and close friends (De Blasio and Nuzzo, 2012)

Checking for the existence of a systematic correlation between the selected instrument and the so called 'bonding social capital' is particularly interesting in the case of Italy where the reliance on networks of family and friends has been traditionally associated with the potential emergence of negative social externalities. Since the seminal work by Banfield (1958) the low propensity to cooperate was associated with, 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 'amoral familism'), high uncertainty and a highly unequal distribution of income and wealth. So far, there has been no conclusive empirical evidence confirming Banfield's hypothesis, but some recent research tends support this view (Alesina and Giuliano, 2010; Giavazzi et al. 2010; Duranton et al. 2009).

Although recent studies pointed out the dangers of assuming a straightforward correlation between the intensity of ties with family and close friends and the emergence of negative social behavior (De Blasio and Nuzzo, 2010), the relevance of a pre-existent extensive literature building on this hypothesis deserves a deeper analysis. To rule out any doubt in this regard a composite indicator for bonding social capital is computed by following the procedure adopted for the creation of our key regressor. In order to capture the strength of ties with family and friends, 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)'[18].

The instrument - namely referendum turnout – is regressed on the composite measure of bonding social capital controlling for macro-regional dummies. Results reported in table 4 confirm that the instrument is not significantly correlated with bonding social capital supporting the reliability of our main findings and confirming that the empirical

[18] 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). Reher (1998) distinguishes the 'weak family ties' tradition of Northern Europe whereby children leave parents' home relatively early in their life from the 'strong family ties tradition' in Southern Europe whereby children move away from their parents at a later stage. Manacorda and Moretti (2006) and Giuliano (2007) provide additional empirical evidence on the role of cultural factors in explaining co-residence of parents and children.

analysis is correctly identifying the impact of a very specific typology of social capital: pro-social behavior and generalized trust between otherwise disconnected groups. .

[Insert Table 4]

6. Conclusions

A large body of literature has looked at the very different ways in which social capital influences economic and social activities. The analysis of innovation has suffered from the lack of a suitable working definition for social capital and from the difficulties in operationalising its links to innovation dynamics. This paper fills this gap by looking at social capital as a fundamental determinant of innovation that facilitates the generation and persistence of the networks favouring the diffusion and circulation of valuable non-redundant knowledge. In this perspective, the effect of social capital on innovation is shaped by the emergence of pro-social behaviour stimulating the attitude towards generalized trust and cooperation and facilitating the exchange of complementary knowledge between individuals belonging to different epistemic communities. This paper has empirically tested these hypotheses by means of the quantitative analysis of the innovative performance of 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 – as propensity towards pro-social behaviour and generalised trust- is an important predictor of innovative performance after controlling for the 'traditional' knowledge inputs (R&D investments and human capital endowment) and for other characteristics of the local economy. 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 social capital and innovation. The identification of these links suggests that – although changes in the local endowment of social capital are certainly hard to promote through public policies - carefully designed innovation policies can contribute towards creating incentives for cooperative behaviour. For example, policies based on the regional and inter-institutional mobility of 'knowledgeable individuals' and cooperative research projects can contribute to the generation of trust-based ties and reinforce the external projection of existing networks among innovative agents. Further exploration of these policy options remains in our agenda for future research but this paper is a step towards opening 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 patents 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
Sectoral Shares and Herfindal Index	Sector employment/total employment ratio defined for agriculture, industry and services. Herfindal calculated as the Sum of the square of these ratios.	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 *Civicness and pro-social behaviour*	Blood donations (Number of blood donations per 100 residents)	Cartocci (2007)	2001
	Voluntary Associations (Number of voluntary associations per Sq-Km)	Cartocci (2007)	2001
Social Capital *'Bonding' [Robustness checks]*	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
Social Capital – *Instrument - Referendum*	Instrumental Variable: Logarithm of the voter turnout to the following historical 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)

Figure 1: Growth Rate of Patents (Per Million Inhabitants), 2001-2007.

