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ORIGINAL PAPER

Social capital and regional innovation in the aftermath of crisis: evidence from Italian provinces

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Abstract
This paper investigates how regions' innovation responses to economic crises vary with their level of social capital. Combining the literature on innovation along the business cycle with that about the role of social capital in spurring regional innovation, we argue that higher social capital levels should enhance the regions' innovative resilience to crises, particularly for their bridging social capital. Using a diff-in-diff approach on Italian provinces (NUTS3) with respect to the 2007 recession, we find that provinces with higher bridging social capital exhibit lesser drops in innovation post-crisis, confirming expectations. However, bonding social capital does not show a similar effect.

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1 Introduction

The recent developments in the business cycle have highlighted that economic crises, particularly those stemming from unforeseen financial shocks, affect firms' innovation in diverse ways, either hindering or catalyzing it across different times and national settings (Archibugi et al. 2010; 2013). The innovation response to a crisis is also heterogeneous across sub-national contexts, with regions showing variable levels of resilience to it also in terms of their innovative outcomes (Bristow & Healy 2018; Muštra et al. 2020). Such a variability of innovation responses can be accounted by different regional factors, spanning from the structure and patterns of local production activities to the configuration of the regional knowledge base, and passing through the setting up of science and technology policies (Holl & Rama 2015). More in general, the literature about the economic resilience of places, of which that about their innovation resilience represents a specific stream, is already quite abundant. The array of territorial factors that have been found to affect local resilience—like tangible and intangible capital, human capital and education, urbanization economies, and geographical patterns of production—has received wide attention across different European countries (Giannakis & Bruggeman 2017), also in dedicated special issues (e.g., Di Caro & Fratesi 2018). However, their investigation is still open. Among these factors, little if no attention has been so far paid to the role of regional social capital, in its different variants. While social capital has been showed to be an important driver of regional innovation in "normal" times (Kobeissi et al. 2023) as well as a crucial shield with which regions can resist and react to economic crises in general (Antonietti & Boschma 2021), the specific interconnection of these two roles of social capital has been so far neglected. Considering the importance of innovation for regional growth, and the related need to keep innovation alive also along adverse phases of the business cycle, this gap of knowledge reveals unfortunate. Indeed, significant evidence about the role of social capital in fostering the innovation resilience of regions to crises would provide policy makers with an additional leverage to contrast its dampening effects.

In trying to fill this gap, we combine different streams of literature and argue that crises can be expected to make regions increase their access to and activation of their local social capital for the sake of innovation, attenuating the stifling effect that the former could exert on the latter. By reviewing the literature on the different configurations of social capital regions can be endowed with, we also posit that the positive moderation effect social capital can play on the innovation impact of the crisis should be greater for its "bridging" than "bonding" variant. Indeed, the weak ties the former induces among heterogeneous partners increase the variety of the knowledge inputs available in their hosting locations; while, the strong ties that mark the latter could even lead local communities to reduce their exposure to innovative concepts in the aftermath of a crisis.

We empirically examine these arguments by revisiting the impact of the global financial crisis on Italian provinces (i.e., NUTS3 regions) in 2007. Although it may

appear distant in the present context, we retain that our novel examination of this historical moment still holds the potential to provide valuable insights into fostering local social capital for promoting innovative and resilient responses to economic crises.

By combining different sources of data, we obtain a new panel dataset of 103 Italian provinces from 2003 to 2012, with respect to which we have been able to obtain information about regional innovation outcomes, regional levels of social capital, and a set of control variables. Using a (relatively) high level of (bridging and bonding) social capital for regions as a treatment, we run a diff-in-diff model with respect to the burst of the crisis in 2007 and find that our arguments are generally confirmed, with some interesting nuances.

The rest of the paper is structured as follows. Section 2 reviews the streams of literature the paper refers to and, by combining them, it puts forward our research hypotheses. Section 3 illustrates the dataset and the identification strategy. Section 4 illustrates its results and Sect. 5 concludes.

2 Background literature

2.1 Economic crises and innovation across regions

The economic literature about the unfolding of innovation in the aftermath of a crisis has a long history. Starting with the seminal contribution by Joseph Schumpeter (1939), downturns in the business cycles have received increasing attention as enabling vs. hampering conditions of firms' innovation. Though the focus has also been placed on previous economic crises (see, for example, Alvarez et al. 2010; Candido et al. 2016), the analysis of their role in affecting innovation has known an important acceleration with the burst of the mortgage sub-prime crises in 2007–2009 (Kanerva & Hollanders 2009; Filippetti & Archibugi 2011; Paunov 2012; Archibugi et al. 2013), on which we focus in the present work. Indeed, while other dramatic crises have subsequently hit economic systems across the globe, these have displayed very special and exceptional traits—being pandemic (the Covid19 one) or warlike (the Ukrainian, and the Israel vs. Palestine one)—and have affected innovation mainly through other factors than inherently economic ones (Gong et al. 2020; Abi Younes et al. 2020), on which we instead focus. Despite its apparent temporal remoteness, the mortgage sub-prime one still represents the prototype of a crisis set off by the level of advancement and interconnectedness of economic and financial markets, following a trajectory that may recur and is not yet entirely understood.

Looking at the literature about this and other economic crisis, two contrasting viewpoints can be identified. On one hand, some scholars argue that economic downturns serve as cleansing phases, helping to alleviate resource misallocations and organizational inefficiencies. Echoing Schumpeter's words, "[*recessions] are but temporary. They are the means to reconstruct each time the economic system on a more efficient plan*" (Schumpeter 1939, vol. 1, p. v) c). During such downturns, the reduced demand for goods and services provides a conducive environment for firms

to innovate since the relative opportunity cost of research decreases "compared to production activities (e.g., Hall 1994; Saint-Paul 1993; Aghion & Saint-Paul 1998). Additionally, investing in innovation during a crisis can enhance firm performance in the post-crisis years (Flammer & Ioannou 2021). Consequently, firms might intentionally focus on acquiring new knowledge during a crisis, triggering internal and external learning mechanisms (Archibugi et al. 2013).

On the other hand, numerous empirical studies support the view that innovation investments are pro-cyclical (e.g., Barlevy 2007; Correa & Iootty 2011; Cincera et al. 2012; Paunov 2012; Archibugi et al. 2013; Arvanitis & Woerter 2014). This view stems from the theory that firms adjust their research efforts based on the expected profitability of innovations, in line with overall demand. Innovators, aiming to maximize returns, intensify their efforts during high-demand periods (Barlevy 2007; Francois & Lloyd-Ellis 2003). Additionally, cyclic shocks negatively impact firms' cash flow, prompting a shift from riskier, long-term projects to safer, short-term investments with immediate cash flow (e.g., Hall 1992; Rafferty & Funk 2008; Kang et al. 2017). Central to this area of research is the question of which types of firms (established vs. emerging) drive innovation during and after downturns. Within the Neo-Schumpeterian framework, two perspectives emerge: "creative accumulation" and "creative destruction." The former emphasizes the role of firms' past innovation trajectories and views innovation as a continuous process driven by cumulative learning, especially in large corporations with substantial R&D investments (e.g., Dosi 1982; Nelson & Winter 1982; Antonelli 1997; Bell & Pavitt 1995; Malerba & Orsenigo 1996; Archibugi et al. 2013). The latter, "creative destruction," posits that downturns present opportunities for new firms to introduce innovative products and processes, leading to a transformative process that Schumpeter described as continuously reshaping economic dynamics from within (Schumpeter 1950 [1942]). The existing empirical literature largely confirms that the innovation process is persistent. Studies focusing on the 2008 crisis reveal that, regardless of the type of driving firms, the reduction in innovation remains marginal and short-lived during economic crises (Filippetti & Archibugi 2011; Paunov 2012; Archibugi et al. 2013; Amore 2015; Antonioli et al. 2021). Typically, any decrease in resources allocated to innovation is brief, followed by a rapid recovery.

Despite the importance of the previous findings, there remains a significant gap in understanding the influence of regional characteristics in the relationship between crisis and innovation. Within the context of the business cycle literature, exploration of the potential impacts of socio-economic characteristics of the territory on innovation activities and outcomes is still rather scant. Scholars have examined various factors influencing innovation during and after crises, ranging from national innovation systems to individual firm characteristics. For instance, Archibugi et al. (2013) analyzed data from 27 European Union member states, Norway, and Switzerland, uncovering a strong correlation between the resilience of company innovation during the 2008 crisis and the robustness of National Innovation Systems (NIS). Key determinants included highly qualified human resources, private credit availability, and a focus on high-tech manufacturing sectors. Recent studies exploring the impact of regional attributes on firm innovation behavior during crises have identified critical factors such as economic size, presence of knowledge-intensive industries,

related sector extent (Tavassoli & Karlsson 2018), public R&D funding (Cruz-Castro & Sanz-Menéndez 2016), and pre-crisis structural economic strength. In a different but related stream of literature, regions have been shown to display different degrees of resilience to crises (and external shocks), also and above all in relation to their capacity to act on their innovation (Bristow & Healy 2018; Muštra et al. 2020).

All in all, these contributions suggest that innovation would react to an economic crisis in a different way across different places. Still, given the wide set of location-related factors that have been found to shape the innovation process by the regional science literature, and the array of learning mechanisms that underpin innovation in local contexts, the set of regional factors that could matter in the relationship between crisis and innovation is larger and deserves further scrutiny. In particular, an important local factor has not yet received attention in the studies of the relationship at stake: the level and type of regional social capital. As we will argue in the following, given its relevance in making regions deal with crisis periods, this is an important gap that we aim at filling with our empirical application.

2.2 Regional social capital and innovation

Generically meant as the set of collective values, norms, and practices that foster trust and collaboration within a local community (Fukuyama 1995), social capital has been found to represent an important complement of the standard determinants of regions' innovations, like R&D, human capital and other less formal inputs of their knowledge base (Asheim & Coenen 2005). Indeed, the existing literature consistently highlights the beneficial impact of social capital on regional innovation, suggesting different mechanisms for that to happen. These include: (i) increasing individuals' relational disposition (Banfield 1958) and trust levels (Akçomak & Ter Weel 2009); (ii) the facilitated exchange of information and access to knowledge (Crescenzi et al. 2013a,b); (iii) promoting interactions, both contractual and non-contractual, while (iv) penalizing deviant behaviors (Coleman 1988; Spagnolo 1999) and reducing transaction costs (Laursen et al. 2012). Specifically, social capital (v) enables collaborative contracts and risk-taking behaviors essential in developing innovations (Kobeissi et al. 2023). Sometimes these collaborations take the form of legally recognized co-operation agreements among firms (like, Network Contracts in Italy), which facilitate their engagement in common innovation projects and increase the relative productivity gains (Caragliu & Landoni 2024). Possibly more often, social capital facilitates trust-based, informal connections among firms, which serve as an informal governance mechanism to facilitate the access to and the diffusion of innovative knowledge sources among them (Mu et al. 2008).

While all relevant, the previous mechanisms are differently associated with different kinds of social capital, on whose distinction the extant literature has been focusing since long (Dekker & Uslaner 2001; Putnam 1995). An important specification, which has appeared relevant also in its effects on innovation, is the one between "bridging" and "bonding" social capital across locations (Schuller et al. 2000). The former refers to inclusion practices and cooperative connections that help the interaction between different networks/communities of agents, typically

marked by different sociocultural traits (Schuller et al. 2000). By facilitating knowledge exchange and coordination among heterogeneous partners, this kind of social capital can be argued to increase the variety of the knowledge inputs available in their hosting locations and has been accordingly found to enhance innovation across regions (Crescenzi et al. 2013a,b). As for bonding social capital, this refers instead to the role that networking relations have in keeping together agents who already share important sociocultural commonalities, that is, trust-based relationships within close-knit groups. Unlike the former, traceable to Granovetter's idea that, through "weak ties" (1973), loosely knit networks can have access to new ideas and opportunities, the latter refers to that of "structural embeddedness." In the latter, strong ties facilitate ordinary interactions but could entail homophilic behaviors (McPherson et al. 2001) that limit the exposure to innovative concepts. Accordingly, bonding social capital has been shown to be less conducive to innovation than the bridging one across regions (Antonietti & Boschma 2021).

The role of different kinds of social capital in spurring regional innovation becomes possibly more salient in the aftermath of a crisis, determining a context conditionality in their relationship that has been unfortunately neglected so far. Similarly to natural crises on which disaster risk studies typically focus, also crises pulled by unexpected financial shocks, on which we do focus, create situations of socio-economic distress among local communities of people and make them individually more vulnerable. Because of that, in the immediate and short-run aftermath of such a kind of crisis, local communities can be expected to increase the access to and the activation of their available social capital, of both bridging and bonding kind, to resist and become resilient to the crisis (Schobert et al. 2023).[1] Indeed, this is consistent with a wide stream of literature in regional studies showing that, especially in the aftermath of the Great Recession at stake, regions marked by a higher level of social capital have been more economically resilient and more capable of reacting to it (Terzo 2021; Tsiapa 2023).

The mechanisms that motivate the role that social capital has in shaping local reactions to crises can be extended. In particular, they could be invoked also to account for the greater innovative role that we expect for social capital in the aftermath of a crisis, when compared to the pre-crisis period. Indeed, this is our focal hypothesis and the one we will test in our empirical application. The starting point of our argument draws on a resources access perspective and claims that, an adverse event like an economic crisis gives to local communities an extra-impulse, with respect to the status quo, to resort to social capital for mobilizing critical resources for the sake of innovation (Donoghue & Sturtevant 2007). In other words, a crisis and the entrepreneurial opportunities that it creates by destroying the pre-crisis equilibrium spur local communities to access and activate the innovation role of available social capital to a greater extent: either to further increase innovation or to

[1] In the medium and long-run, crises can also be expected to affect the strength of local social capital and modify its level (see, for example, Iglič et al. 2021). Still, this would occur once communities have tried to resort and activate their local available one soon after.

attenuate its pro-cyclical reduction. This could be in principle true for both bridging and bonding social capital.

As for the former, a crisis can lead regional players to make a more intense and innovative use of the relationships across (i.e., bridging) different groups and organizations that, before of its burst, could have been under-exploited for the sake of innovation. While bridging social capital could have already been in place and stimulated the innovative exploitation of weak ties, the pressure to recovery could make the search of their innovative benefits more intense. Similarly, as for bonding social capital, a crisis can make regions more compelled to draw on the innovation enabling role played by the mechanisms of financial risk sharing and of (tacit) information spread allowed by strong ties within pre-existing socio-economic groups. In so doing, the innovative power of the available bonding social capital of regions can be exploited more effectively in the aftermath of a crisis. While this could hold true in principle, we should also retain that, as we have noted above, the available bonding social capital of regions can also induce local communities to pursue sectarian and/or internal lobby behaviors, which can hamper their capacity to mobilize and recombine internal resources for the sake of innovation (Cortinovis et al. 2017; Crescenzi et al. 2013a, b). As this could also occur to a greater extent in the attempt of getting protection from the crisis, the innovative role of bonding social capital could be also dampened by a crisis, and its net effect be thus possibly smaller than that of bridging social capital.

All in all, based on the previous arguments, we expect that high levels of both bridging and bonding social capital can shield regions from economic shocks by inducing them to exploit more their innovation potential. In other words, we maintain that the relationship between regional social capital and innovation should be stronger after than before the crisis. In testing this hypothesis, we contribute to the literature on regional resilience from an evolutionary perspective (Martin & Sunley 2015; Boschma 2017; Liang 2017). Furthermore, we also contribute to those studies that consider regional responses to crises, including recovery in innovation outcomes and industrial dynamics (Antonietti & Boschma 2021).

3 Data

3.1 Data sources and variables

We have assembled a panel dataset encompassing information on regional innovation outcomes, social capital level, and a set of control variables to account for determinants of innovation levels across different geographical areas, focusing on the period before and after the 2007 financial crisis. The unit of analysis in our dataset is at the province-year level (i.e., NUTS3).[2] As a result of our selection criteria,

[2] This choice of this unit of analysis is motivated by the intersection of data availability, granularity in the analysis of territorial aspects, and comparability with previous studies (e.g., Crescenzi et al. (2013a, b), Antonietti, R., & Boschma (2021), Terzo (2021).

and considering available data, we have focused our analysis on 103 Italian provinces from 2003 to 2012. As mentioned earlier, this period may seem somewhat distant to consider in the present day. However, on the one hand, extending too far the analysis beyond this period could introduce confounding factors unrelated to the crisis itself—such as subsequent economic shocks, structural policy changes, or unrelated technological advancements—which might bias the specific crisis-related effects we seek to identify. On the other hand, we believe that our novel analysis of that historical period could still offer valuable insights into how local social capital can be cultivated to promote innovative and resilient responses to economic crises.

The main dependent variable in our study is regional technological innovation. While social capital has been recently argued to be possibly more salient in conducing non-technological innovation of a softer kind—like marketing and branding innovations, especially in cultural and creative industries (Dellisanti 2023)—which could be proxied with trademarks (Hasan et al. 2020), our choice has two motivations. First, we wanted to obtain results that could be comparable with previous studies on social capital and innovation, which have mainly focused on the technological one. Second, at the NUTS3 level of analysis we are employing, granular data about trademarks at the local level are unfortunately not directly available. Following this choice, we first measure regional innovation with the natural logarithm (ln henceforth) of patent applications (*lnPatents*). We sourced our patent application data from the European Patent Office (EPO), as provided in EUROSTAT's 'Science and Technology' section. The latter offers detailed information, allowing us to identify patent applications at the NUTS3 region level, hence at the province-year level. We adopt a common practice in the field by calculating patent counts based on application years rather than grant years. This methodological choice is underpinned by the recognition that application years offer a more precise reflection of the actual timing of innovation, regardless of procedural delays.[3]

To make our analysis more robust and nuanced, we also employ a range of alternative measures still derived from patent application data. More precisely, we compute a set of innovation intensities at the province-year level, including *lnPatPop* (defined as ln of the ratio of patent applications to population), *lnPatFir* (ln of the ratio of patent applications to the number of firms), *lnPatGDP* (ln of the ratio of patent applications to GDP), and *lnPatRD* (ln of the ratio of patent applications to R&D firms). Considering *lnPatFir* we may provide insights into the role

[3] We use patent applications as a measure of innovation despite its acknowledged limitations in capturing the full scope of innovation (Arundel & Kabla 1998; Griliches 1998). These limitations stem from the fact that not all innovations are patented, firms may prefer secrecy over applying for a patent or exploit their lead time to establish market dominance before competitors can catch up (Cohen et al. 2000). Moreover, companies may engage in strategic patenting, such as patenting simply to block competitors or to create a portfolio for litigation or negotiation purposes, rather than for actual innovation (Grindley & Teece 1997; Hall & Ziedonis 2001; Ziedonis 2004). Despite these limitations, patents are still a widely accepted and utilized indicator for assessing variations in innovation across different regions. This is mainly attributed to the criteria of novelty, non-obviousness, and industrial applicability, among others, which ensure the substantial appropriateness of this innovation measure.

of innovation in shaping the business landscape. Moreover, exploring *lnPatGDP* informs on the contribution of innovation to the overall economic output. Lastly, examining *lnPatRD* helps assessing the effectiveness of R&D initiatives in fostering innovation.

Regarding the measures of social capital, we utilize a variety of data sources. We derive bonding social capital (*BondingSC*) using the methodology proposed by Antonietti and Boschma (2021), which leverages data from the European Value Study (EVS). The EVS is a comprehensive cross-sectional survey that explores human values across Europe. This method addresses potential limitations commonly found in direct survey-based measures due to the extensive scale of the survey. By examining voluntary membership in specific association categories (such as political parties, trade unions, and professional associations), we can gauge individuals' involvement in 'Olson groups'. These groups are indicative of rent-seeking behavior, as noted in studies by Cortinovis et al. (2017) and Antonietti & Boschma (2021). Unlike Antonietti & Boschma (2021), we focus solely on the 1999 wave of the EVS to capitalize on the 'exogeneity' of characteristics that were established before the crisis period. We calculate the ratio of respondents participating in at least one of these association categories to the total number of respondents in the NUTS2 region. This ratio is then scaled by the number of resident family units in the NUTS3 region, thus providing a measure of *Bonding SC* at the NUTS3 level. As an alternative bonding social capital measure, we consider the frequency of meetings with friends in their spare time (Geraci et al. 2022) in each province.

As for bridging social capital (*BridgingSC*), following the extant literature, this is quantified by the number of non-profit associations per 100 inhabitants in each province. As an alternative bridging social capital measure, we consider the number of associations registered to CONI (i.e., the Italian National Olympic Committee) per 100 inhabitants in each province. Both bridging social capital measures are recorded by ISTAT (i.e., the Italian National Institute of Statistics) in the 2001 census and are widely recognized in academic literature for their direct observation of subjects' voluntary behaviors, which are considered reliable indicators of social network dynamics and norms. This approach is employed by Cartocci (2007), Guiso et al. (2008), and Nannicini et al. (2013).

For the sake of our identification strategy, we categorize provinces according to their levels of *BridgingSC* and *BondingSC*. Provinces are classified as having *High-BridgingSC* (*HighBondingSC*) if their reported levels fall within the third tercile, representing the uppermost distribution of *BridgingSC* (*BondingSC*). Conversely, provinces are considered to have *LowBridgingSC* (*LowBondingSC*) if their measures are situated in the first or second terciles, indicating lower distributions of social capital. This classification allows us to systematically examine the influence of varying degrees of social capital measures on the outcomes of interest. Robustness checks are performed by classifying provinces as HighBridgingSC (HighBondingSC) if their reported levels fall within the top quartile. Figures 1 and 2 show the geographical distribution of the terciles of non-profit associations per capita and the share of individuals affiliated with political parties, trade unions, and professional

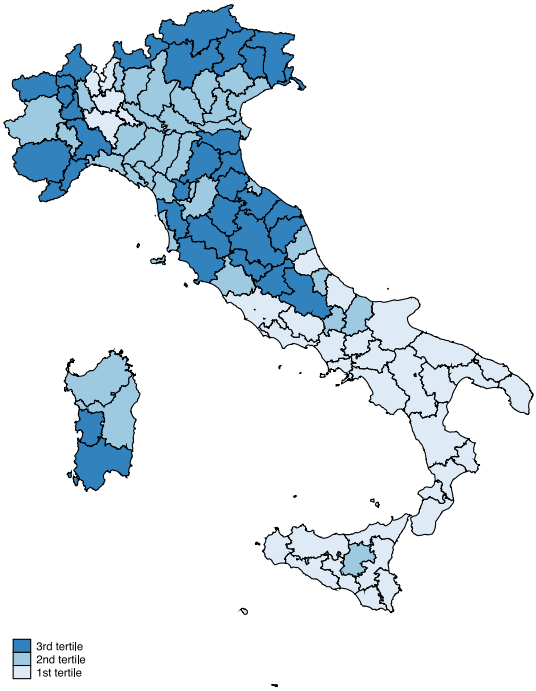

Fig. 1 Bridging social capital—terciles of non-profit associations per capita

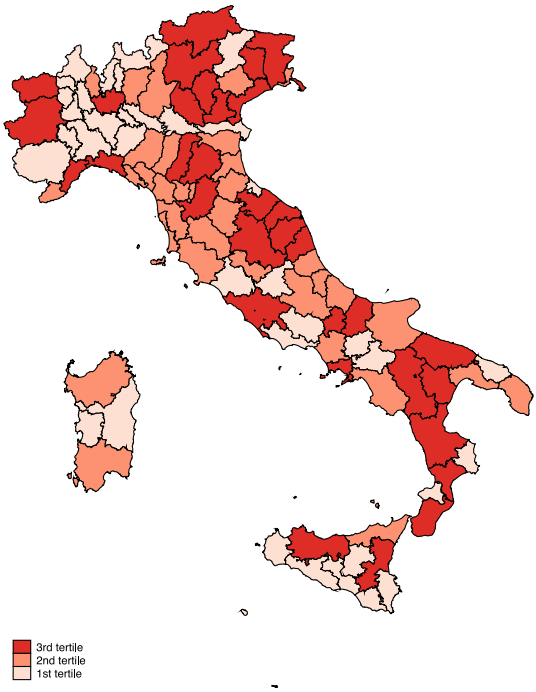

Fig. 2 Bonding social capital—terciles of share of individuals affiliated with political parties, trade unions and professional associations

associations, respectively.[4] Quite interestingly, Fig. 1 reveals that provinces with high levels of bridging social capital are located in the North-Centre of the country, while those with the more bonding social capital are more geographically widespread.