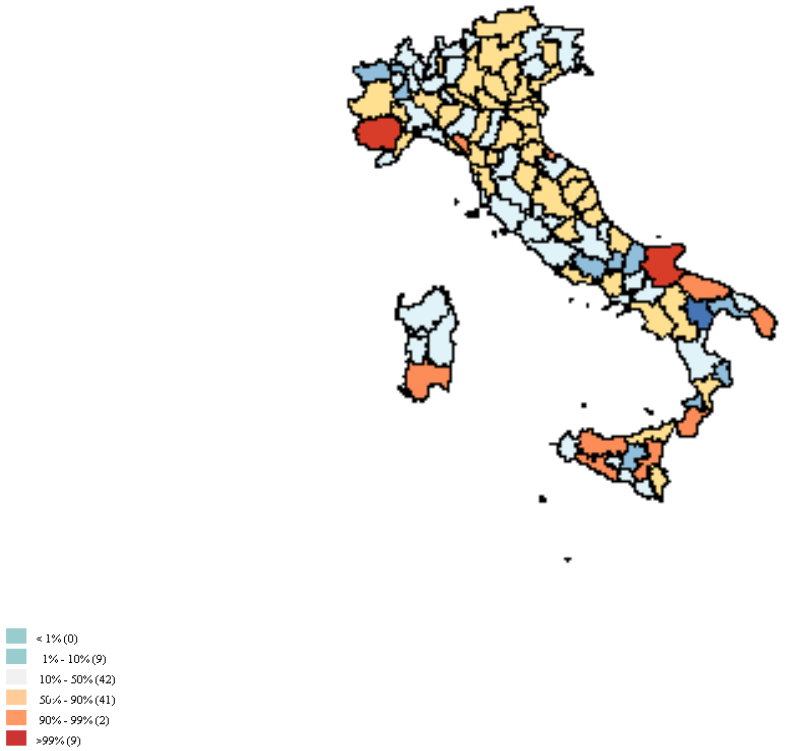

Figure 2: Social Capital, Composite Indicator, 2001

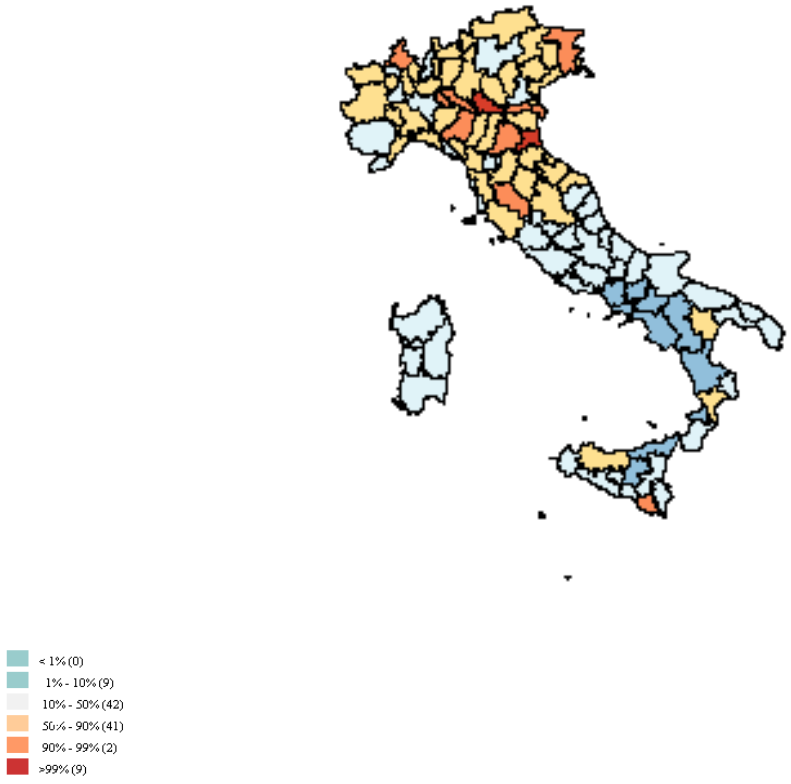

Table 1: Estimation of the Empirical Model: Regional Knowledge Production Function with Social Capital: Annual growth rate of regional patenting (2001-2007)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep.Var.: Patent growth	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**2SLS**
Patents (level in 2001)	-0.0407***	-0.0547***	-0.0536***	-0.0524***	-0.0518***	-0.0548***	-0.0685***	-0.0771***
	(0.0104)	(0.0101)	(0.0099)	(0.0100)	(0.0100)	(0.0088)	(0.0115)	(0.0113)
Private R&D	0.0373***	0.0277**	0.0264**	0.0262**	0.0256**	0.0167	0.0048	0.0023
	(0.0099)	(0.0098)	(0.0109)	(0.0113)	(0.0107)	(0.0120)	(0.0153)	(0.0140)
Graduates	0.0766	0.0386	0.0376	0.0460	0.0889	0.0759	0.0545	0.0239
	(0.0488)	(0.0515)	(0.0507)	(0.0562)	(0.0700)	(0.0660)	(0.0649)	(0.0649)
Social Capital		0.182***	0.185***	0.180***	0.191***	0.207***	0.169***	0.458***
		(0.0426)	(0.0410)	(0.0399)	(0.0428)	(0.0427)	(0.0516)	(0.0742)
Spatial lag of Bridging Social Capital			-0.0126	-0.0142	-0.0149	-0.0131	-0.0191*	-0.0174
			(0.0117)	(0.0130)	(0.0119)	(0.0090)	(0.0103)	(0.0171)
Female unemployment				0.0090	0.0145	0.0093	0.0133	0.0107
				(0.0145)	(0.0218)	(0.0204)	(0.0194)	(0.0189)
Employment in agriculture					0.0231	0.0217	0.0146	0.0228
					(0.0155)	(0.0142)	(0.0124)	(0.0151)
Employment in industry					0.0526	0.0338	0.0247	0.0573*
					(0.0426)	(0.0374)	(0.0404)	(0.0340)
Population density						0.0294**	0.0301**	0.0372***
						(0.0120)	(0.0111)	(0.0091)
Spatial lag of population density						-0.0018	-0.0008	-0.0008
						(0.00318)	(0.00314)	(0.00300)
Macro-regional dummies							YES	YES
Constant	0.428**	0.291	0.288	0.328	0.578*	0.353	0.335	0.194
	(0.165)	(0.172)	(0.170)	(0.196)	(0.294)	(0.293)	(0.282)	(0.278)
Observations	97	97	97	97	97	97	97	97
R-squared	0.181	0.276	0.281	0.285	0.303	0.355	0.399	0.209
Moran's I	0,0082	-0,0442	-0,0263	-0,0153	-0,0387	-0,0477	-0,0777	-0,0420
P-value	0.362	0.354	0.408	0.468	0.376	0.296	0.164	0.360

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

Table 2a: First stage regression

	(1)
Dep.Var.:	**Social Capital**
Patents	0.0084
(level in 2001)	(0.0224)
Private R&D	0.0004
	(0.0218)
Graduates	0.0743