Our dataset comprises a variety of control variables at the province level that are sourced from ISTAT. These variables are included to account for a range of economic, institutional, and social factors that could affect patenting activity.

We include a measure of R&D firms (*lnRDFir*) as it is a critical factor influencing innovation outcomes. Engaging in R&D activities enhances the ability to secure intellectual property rights and amplifies the possibilities for subsequent research to leverage technological advancements (Miroshnychenko & De Massis 2020; Cohen & Levinthal 1989). Furthermore, R&D investment fosters the aggregation of key knowledge, establishing a robust absorptive capacity that becomes the foundation for generating novel technological breakthroughs (Lewin et al. 2011; Miller et al. 2007).

Considering that both regional innovation and social capital are localized phenomena, we have included controls for population density. This factor is crucial as it can enhance regional innovation through agglomeration and knowledge spillover effects (Chen et al. 2020), and bolster social capital by promoting denser social networks and increased social interactions. Population density (*PopDen*) is calculated as the ratio of the population in a province to its total land area in square kilometers.

Additionally, we factor in two key indicators of regional economic development: the ln of the gross value-added per capita (*lnGVA*) and the unemployment rate (*un_rate*). These measures control for the links between innovation and the value of economic production and local labor market conditions, respectively (Montresor & Quatraro 2017; Cappelli et al. 2021).

The presence of big banks, which are adept at managing risky credit costs, serves as a proxy for credit market conditions (King & Levine, 1993). This control variable is important since the quality of the local credit market can influence regional investment in innovation, especially given the uncertainties associated with intangible outcomes. Furthermore, regions with advanced financial development, characterized by high levels of trust and civic engagement, often indicate greater social capital, as shown by Guiso et al. (2004). We quantify this aspect using the ratio of big banks (those with a total value of traded funds exceeding EUR 26 billion) to the total number of banks in each region (*big_banks*).

We have also included measures that capture the quality of both the institutional and social environments. The efficiency of the judicial system is gauged by the average duration (in days) of a bankruptcy trial (*trial*). This metric may reflect the impact of the institutional framework on innovation (Varsakelis, 2006; Tebaldi & Elmslie, 2008). Additionally, we use newspaper circulation

[4] The list of provinces in the top tercile of Bridging and Bonding Social Capital are reported in Table A2.

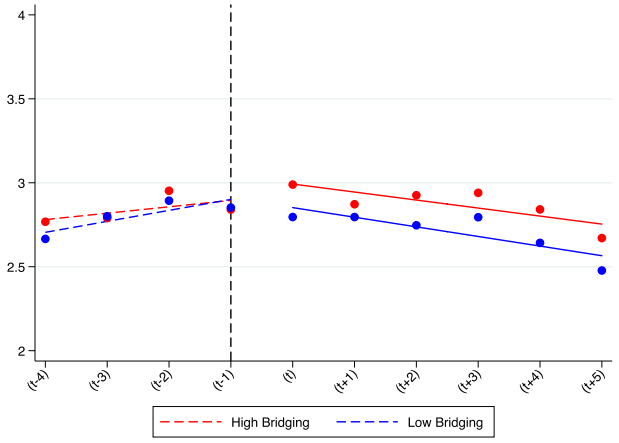

Fig. 3 Trends in lnpatents—high vs low bridging social capital

(*newspapers*), quantified as the number of newspapers per 1000 inhabitants, as a proxy for the quality of the cultural and local environment.

To capture linkages with foreign markets that may potentially foster technology spillovers and stimulating local innovation through like technological learning and competition mechanisms (Fassio 2018), we control for the share of local exports relative to GDP (*Exp_GDP*).

Lastly, we include the proportion of inhabitants with tertiary and post-secondary educational attainments to account for the innovation-enhancing role of human capital (Faggian et al. 2019). However, these variables (*TerEdu* and *PostSecEdu*) are measured at the NUTS2 level, given that this information is missing at the provincial level for some years at the beginning of our sample. Table 8 provides a comprehensive overview of the data sources and variables used in the analysis.

3.2 Identification strategy

Our identification strategy rests on three key elements. First, the availability of reliable data on patent applications at the NUTS3 level. Second, the exogeneity and uniform geographical impact of the 2007 financial and economic crisis, which serves as a substantial shock to the regional economies. Third, the expectation that provinces with higher levels of social capital exhibit a comparatively lesser decline in innovation (patenting activity) following the crisis compared to regions with lower social capital. These premises form a crucial aspect of our identification strategy.

Pertaining to the first point, as discussed in the previous paragraph, despite patents' limitations in capturing innovation across all industries, we utilize patent counts as a standard measure for regional innovation due to the absence of a universally accepted metric (e.g., Jaffe & Trajtenberg 2002). Additionally, in adherence to the territoriality principle governing patent laws, innovators aiming to secure

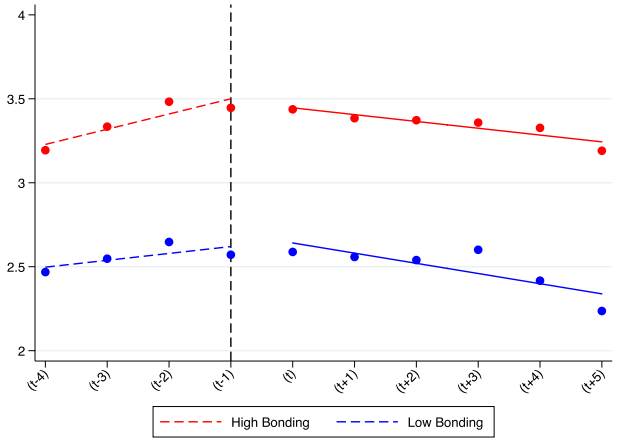

Fig. 4 Trends in lnpatents—high vs low bonding social capital

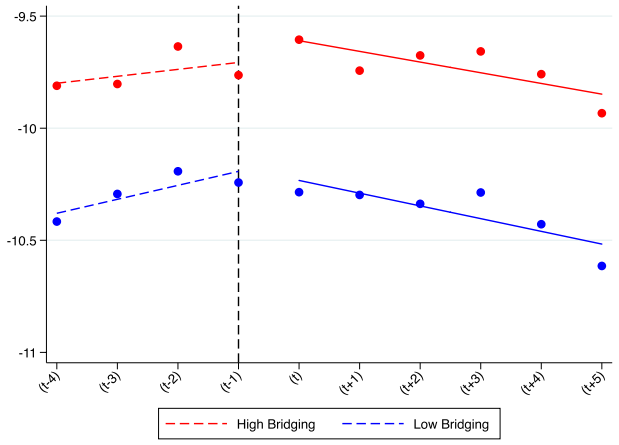

Fig. 5 Trends in lnpatpop—high vs low bridging social capital

exclusive rights for their inventions across European regions file patent applications with the EPO. Given the European Union's longstanding status as a prominent global technology consumer market, it is conventionally assumed, as widely recognized in the literature, that important innovations emerging from major players would find representation through patents within the EU.

As for the second element, the 2007 economic crisis unfolded unexpectedly and affected regions, regardless of their social capital levels, making it an ideal event for comparative analysis. This crisis, originating in the United States and swiftly spreading worldwide, caught the credit market unprepared, including Italy's market. This is evident in the sharp increase in the difference between interbank interest rates, indicating a notable shift in banking system liquidity and counterparty risk.

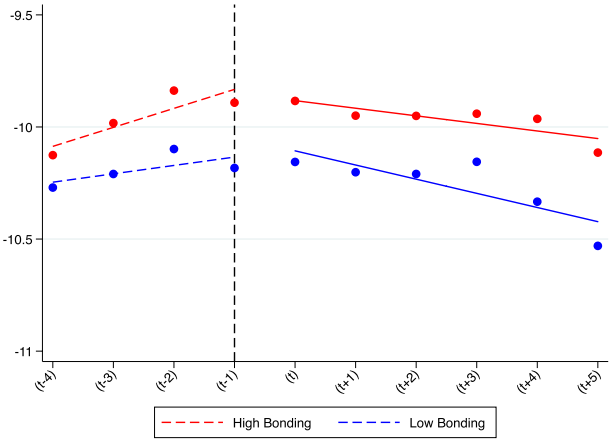

Fig. 6 Trends in lnPatPop—high vs low bonding social capital

The subsequent loss of confidence among financial institutions directly impacted their lending practices, leading to a tightening of credit standards, as indicated by the European Central Bank (ECB) and the Bank Lending Survey (BLS) diffusion index (ECB 2008; Trichet 2010).

Figures 3, 4, 5, 6 depict the linear fit of key dependent variables, specifically *lnPatents* and *lnPatPoP*, over time, distinguishing between provinces with high (third tercile) and low (first and second terciles) levels of *BridgingSC* and *BondingSC*. Figures 3 and 5 show that *HighBridgingSC* provinces show no evident anticipation effect. During this phase, both the counts and intensity of patents display an increasing trend from 2004 to 2006. In the year preceding the crisis, the linear fits for *lnPatPoP* (Fig. 5) proceed in parallel, while those for *lnPatents* (Fig. 3) align or almost overlap, suggesting the possibility that the parallel trend assumption may be applicable to the high and low *Bridging SC* groups. However,

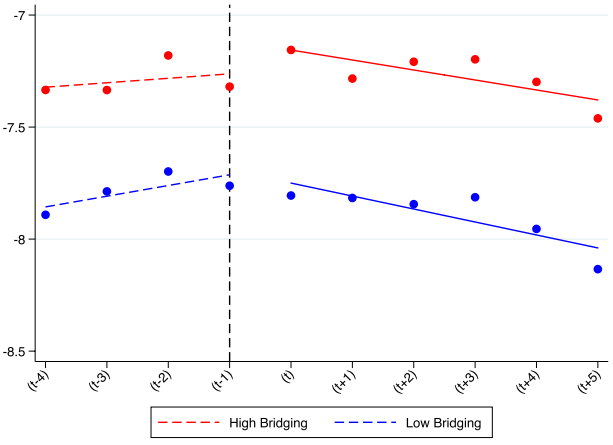

Fig. 7 Trends in lnPatFir—high vs low bridging social capital

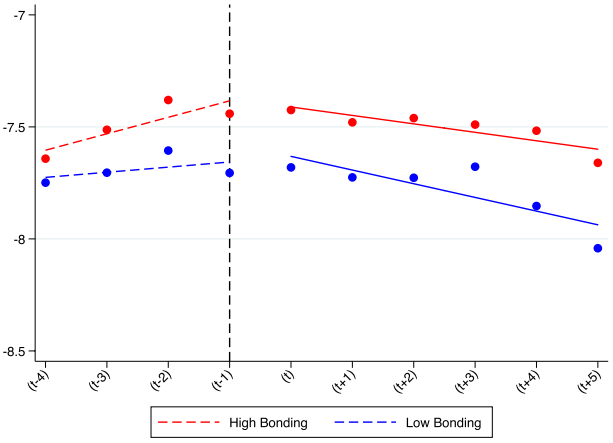

Fig. 8 Trends in lnPatFir—high vs low bonding social capital

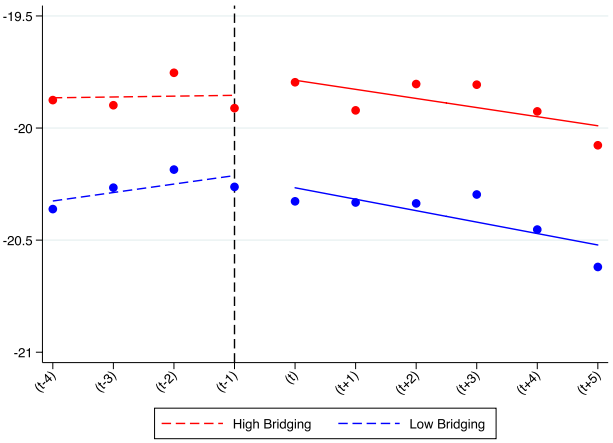

Fig. 9 Trends in lnPatGDP—high vs low bridging social capital

the upward trend halts abruptly around 2008 (possibly starting in 2007), shifting to a downward trend and indicating a significant change in innovation dynamics.

Figures 4 and 6 showcase the linear fits for the dependent variables in regions with high and low levels of *BondingSC*, revealing a similar pattern of an initial rise (before the crisis) followed by a decline (after it). However, it is important to note that, unlike with *BridgingSC*, the pre-crisis trends for bonding social capital do not follow parallel paths. This discrepancy may suggest that the method used to measure bonding social capital could lack precision, potentially explaining the observed divergence in trends for the outcome variables. Similar conclusions can be drawn for the alternative innovation outcome variables, as illustrated in Figs. 7, 8, 9, 10, 11, 12.

In addressing the third aspect, our analysis—drawing on both descriptive evidence (Figs. 3, 4, 5, 6) and statistical analysis (Tables 1 and 2)—unveils larger

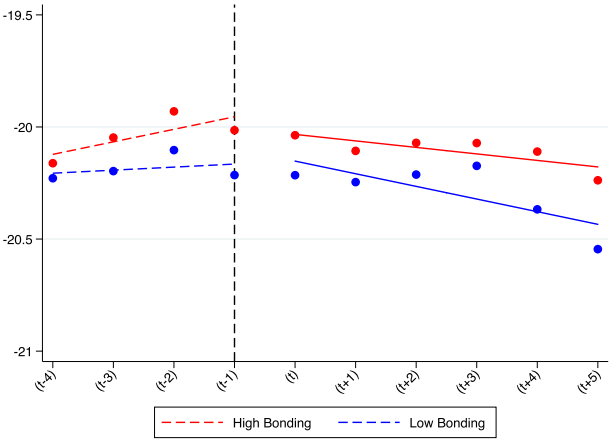

Fig. 10 Trends in lnPatGDP—high vs low bonding social capital

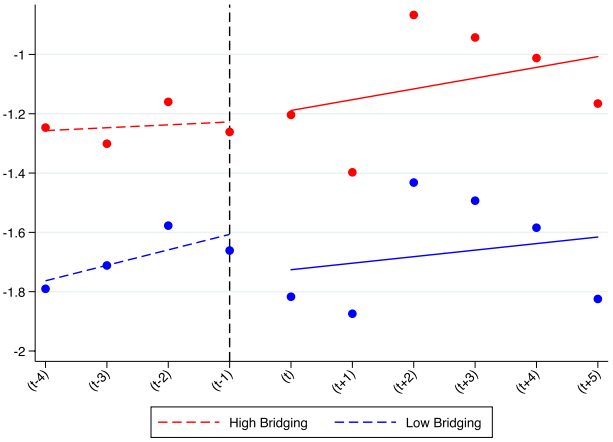

Fig. 11 Trends in lnPatRD—high vs low bridging social capital

differences in outcome variables between regions characterized by high versus low levels of social capital measures after the crisis, in contrast to the period before the crisis. Specifically, when we examine the differences in the average of our principal dependent variables between high and low *BridgingSC* regions (as detailed in Table 1), and compare them between the post- and the pre-crisis, we find that the difference in *lnPatents* increase by approximately 15 percentage points (pp) ([2.93 – 2.71] – [2.87 – 2.80]). Similarly, the difference in *lnPatPop* between high and low social capital regions shows an augmentation, from after to before the crisis, of around 14 pp (([−9.70 – (−10.38)] – [−9.75 – (−10.29)]). When analyzing the data for high versus low *BondingSC* groups (Table 2), we notice an uplift in *lnPatents* and *lnPatPop* by approximately 8 pp and 9 pp, respectively.

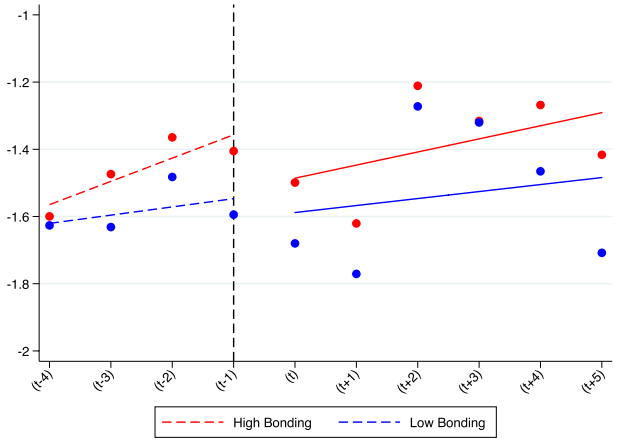

Fig. 12 Trends in lnPatRD—high vs low bonding social capital

It is crucial to note, however, that these findings, while indicative of notable differences, represent preliminary evidence derived from descriptive analyses. As such, they should not be interpreted as causal inferences but rather as prima facie evidence. (Tables 1 and 2).

3.3 The difference in difference estimator

In order to draw such a causal inference, we deploy a Difference-in-Difference (DiD) estimation approach based on the following model:

$$Y_{it} = \alpha + \beta HighBridgingSC_i \times Crisis_t + \gamma HighBondingSC_i \times Crisis_t + X_{it}\vec{\theta} + \tau_t + u_i + \varepsilon_{it}$$

where i and t refer to the province and the year, respectively. Y indicates the innovation outcome. As aforementioned, *HighBridgingSC* (*HighBondingSC*) is an indicator variable informing on whether a province belongs to the top tercile of *BridgingSC* (*BondingSC*). *Crisis* is also a dummy, which takes value 1 if year ≥ 2007. The vector X'_{it} includes all control variables introduced in Section Data. Time-invariant heterogeneity at the provincial level is captured by u (province Fixed Effect, FE).

Our goal is to estimate the parameters β and γ, which represent our treatment effects. Positive values of β and γ would suggest that provinces with *HighBridgingSC* and *HighBondingSC* have outperformed their counterparts (with low social capital) in terms of innovation outcomes when compared to the period before the crisis. Essentially, such positive estimates would highlight a superior performance (i.e., lower drop in innovation outcomes) for provinces with higher levels of social capital measures, relative to their respective reference groups, in the aftermath of the crisis.

The DiD estimation approach relies on the assumption of pre-treatment (pre-crisis) parallel trends in the outcome variables between treatment (*HighBridgingSC* or *HighBondingSC)* and control (complementary subset) groups. In the previous section we

Table 1 Descriptive statistics: high vs low bridging social capital, before- and after-crisis

	High bridging social capital			Low bridging social capital		
	N	Mean	SD	*N*	Mean	SD
Before crisis						
Depvars						
lnPatents	136	2.87	1.11	276	2.80	1.62
lnPatPop	136	−9.75	0.89	276	−10.29	1.27
lnPatFir	136	−7.28	0.87	276	−7.78	1.18
lnPatGDP	136	−19.87	0.78	276	−20.27	1.04
lnPatRD	136	−1.24	0.76	276	−1.69	0.94
Controls						
lnRDFir	136	4.14	0.71	276	4.54	0.98
pop_den	136	155.38	181.70	276	298.81	405.26
lnGVA	136	8.84	0.56	276	9.17	0.86
un_rate	136	0.05	0.02	276	0.88	0.05
big_banks	136	0.31	0.13	276	0.40	0.16
trial	136	99.44	23.61	276	108.07	23.39
newspapers	136	126.39	34.25	276	99.75	47.79
exp_GDP_ratio	136	0.22	0.10	276	0.17	0.14
TerEdu	136	0.13	0.02	276	0.12	0.02
PostSecEdu	136	0.31	0.03	276	0.30	0.03
After-crisis						
Depvars						
lnPatents	204	2.93	1.10	414	2.71	1.61
lnPatPop	204	−9.70	0.84	414	−10.38	1.26
lnPatFir	204	−7.24	0.85	414	−7.89	1.19
lnPatGDP	204	−19.88	0.73	414	−20.39	1.03
lnPatRD	204	−1.08	0.74	414	−1.67	0.94
Controls						
lnRDFir	204	4.03	0.74	414	4.41	1.03
pop_den	204	156.96	179.32	414	299.08	391.70
lnGVA	204	8.84	0.58	414	9.16	0.87
un_rate	204	0.06	0.03	414	0.09	0.05
big_banks	204	0.29	0.12	414	0.37	0.15
trial	204	100.00	21.76	414	108.36	22.75
newspapers	204	110.40	35.31	414	88.57	45.23
exp_GDP_ratio	204	0.23	0.13	414	0.20	0.17
TerEdu	204	0.15	0.02	414	0.14	0.02
PostSecEdu	204	0.33	0.03	414	0.33	0.03

discussed the plausibility of this assumption for our key outcome variables (*lnPatents* and *lnPatPop*). Additional statistical analysis further supports this, as none of the estimated pre-crisis coefficients being statistically significant in Figs. 13, 14, 15, 16. Furthermore, similar analyses have been conducted on the alternative innovation outcome

Table 2 Descriptive statistics: high vs low bonding social capital, before− and after−crisis