	(0.0782)
Female unemployment	-0.0122
	(0.0342)
Population density	-0.0172
	(0.0142)
Spatial lag of population density	-0.0168
	(0.0225)
Employment in agriculture	-0.0159**
	(0.0064)
Employment in industry	-0.0502
	(0.0326)
Spatial lag of Social Capital	0.2355
	(0.1699)
Referendum	1.1679***
	(0.2923)
Macro-regional dummies	YES
Constant	-4.9766***
	(1.5394)
Observations	97
R-squared	0.628

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

Table 2b: First stage statistics

Variable	Shea Partial R2	Partial R2	F(2, 19)	P-value
Social Capital	0.1056	0.1056	15.97	0.008

Table 3: Robustness Checks (1): Estimation of the Empirical Model: Regional Knowledge Production Function with Blood donations and Voluntary Associations: Annual growth rate of regional patenting (2001-2007)

	(1)
Dep.Var.: Patent Growth	**OLS**
Patents (level in 2001)	-0.0739***
	(0.0115)
Private R&D	0.0140
	(0.0133)
Graduates	0.0429
	(0.0687)
Voluntary Associations	0.0514***
	(0.0115)
Blood Donations	0.0855***
	(0.0257)
Female unemployment	0.0108
	(0.0179)
Employment in agriculture	0.0099
	(0.0128)
Employment in industry	0.0235
	(0.0353)
Population density	0.0220*
	(0.0112)
Spatial lag of population density	-0.0008
	(0.0032)
Macro-regional dummies	YES
Constant	0.243
	(0.342)
Observations	97
R-squared	0.430

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

Table 4: Robustness Checks (2): Correlation between the instrument and alternative social capital proxies

	(1)
Dep.Var.:	**Referendum**
	OLS
'Bonding' Social Capital	-0.0518
	(0.0697)
Macro-regional dummies	YES
Constant	4.5060***
	(0.0691)
Observations	97
R-squared	0.804

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

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[ON LINE ONLY]
Online Appendix B – Further Robustness Checks

Table B-1 reports the key instrumental variable regression re-estimated with the dependent variable in levels (rather than in growth rates). When compared to the initial specification, where patent growth-rate was used as dependent variable while also controlling for the initial patent intensity in each province, this additional specification aims to capture the dynamic effect of social capital on innovation in a complementary manner. 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.