Before crisis						
	High bonding social capital			Low bonding social capital		
	N	Mean	SD	*N*	Mean	SD
Depvars						
lnPatents	136	3.37	1.62	276	2.56	1.32
lnPatPop	136	−9.94	1.21	276	−10.19	1.17
lnPatFir	136	−7.47	1.12	276	−7.69	1.10
lnPatGDP	136	−20.04	0.99	276	−20.19	0.98
lnPatRD	136	−1.45	0.92	276	−1.658	0.90
Controls						
lnRDFir	136	4.88	1.11	276	4.18	0.70
pop_den	136	377.83	571.85	276	189.19	122.22
lnGVA	136	9.52	0.96	276	8.85	0.57
un_rate	136	0.07	0.05	276	0.08	0.04
big_banks	136	0.40	0.18	276	0.35	0.14
trial	136	101.47	26.11	276	107.07	22.37
newspapers	136	113.49	45.13	276	106.11	45.57
exp_GDP _ratio	136	0.18	0.12	276	0.19	0.13
TerEdu	136	0.12	0.02	276	0.12	0.02
PosSec Edu	136	0.31	0.03	276	0.31	0.03
After−crisis						
Depvars						
lnPatents	204	3.37	1.56	414	2.49	1.32
lnPatPop	204	−9.93	1.20	414	−10.26	1.16
lnPatFir	204	−7.46	1.14	414	−7.78	1.11
lnPatGDP	204	−20.08	0.97	414	−20.29	0.96
lnPatRD	204	−1.35	0.93	414	−1.54	0.91
Controls						
lnRDFIr	204	4.78	1.10	414	4.04	0.78
pop_den	204	371.86	550.46	414	193.19	128.15
lnGVA	204	9.52	0.96	414	8.82	0.58
un_rate	204	0.08	0.04	414	0.08	0.04
big_banks	204	0.36	0.16	414	0.34	0.14
trial	204	102.22	25.64	414	107.26	21.02
newspapers	204	101.64	41.89	414	92.89	43.91
exp_GDP_ratio	204	0.19	0.13	414	0.22	0.17
TerEdu	204	0.14	0.02	414	0.15	0.02
PostSecEdu	204	0.33	0.03	414	0.33	0.03

variables that we have proposed, which largely confirm that no significant differences emerge between the treated groups and controls prior to the 2007 crisis (see Figs. 17, 18, 19, 20, 21, 22). Figures 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 display the point estimates for *HighBridgingSC* and *HighBondingSC* for each year from 2003 to 2012,

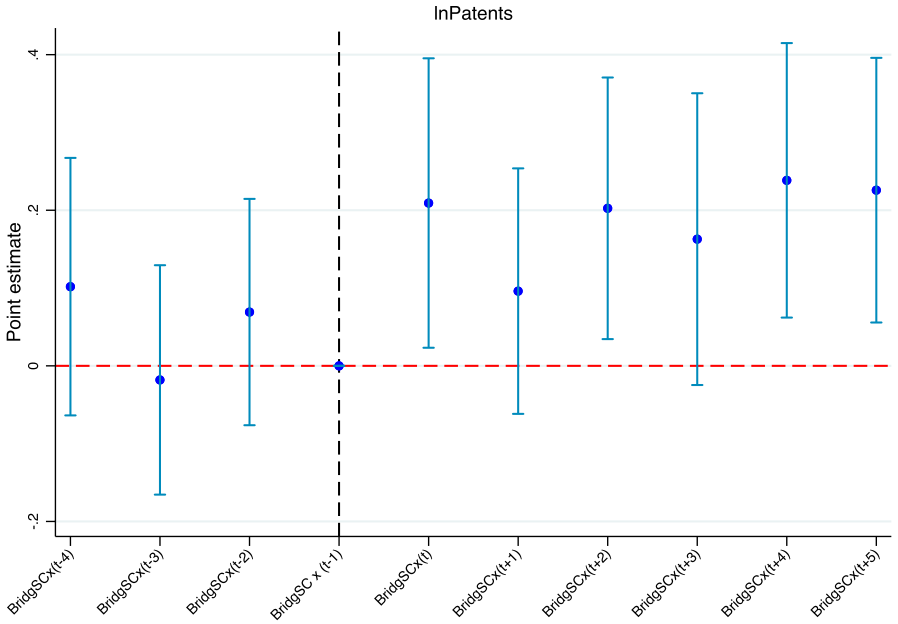

Fig. 13 Testing parallel trends, depvar: lnpatents—high vs low bridging social capital *Note*: This figure presents the event study analysis spanning from 2003 to 2012. The dependent variable is the number of patent applications (logarithmic scale). The interaction terms BridgSC$\times(t+\tau)$ combine bridging social capital endowments—specifically, an indicator variable set to 1 for provinces in the top tercile of bridging social capital distribution—with annual indicator variables. The period t marks the onset of the 2007 crisis, with a black vertical dashed line delineating the pre-crisis from the post-crisis periods. The analytical model incorporates province- and year-fixed effects. The figure illustrates point estimates of BridgSC$\times(t+\tau)$, representing the impact of social capital levels in specific years, alongside 90% confidence intervals (denoted in blue)

alongside their 90% confidence intervals. The onset of the 2007 crisis is marked by a black vertical dashed line, visually delineating the pre-crisis from the post-crisis periods. These estimates are derived from conducting an event study analysis over the sample period. In this analysis, *HighBridgingSC* and *HighBondingSC* are interacted with annual dummies to pinpoint the specific effects of interest for each year, while controlling for all covariates included in the previously mentioned DiD model.

Finally, as part of our robustness checks, we also perform the DiD model by computing Conley spatial HAC standard errors (Conley, 2008) to account for both spatial and serial correlations of social capital indicators. We define the spatial lag as 200 km and set the temporal lag to 10 years, corresponding to the full span of our observational period.[5]

[5] The correlogram analysis, as depicted in Table A2, supports the selection of a 200-km spatial lag. This analysis demonstrates that the spatial correlation of social capital levels diminishes significantly beyond a 200-km radius from the centroid of the main city in each province.

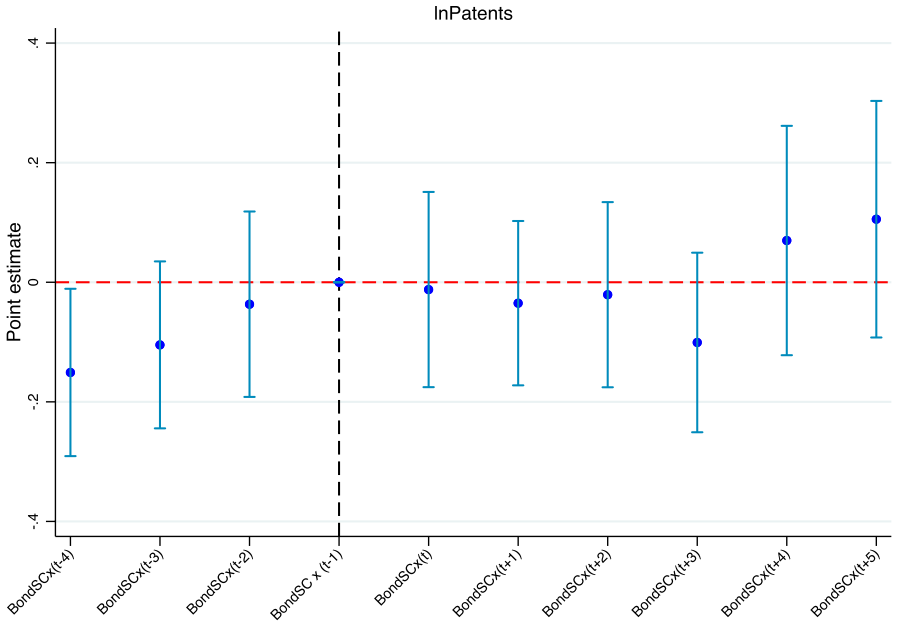

Fig. 14 Testing Parallel Trends, Depvar: lnPatents—High vs Low Bonding Social Capital *Note*: This figure presents the event study analysis spanning from 2003 to 2012. The dependent variable is the patent intensity measured as the number of patent applications (logarithmic scale). The interaction terms BondSC$\times$(t$+\tau$) combine bonding social capital endowments—specifically, an indicator variable set to 1 for provinces in the top tercile of bonding social capital distribution—with annual indicator variables. The period t marks the onset of the 2007 crisis, with a black vertical dashed line delineating the pre-crisis from the post-crisis periods. The analytical model incorporates province- and year-fixed effects. The figure illustrates point estimates of BondSC$\times$(t$+\tau$), representing the impact of social capital levels in specific years, alongside 90% confidence intervals (denoted in blue)

4 Results

4.1 Main results

The main estimation results are displayed in Table 3. For clarity, those tables are organized into two subpanels. The left panel, columns *(i)* to *(iii)*, presents the results for *lnPatents*; while, the right panel, columns *(iv)* to *(vi)*, shows the results for *lnPatPop*. Specifications are gradually augmented and enable us to assess whether and to what extent the sequential inclusion of controls impacts our estimates of interest. All models include province FE; columns *(i)* and *(iv)* represent the baseline specifications, columns *(ii)* and *(v)* incorporate the controls mentioned in the Data section; columns *(iii)* and *(vi)* refer to the fully specified models, which also accounts for the 1-year lagged dependent variable.

Our main results support the prima facie evidence discussed in Sect. 3.2. We find consistent and statistically significant evidence of a distinction in innovation performance between the treated and control groups during the post-crisis period. Notably, provinces with higher levels of pre-crisis bridging social capital showed a greater

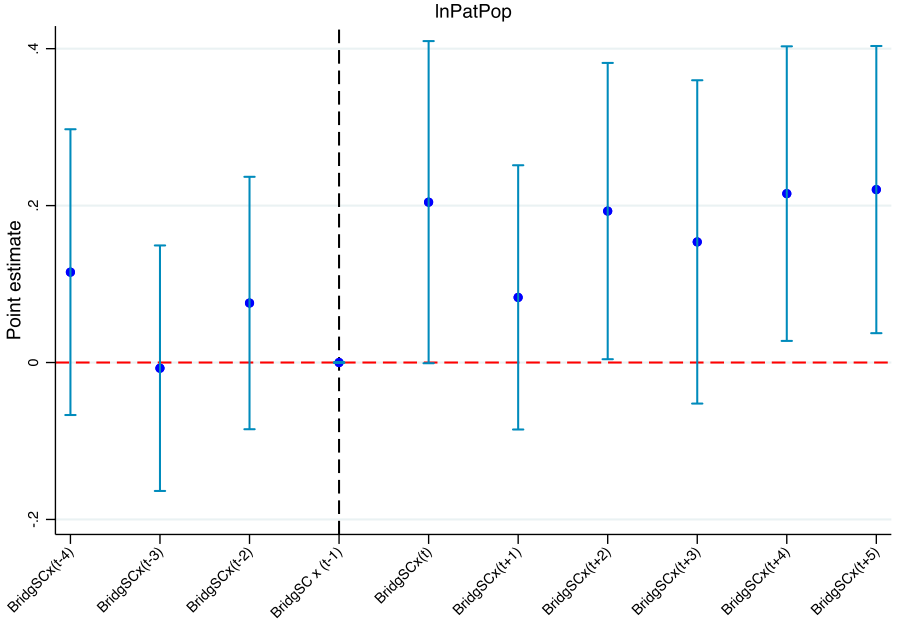

Fig. 15 Testing Parallel Trends, Depvar: lnPatPop—High vs Low Bridging Social Capital *Note*: This figure presents the event study analysis spanning from 2003 to 2012. The dependent variable is the number of patent applications scaled to the population (logarithmic scale). The interaction terms BridgSC$\times(t+\tau)$ combine bridging social capital endowments—specifically, an indicator variable set to 1 for provinces in the top tercile of bridging social capital distribution—with annual indicator variables. The period t marks the onset of the 2007 crisis, with a black vertical dashed line delineating the pre-crisis from the post-crisis periods. The analytical model incorporates province- and year-fixed effects. The figure illustrates point estimates of BridgSC$\times(t+\tau)$, representing the impact of social capital levels in specific years, alongside 90% confidence intervals (denoted in blue)

ability to navigate through the crisis and initiated more innovative endeavors afterward. Specifically, the key outcome variables (*lnPatents* or *lnPatPop*), measuring patenting activities in provinces with high bridging social capital (*HighBridgingSC*), were approximately 15 to 14 pp higher compared to their counterparts. In contrast, provinces with high bonding social capital (*HighBondingSC*) did not exhibit a similar advantage. Among the control variables, newspaper circulation and GVA consistently show positive and significant coefficients, indicating a positive relationship with both the absolute and per capita number of patent applications registered at the provincial level. The estimates for the other control variables are either insignificant or negligible. This may be due to the inclusion of province fixed effects (FE), which likely capture much of the remaining variation in the dependent variable. The stable and relatively high adjusted R-squared values (≥ 0.90) further confirm the model's effectiveness in explaining variations in innovation at the NUTS3 level.

Several arguments can support and contextualize our findings. Provinces with high levels of bridging social capital prior to the crisis possessed both tangible and intangible assets crucial for not just surviving economic downturns, but also for emerging with innovative solutions that facilitate post-crisis recovery. Consistently

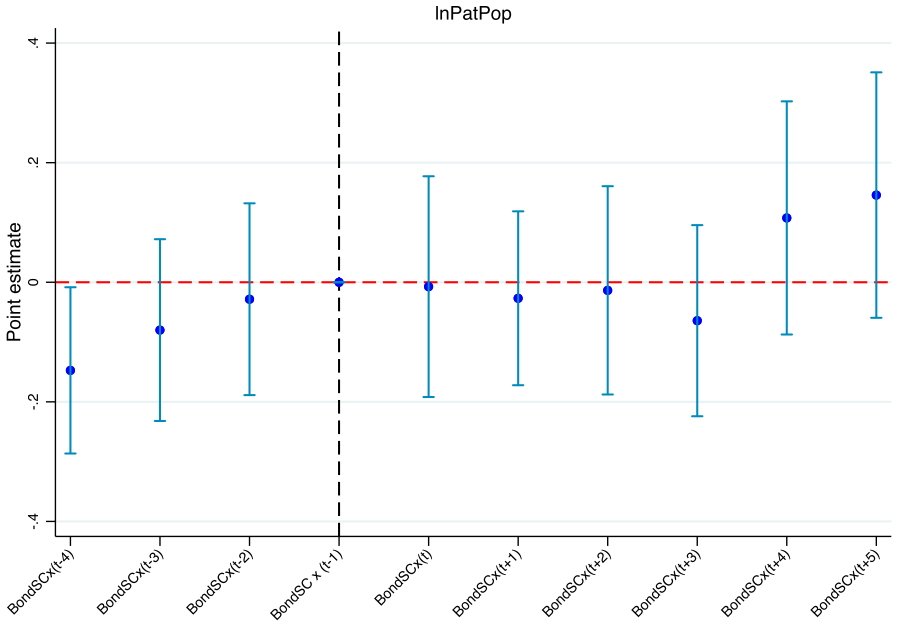

Fig. 16 Testing Parallel Trends, Depvar: lnPatPop—High vs Low Bonding Social Capital *Note*: This figure presents the event study analysis spanning from 2003 to 2012. The dependent variable is the patent intensity measured as the number of patent applications scaled to the population (logarithmic scale). The interaction terms BondSC$\times(t+\tau)$ combine bonding social capital endowments—specifically, an indicator variable set to 1 for provinces in the top tercile of bonding social capital distribution—with annual indicator variables. The period t marks the onset of the 2007 crisis, with a black vertical dashed line delineating the pre-crisis from the post-crisis periods. The analytical model incorporates province- and year-fixed effects. The figure illustrates point estimates of BondSC$\times(t+\tau)$, representing the impact of social capital levels in specific years, alongside 90% confidence intervals (denoted in blue)

with the theoretical predictions (Crescenzi et al. 2013a,b; Antonietti & Boschma 2021), *HighBridgingSC* provinces benefited from robust networks of trust and communication, which streamlined the flow of information. This dynamic allowed firms to more efficiently discern opportunities and threats. Moreover, these social networks provided enhanced access to essential resources such as capital, labor, and knowledge, enabling a swifter mobilization of these assets during crises. This support underpinned both ongoing and novel business activities, including R&D and innovation initiatives.

In the midst of a crisis, the activation of these networks (i.e., the activation of bridging social capital) apparently became even more pronounced, offering critical and timely insights crucial for rapid adaptation and innovation. The crisis arguably led locals to better exploit existing (high) levels of bridging social capital to undertake co-operation and collective action, leading to shared problem-solving, resource pooling, and coordinated efforts to diminish the crisis effects and catalyze innovative solutions. Furthermore, as *HighBridgingSC* provinces arguably exhibited cultural norms conducive to innovation and risk-taking, the crisis might have motivated

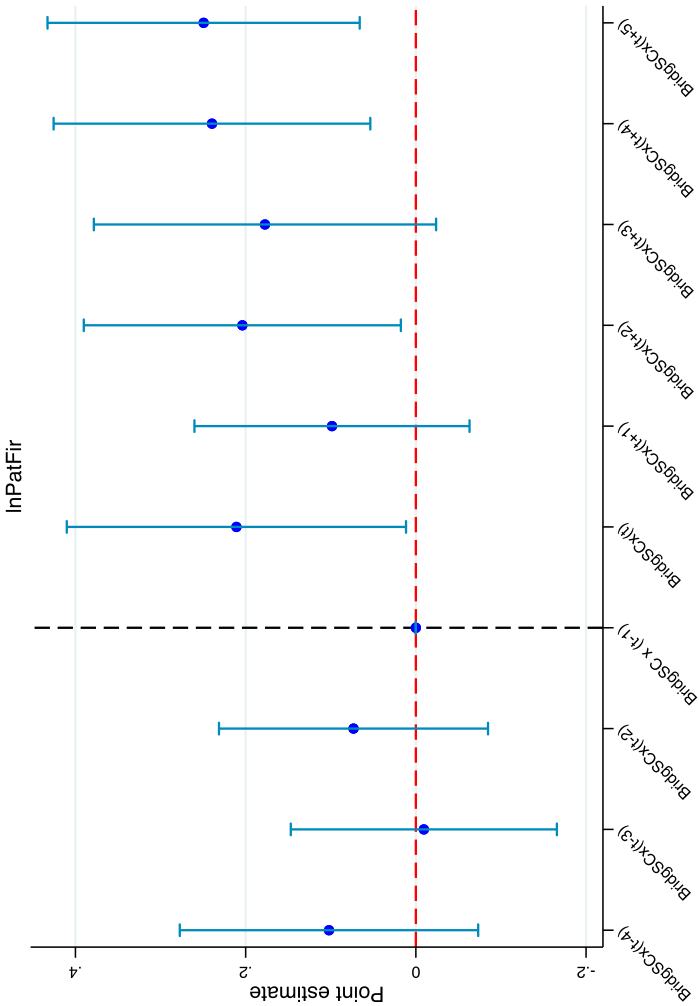

Fig. 17 Testing Parallel Trends, Depvar: lnPatFir—High vs Low Bridging Social Capital *Note*: This figure presents the event study analysis spanning from 2003 to 2012. The dependent variable is the number of patent applications scaled to the number of active firms (logarithmic scale). The interaction terms BridgSC$\times$(t+τ) combine bridging social capital endowments—specifically, an indicator variable set to 1 for provinces in the top tercile of bridging social capital distribution—with annual indicator variables. The period t marks the onset of the 2007 crisis, with a black vertical dashed line delineating the pre-crisis from the post-crisis periods. The analytical model incorporates province- and year-fixed effects. The figure illustrates point estimates of BridgSC$\times$(t+τ), representing the impact of social capital levels in specific years, alongside 90% confidence intervals (denoted in blue)

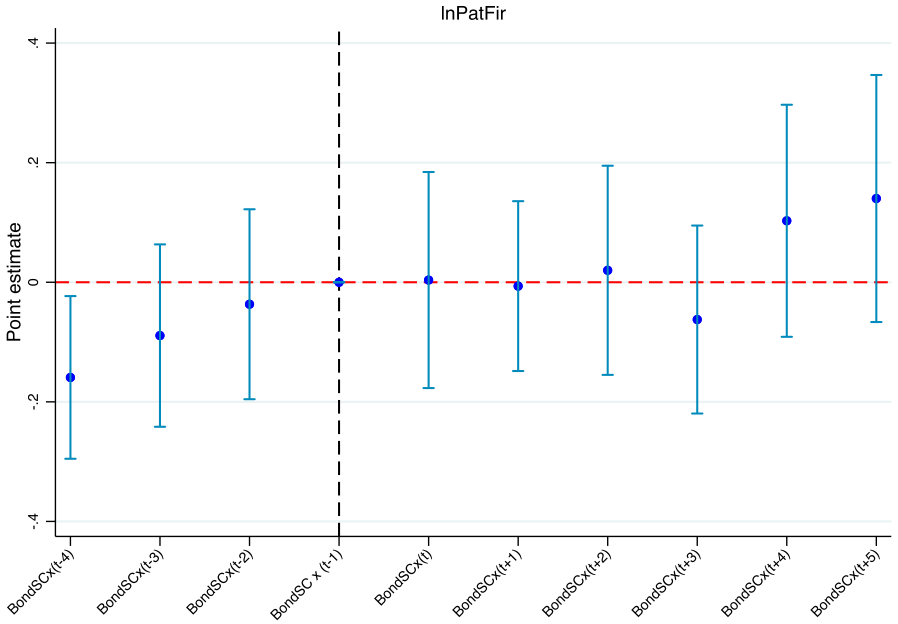

Fig. 18 Testing Parallel Trends, Depvar: lnPatFir—High vs Low BondingSocial Capital *Note*: This figure presents the event study analysis spanning from 2003 to 2012. The dependent variable is the patent intensity measured as the number of patent applications scaled to the number of active firms (logarithmic scale). The interaction terms BondSC$\times(t+\tau)$ combine bonding social capital endowments—specifically, an indicator variable set to 1 for provinces in the top tercile of bonding social capital distribution—with annual indicator variables. The period t marks the onset of the 2007 crisis, with a black vertical dashed line delineating the pre-crisis from the post-crisis periods. The analytical model incorporates province- and year-fixed effects. The figure illustrates point estimates of BondSC$\times(t+\tau)$, representing the impact of social capital levels in specific years, alongside 90% confidence intervals (denoted in blue)

individuals and firms to use these norms to explore new ideas and innovations, responding proactively to the challenges posed by the crisis.

While bridging social capital does appear to foster broader interactions and the exchange of diverse ideas in the aftermath of the crisis, in the same scenario bonding social capital does not seem to inherently create the conditions conducive to more significant innovation. As we have noted in the literature section, bonding social capital typically involves homogenous groups whose members share similar backgrounds, perspectives, and knowledge. And such homogeneity can normally restrict access to a variety of ideas (Coleman 1988), diminishing the cross-pollination of thoughts critical for sparking innovation. Our results show that, with the advent of the crisis, these innovation dampening effects of bonding social capital, shared by provinces with the highest levels of it, have apparently counteracted the innovation enabling ones that, at least theoretically, the crisis can also be thought to stimulate by increasing the access to bonding social capital (see the literature section). Indeed, as a result of that, a higher level of the same kind of social capital, does not provide to provinces neither an advantage nor a disadvantage with respect to lower-level provinces facing the crisis.