Columns 1, 2 and 3 in Table B-1 report the estimation results using, respectively, the number of patents per million of inhabitants in 2002, 2005 and 2007 as dependent variables[19], while 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 social capital and innovation and show that it is stronger over time, highlighting a path-dependency/cumulative effect of social capital on innovation.

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

Table B-1 - On line : Further Robustness Checks (1): Estimation of the Empirical Model: Regional Knowledge Production Function with Social Capital: Level of Patents (2002, 2005, 2007)

	(1)	(2)	(3)
Dep.Var.:	**Patents (level in 2002)**	**Patents (level in 2005)**	**Patents (level in 2007)**
	2SLS	**2SLS**	**2SLS**
Social Capital	4.395***	4.024***	4.456***
	(1.498)	(1.419)	(1.029)
Private R&D	-0.0297	-0.0228	0.0050
	(0.143)	(0.152)	(0.155)
Graduates	0.485	-0.472	0.0558
	(0.482)	(0.343)	(0.513)
Spatial lag of Social Capital	-0.809*	0.180	-0.0523
	(0.414)	(0.190)	(0.192)
Female unemployment	0.0962	-0.157	-0.0406
	(0.109)	(0.106)	(0.158)
Employment in agriculture	0.159	0.241	0.226
	(0.224)	(0.169)	(0.163)
Employment in industry	0.218	0.0030	0.311
	(0.393)	(0.376)	(0.315)
Population density	0.274***	0.255***	0.367***
	(0.0998)	(0.0980)	(0.0775)
Spatial lag of population density	-0.0401	-0.0289	-0.0303
	(0.0414)	(0.0469)	(0.0463)
Macro-regional dummies	YES	YES	YES
Constant	2.871*	-0.101	1.398
	(1.744)	(1.391)	(2.010)
Observations	97	103	103
R-squared	0.492	0.541	0.550

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

The robustness of our result is further tested against changes in the specification of our estimation equation by re-estimating the instrumental variable regression and progressively eliminating all control variables (Table B- 2). This showed that the effect of social capital remains consistent in all specifications of the model independently of the inclusion of additional regressors suggesting that social capital has an independent

effect on innovation above and beyond its potential second order effect on physical and human capital.

Table B-2-Online: Further Robustness Checks (2): Estimation of the Empirical Model: Regional Knowledge Production Function with Social Capital: Annual growth rate of regional patenting (2001-2007)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep.Var.: Patent growth	**2SLS**	**2SLS**	**2SLS**	**2SLS**	**2SLS**	**2SLS**	**2SLS**
Social Capital	0.458***	0.424***	0.425***	0.431***	0.446***	0.439***	0.480***
	(0.0742)	(0.0932)	(0.0946)	(0.0966)	(0.101)	(0.0988)	(0.111)
Patents (level in 2001)	-0.0771***	-0.0735***	-0.0758***	-0.0764***	-0.0771***	-0.0768***	-0.0772***
	(0.0113)	(0.0110)	(0.0122)	(0.0119)	(0.0121)	(0.0123)	(0.0132)
Private R&D	0.0023	0.0116	0.0120	0.0122	0.0152	0.0161	
	(0.0140)	(0.0141)	(0.0147)	(0.0145)	(0.0138)	(0.0131)	
Graduates	0.0239	0.0419	-0.0190	-0.0238	-0.0244		
	(0.0649)	(0.0693)	(0.0600)	(0.0559)	(0.0581)		
Spatial lag of Social capital	-0.0174	-0.0188	-0.0184	-0.0175			
	(0.0171)	(0.0194)	(0.0211)	(0.0204)			
Female unemployment	0.0107	0.0178	0.0052				
	(0.0189)	(0.0198)	(0.0151)				
Employment in agriculture	0.0228	0.0250					
	(0.0151)	(0.0164)					
Employment in industry	0.0573*	0.0814**					
	(0.0340)	(0.0391)					
Population density	0.0372***						
	(0.0091)						
Spatial lag of population density	-0.0008						
	(0.0030)						
Macro-regional dummies	YES	YES	YES	YES	YES	YES	YES
Constant	0.194	0.489*	0.143	0.117	0.109	0.178***	0.147***
	(0.278)	(0.277)	(0.202)	(0.181)	(0.190)	(0.0506)	(0.0507)
Observations	97	97	97	97	97	97	97
R-squared	0.209	0.173	0.144	0.134	0.105	0.113	0.035