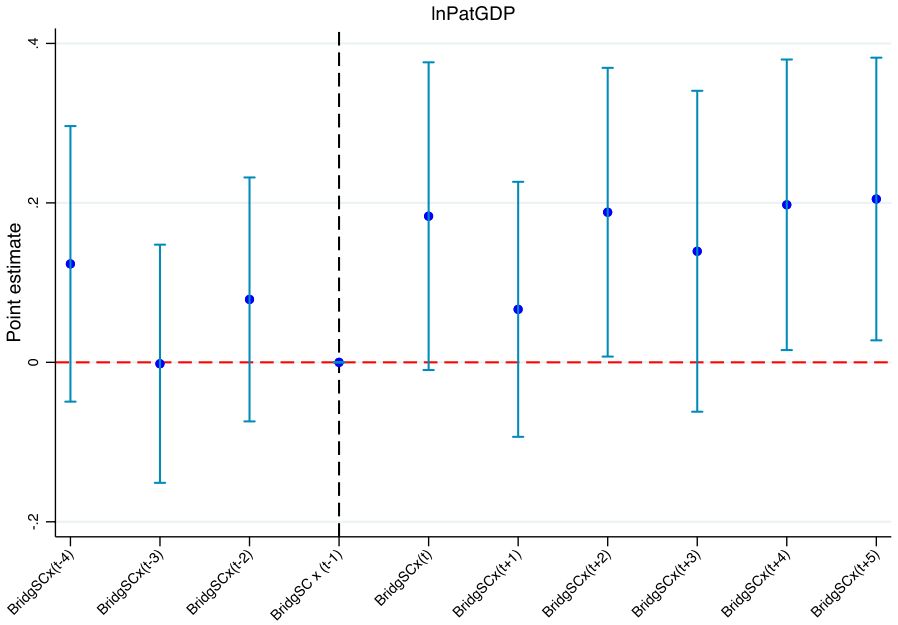

Fig. 19 Testing Parallel Trends, Depvar: lnPatGDP—High vs Low Bridging Social Capital *Note*: This figure presents the event study analysis spanning from 2003 to 2012. The dependent variable is the patent intensity measured as the number of patent applications scaled to the GDP (logarithmic scale). The interaction terms BridgSC$\times(t+\tau)$ combine bridging social capital endowments—specifically, an indicator variable set to 1 for provinces in the top tercile of bridging social capital distribution—with annual indicator variables. The period t marks the onset of the 2007 crisis, with a black vertical dashed line delineating the pre-crisis from the post-crisis periods. The analytical model incorporates province- and year-fixed effects. The figure illustrates point estimates of BridgSC$\times(t+\tau)$, representing the impact of social capital levels in specific years, alongside 90% confidence intervals (denoted in blue)

In interpreting these results, we should retain that these tight-knit groups can transform into echo chambers, reinforcing existing ideas while external viewpoints struggle to find entry (Antonietti & Boschma 2021). This environment may stifle creativity and deter the critical questioning of conventional approaches, which is vital for innovation. Additionally, the strong bonds of loyalty and trust within these groups may foster risk aversion (Maskus et al. 2012), making members reluctant to embark on innovative ventures that carry the risk of failure or could disrupt the group's unity.

4.2 Sensitivity analyses

Table 4 presents results considering alternative dependent variables, namely *lnPatFir*, *lnPatGDP* and *lnPatRD*. Employing those alternative dependent variables enhances the depth and breadth of our analysis, allowing for a comprehensive exploration of the relationship between social capital and innovation performance in the aftermath of the crisis. This approach provides a more nuanced understanding of

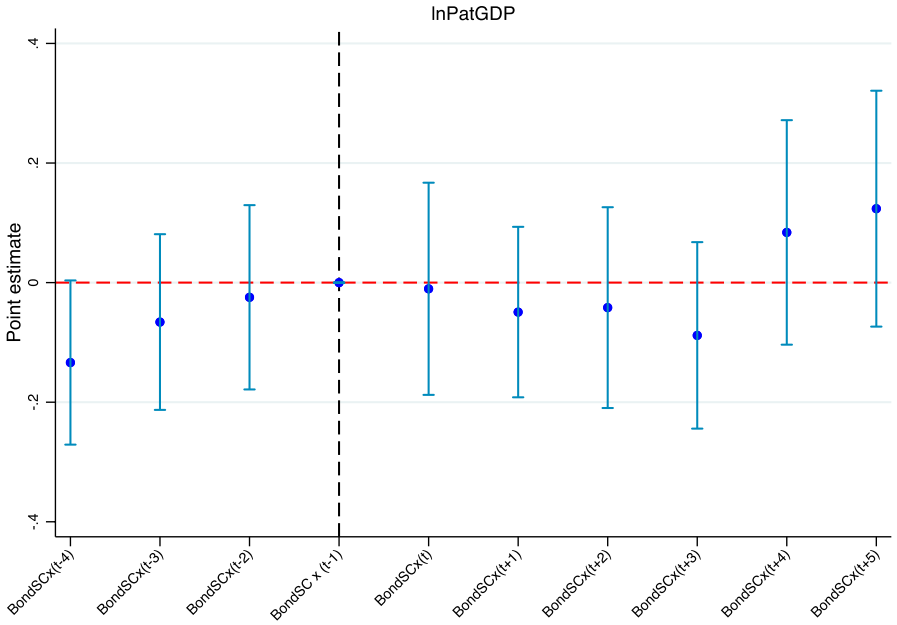

Fig. 20 Testing Parallel Trends, Depvar: lnPatGDP—High vs Low Bonding Social Capital *Note*: This figure presents the event study analysis spanning from 2003 to 2012. The dependent variable is the patent intensity measured as the number of patent applications scaled to the GDP (logarithmic scale). The interaction terms BondSC × (t + τ) combine bonding social capital endowments—specifically, an indicator variable set to 1 for provinces in the top tercile of bonding social capital distribution—with annual indicator variables. The period t marks the onset of the 2007 crisis, with a black vertical dashed line delineating the pre-crisis from the post-crisis periods. The analytical model incorporates province- and year-fixed effects. The figure illustrates point estimates of BondSC × (t + τ), representing the impact of social capital levels in specific years, alongside 90% confidence intervals (denoted in blue)

this at the province level. Specifically, we observe that *HighBridgingSC* provinces display innovation performance levels that are approximately 12 to 16 pp higher with respect to their counterparts in the complementary sample. Conversely, no significant differences are observed for *HighBondingSC* provinces.

To offer a more comprehensive understanding of the influence of various facets of social interactions on regional innovation dynamics, Table 5 details the results for alternative measures of social capital. Specifically, *BridgingSC* is represented by the number of CONI associations per 100 inhabitants in a province; while, *BondingSC* is measured by the frequency of people aged 6 and older meeting friends at least once a week per 100 inhabitants in the same area. The findings in Table 5 corroborate those presented in Tables 3 and 4, further emphasizing the crucial role that high levels of bridging social capital play in navigating regions through economic crises and boosting their innovation capabilities post-crisis. The impact on innovation outcomes varies between 13 and 15 pp, depending on the specific outcome variables considered, highlighting the importance of bridging social capital in driving regional innovation performance during challenging economic times. Interestingly, the coefficient for bonding social capital, though not statistically significant, carries

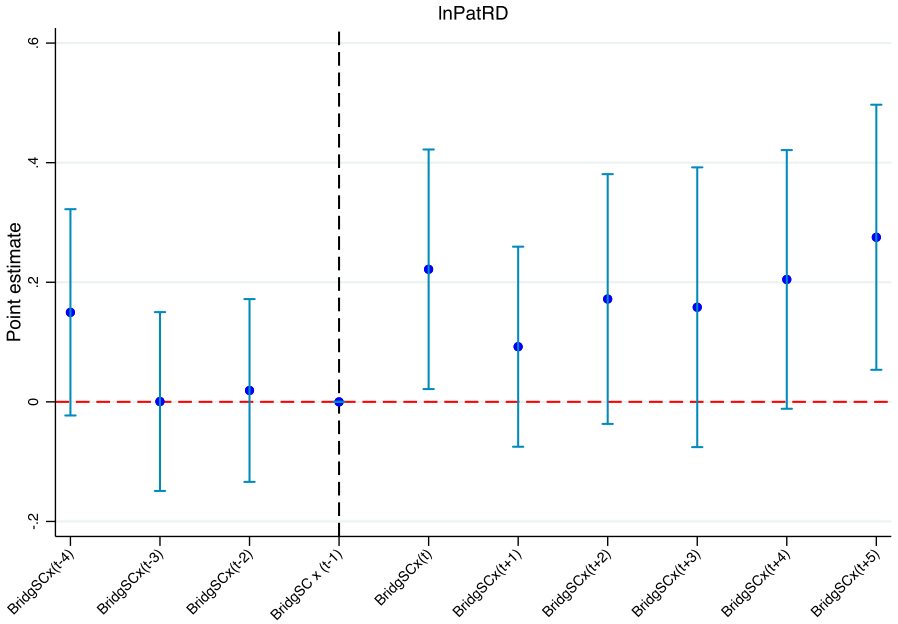

Fig. 21 Testing Parallel Trends, Depvar: lnPatRD—High vs Low Bridging Social Capital *Note*: This figure presents the event study analysis spanning from 2003 to 2012. The dependent variable is the patent intensity measured as the number of patent applications scaled to the R&D expenditure (logarithmic scale). The interaction terms BridgSC$\times(t+\tau)$ combine bridging social capital endowments—specifically, an indicator variable set to 1 for provinces in the top tercile of bridging social capital distribution—with annual indicator variables. The period t marks the onset of the 2007 crisis, with a black vertical dashed line delineating the pre-crisis from the post-crisis periods. The analytical model incorporates province- and year-fixed effects. The figure illustrates point estimates of BridgSC$\times(t+\tau)$, representing the impact of social capital levels in specific years, alongside 90% confidence intervals (denoted in blue)

a negative sign. This indicates that frequent social interactions with friends could potentially detract from a region's overall ability to endure an economic crisis.

Tables 6 and 7 present the results using an alternative estimation approach that accounts for potential serial and spatial correlation in social capital levels across regions. Addressing serial and spatial correlations is crucial, as it helps mitigate potential dependencies that may manifest over time or among neighboring provinces, a common issue in regional data studies. Neglecting these correlations could result in biased estimates. In our analysis, we utilize Conley spatial HAC standard errors to address both spatial and serial correlations in social capital allocations effectively. This method ensures that our model accurately captures any spatiotemporal patterns affecting the relationship between social capital and regional responses to economic crises, thereby enhancing the validity and robustness of our findings.