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

Online Appendix C – Spatial autocorrelation tests

Figure C.1. - Moran's I test on the dependent variable (Patents' growth rate)

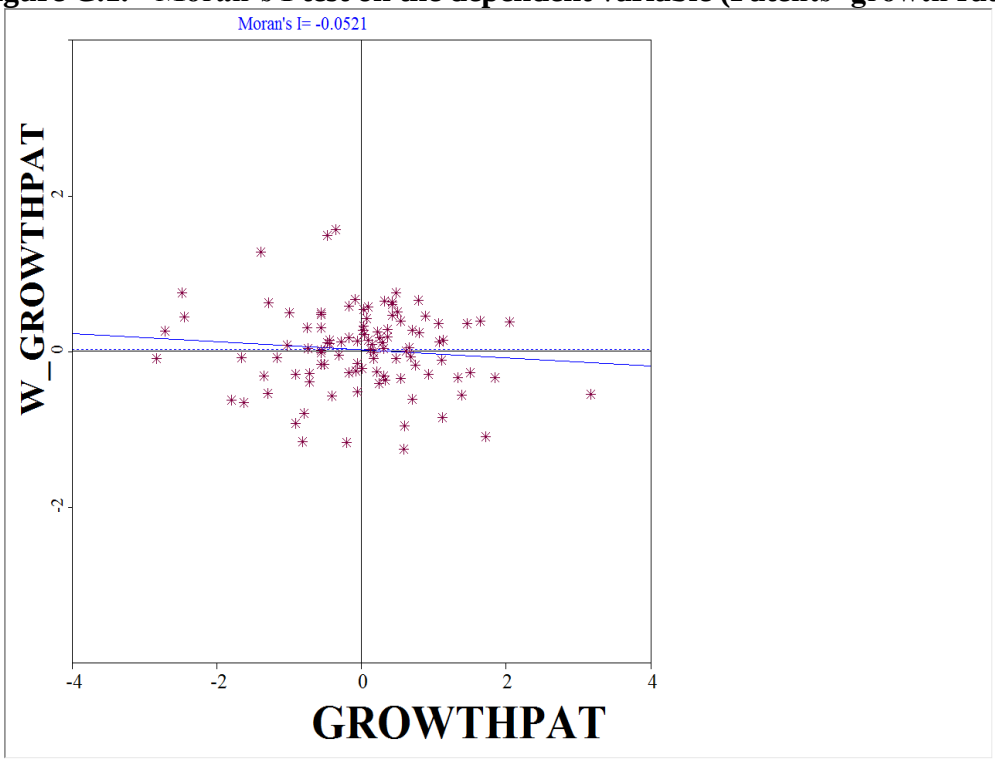
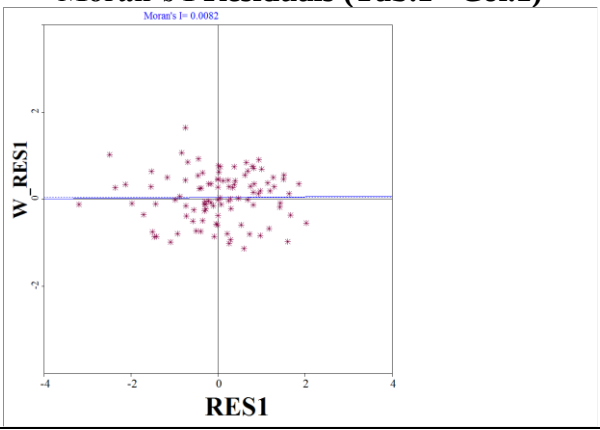
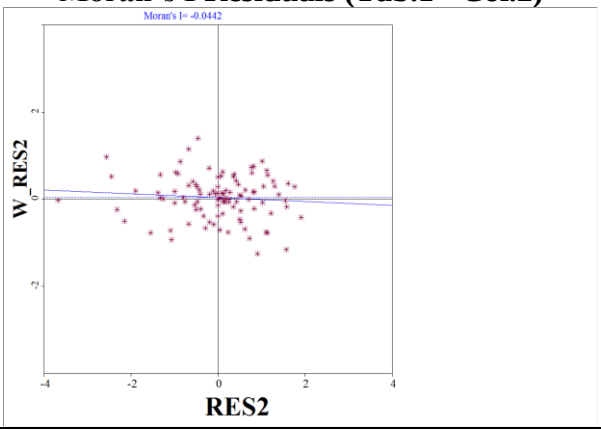
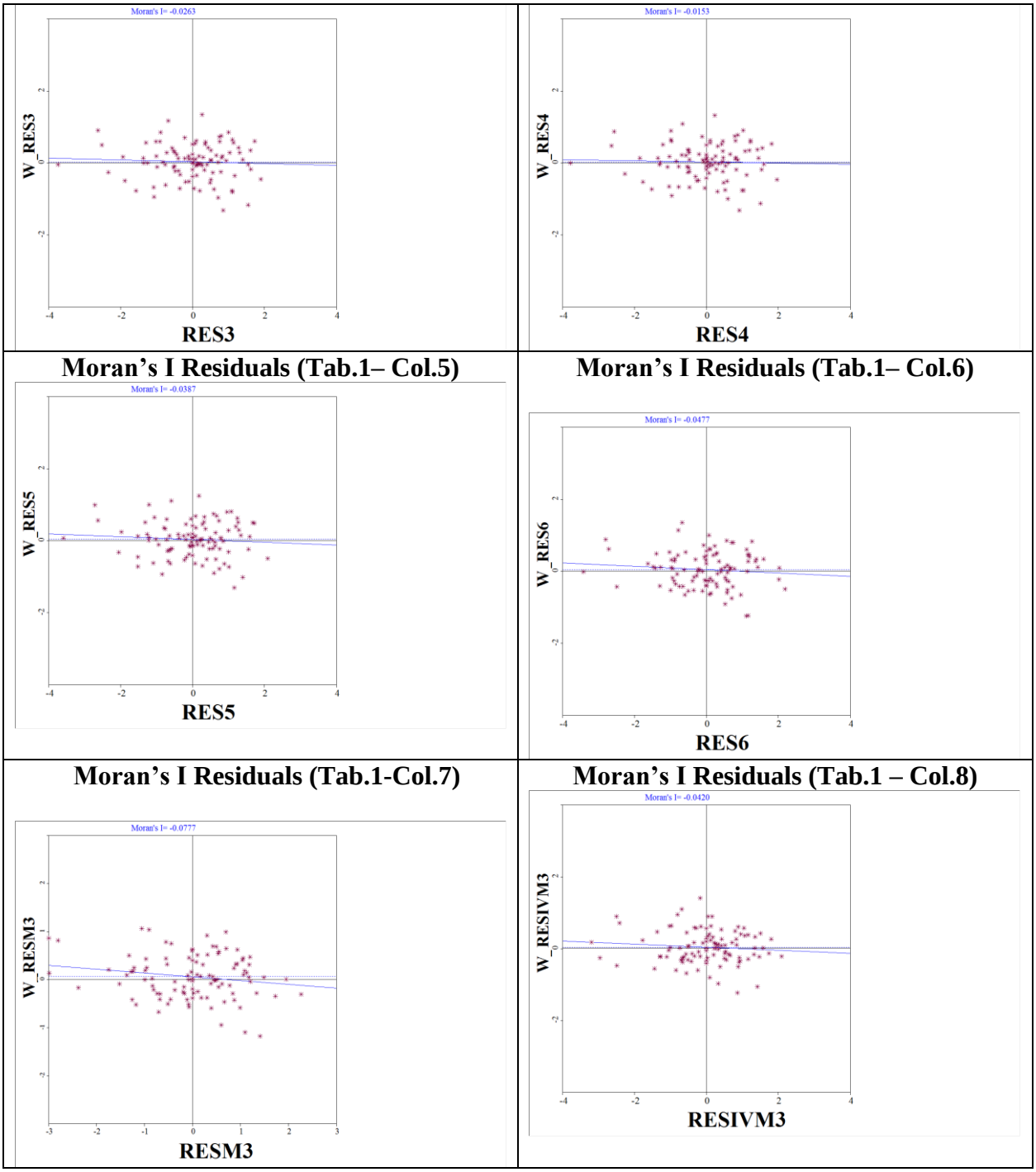


Figure C.2 – Moran's I Test for the Regression Residuals

Moran's I Residuals (Tab.1 - Col.1)	Moran's I Residuals (Tab.1 - Col.2)
	
Moran's I Residuals (Tab.1- Col.3)	**Moran's I Residuals (Tab.1 – Col.4)**



Moran's I Residuals (Tab.1– Col.5)

Moran's I Residuals (Tab.1– Col.6)

Moran's I Residuals (Tab.1-Col.7)

Moran's I Residuals (Tab.1 – Col.8)