Table 6 reinforces the insights observed in Tables 3 and 4, indicating a significant positive impact (ranging from 11 to 15 pp) on innovation outcomes in provinces with *HighBridgingSC*, while revealing no statistically significant effects for *HighBondingSC* provinces. Table 7 aligns with the findings reported in Table 5,

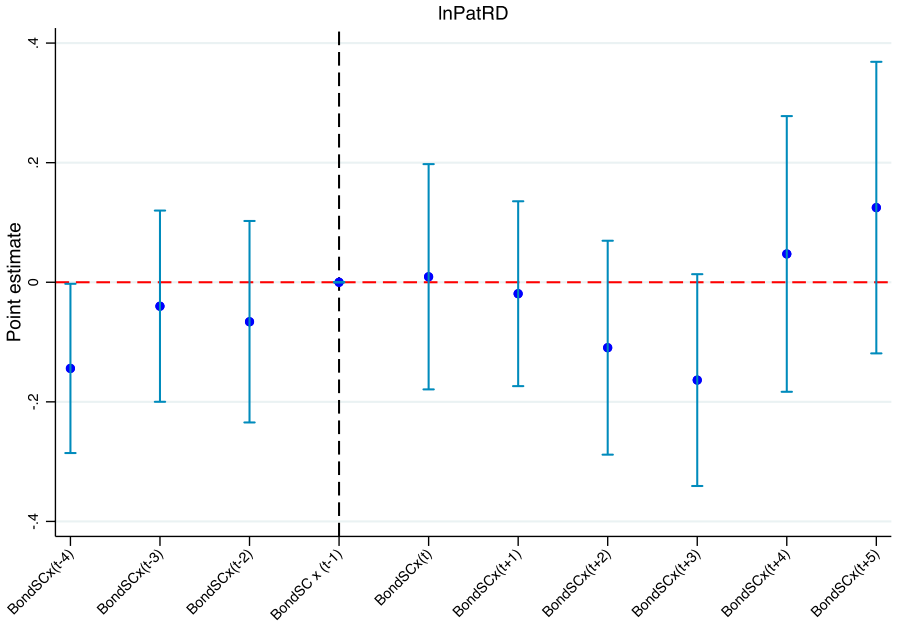

Fig. 22 Testing Parallel Trends, Depvar: lnPatRD—High vs Low Bonding Social Capital *Note*: This figure presents the event study analysis spanning from 2003 to 2012. The dependent variable is the patent intensity measured as the number of patent applications scaled to R&D expenditure (logarithmic scale). The interaction terms BondSC$\times$(t$+\tau$) combine bonding social capital endowments—specifically, an indicator variable set to 1 for provinces in the top tercile of bonding social capital distribution—with annual indicator variables. The period t marks the onset of the 2007 crisis, with a black vertical dashed line delineating the pre-crisis from the post-crisis periods. The analytical model incorporates province- and year-fixed effects. The figure illustrates point estimates of BondSC$\times$(t$+\tau$), representing the impact of social capital levels in specific years, alongside 90% confidence intervals (denoted in blue)

employing alternative social capital measures and documenting comparable patterns of innovation activity for *HighBridgingSC* or *HighBondingSC* provinces.

Overall, all robustness checks performed in the sensitivity analyses corroborate our main findings.

5 Conclusions

Economic crises represent pivotal junctures for innovation dynamics, where firms and their surrounding local systems grapple with the balance between the prospects of creative destruction and the risks posed by decelerated creative accumulation (Archibugi et al. 2010; 2013). While an enduring research topic, dating back to Schumpeter's seminal work (Schumpeter 1939), the analysis of this issue remained relatively dormant until the burst of the sub-prime mortgage crisis in 2007, which sparked renewed interest and revitalized its investigation from various angles. Such an event in fact spurred the emergence of an important research stream on the so-called innovation resilience of countries and regions to crises (e.g., Baycan & Pinto

Table 3 Main estimates

	InPatents			lnPatPop		
	(I)	*(II)*	*(HI)*	*(I)*	*(II)*	*(III)*
High bridging social capital X Crisis	0.15**	0.15**	0.15**	0.13**	0.14**	0.14**
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
High bridging social capital X Crisis	0.07	0.05	0.05	0.08	0.06	0.06
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
lnRDFir		−0.02	−0.02		−0.05	−0.05
		(0.06)	(0.06)		(0.06)	(0.06)
Ungrate		−0.01	−0.01		−0.02	−0.02
		(0.85)	(0.85)		(0.87)	(0.87)
Pop-den		0.0005*	0.0005*		−0.0004	−0.0004
		(0.0003)	(0.0003)		(0.0007)	(0.0007)
Big^banks		0.08	0.08		0.01	0.01
		(0.34)	(0.34)		(0.35)	(0.35)
Trial		0.002	0.002		0.002	0.002
		(0.001)	(0.001)		(0.001)	(0.001)
Newspapers		0.002***	0.002***		0.003***	0.003***
		(0.001)	(0.001)		(0.001)	(0.001)
exp_GDP_ratio		−0.12	−0.12		−0.04	−0.03
		(0.23)	(0.23)		(0.25)	(0.25)
lnGVA		0.98***	0.95**		0.89**	0.86**
		(0.36)	(0.37)		(0.37)	(0.37)
TerEdu		−0.41	−0.45		−0.94	−0.96
		(1.97)	(1.97)		(2.10)	(2.10)
PostSecEdu		−1.03	−1.07		−0.99	−1.04
		(1.59)	(1.57)		(1.70)	(1.67)
L1. depvar			0.02 (0.04)			0.02 (0.05)
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time-varying Controls	No	Yes	Yes	No	Yes	Yes
L1.Depvar	No	No	Yes	No	No	Yes
Observations	1,030	1030	1030	1030	1030	1030
Clusters	103	103	103	103	103	103
Adjusted_R2	0.94	0.94	0.94	0.90	0.91	0.91

Bridging social capital is proxied by the number of non-profit associations per 100 inhabitants in a province. Bonding social capital is computed following the approach proposed by Antonietti and Boshma (2021). Standard errors are robust and clustered at the province level. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively

2018), whose investigation has continued and evolved with respect to subsequent crises, like the global one determined by the Covid19 pandemics (e.g., Lien and Timmermans 2024).

While it has obtained important results and policy implications, such a line of research has only marginally intersected with another stream of studies about the

Table 4 Robustness checks: alternative dependent variables

	lnPatFir	lnPatGDP	lnPatRD
High bridging social capital X Crisis	0.16**	0.13**	0.16**
	(0.06)	(0.06)	(0.06)
High bridging social capital X Crisis	0.08	0.04	0.05
	(0.07)	(0.07)	(0.06)
Province fixed effects	Yes	Yes	Yes
Time-varying controls	No	Yes	Yes
L1.Depvar	No	No	Yes
Observations	1030	1030	1030
Clusters	103	103	103
Adjusted_R2	0.90	0.87	0.85

Bridging social capital is proxied by the number of non-profit associations per 100 inhabitants in a province. Bonding social capital is computed following the approach proposed by Antonietti and Boshma (2021). Standard errors are robust and clustered at the province level. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively

Table 5 Robustness Checks: Alternative Measures of Social Capital

	lnPatents	lnPatPop	lnPatFir	lnPatGDP	lnPatRD
High bridging social capital X Crisis	0.14**	0.13*	0.15**	0.13**	0.15**
	(0.06)	(0.07)	(0.07)	(0.06)	(0.06)
High bridging social capital X Crisis	−0.06	−0.06	−0.05	−0.05	−0.03
	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)
Province fixed effects	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes
L1.Depvar	Yes	Yes	Yes	Yes	Yes
Observations	1030	1030	1030	1030	1030
Clusters	103	103	103	103	103
AdjustecLR2	0.94	0.91	0.90	0.87	0.85

Bridging social capital is proxied by the number of CONI associations per 100 inhabitants in a province. Bonding social capital is proxied by the number of people aged 6 and older meeting friends at least once a week, for every 100 people in the same area. Standard errors are robust and clustered at the province level. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively

regional resilience to crises, pointing to the driving role of social capital in its construction (Terzo 2021; Tsiapa 2023; Antonietti & Boschma 2021). Indeed, while social capital has been found to act as an important shield for regions facing crises, the extent to which such a role passes through the social capital contribution to regional innovation has remained relatively investigated so far.

In trying to fill this gap, in this paper we have focused on how regions' innovation responses to economic crises vary with their level of social capital. Returning to investigate the global financial crisis of 2007, we have addressed this research issue with respect to the Italian (NUTS3) provinces over the period 2003–2012 by finding

Table 6 Robustness Checks: Correction for Cross Sectional Spatial Dependence & Panel-Specific Serial Correlation

	lnPatents	lnPatPop	lnPatFir	lnPatGDP	lnPatRD
High bridging social capital X Crisis	0.14**	0.13*	0.15**	0.12**	0.15**
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
High bridging social capital X Crisis	0.08	0.09	0.11	0.08	0.09*
	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)
Province fixed effects	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes
L1.Depvar	Yes	Yes	Yes	Yes	Yes
Observations	1030	1030	1030	1030	1030
Clusters	103	103	103	103	103
AdjustecLR2	0.02	0.02	0.02	0.02	0.19

Bridging social capital is proxied by the number of non-profit associations per 100 inhabitants in a province. Bonding social capital is computed following the approach proposed by Antonietti and Boshma (2021). Standard errors are robust and clustered at the province level. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively

Table 7 Robustness Checks: Alternative Social Capital Measures & Correction for Cross-Sectional Spatial Dependence and Serial Correlation

	lnPatents	lnPatPop	lnPatFir	lnPatGDP	lnPatRD
High bridging social capital X Crisis	0.13**	0.12**	0.13**	0.11**	0.13**
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
High bridging social capital X Crisis	−0.06	−0.06	−0.05	−0.06	−0.04
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Province fixed effects	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes
L1.Depvar	Yes	Yes	Yes	Yes	Yes
Observations	1030	1030	1030	1030	1030
Clusters	103	103	103	103	103
AdjustecLR2	0.02	0.02	0.02	0.02	0.18

Bridging social capital is proxied by the number of coni associations per 100 inhabitants in a province. Bonding social capital is proxied by the number of people aged 6 and older meeting friends at least once a week, for every 100 people in the same area. Standard errors are robust and clustered at the province level. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively

quite interesting results. Measuring regional innovation with different variables of patenting activities, we have found that in the aftermath of the 2007 crisis, provinces with high bridging social capital have been substantially more innovative (approximately 15 to 14 percentage points more) than provinces with a low social capital of the same kind. In contrast, provinces with high bonding social capital did not exhibit a similar advantage. Such a result has revealed pretty robust and, by retaining the decline in innovation activities that all Italian provinces experienced after the burst of the crisis, suggests that those with a higher bridging social capital, unlike those with a higher bonding one, exhibited lesser drops in innovation post-crisis.

These results provide an important contribution to different research streams. Firstly, they enrich the literature about innovation along the business cycle (Archibugi et al., 2021; 2023; Antonioli & Montresor 2021), confirming that innovation responses to crises are indeed region-specific (Baycan & Pinto 2018) and adding to this debate that the local endowment of social capital represents an important driver of this specificity, which has been so far relatively neglected. Secondly, our analysis does also contribute to the literature about the relationship between regional social capital and innovation (Cortinovis et al. 2017; Kobeissi et al. 2023). On the one hand, we confirm in a possibly more causal setting than previous studies that a larger endowment of bridging social relationships can spur knowledge variety and thus increase local innovation; and that more pervasive ties of a bonding nature could instead induce a resistance to change that prevents local innovation from increasing (Antonietti & Boschma 2021). On the other hand, we add to this debate the evidence that it is possibly the burst of a crisis that, by pushing local communities to resort to and activate more their social capital, makes it capable to spur innovation at least with respect to its bridging variant.

Our results do also provide some interesting regional policy implications. Indeed, they suggest that the support to local bridging social capital—passing through networking events, collaboration platforms, and initiatives that bring together diverse stakeholders from different sectors and backgrounds—could make regions more capable of resisting economic crises by attenuating the drop these could entail in their innovation activities. Investments in programs that encourage cross sectoral partnerships and knowledge exchange can enhance innovation capacities and resilience, particularly in times of economic uncertainty. Of course, while the study found no significant advantage for provinces with high bonding social capital in terms of innovation, policymakers should not overlook the importance of bonding ties within local communities. Initiatives aimed at enhancing trust, reciprocity, and social cohesion among community members can still contribute to innovation resilience. However, this does not appear evident in the aftermath of a crisis. A more detailed analysis of the role of bonding social capital, perhaps distinguishing between different forms or intensities of bonding ties, could elucidate under what conditions, if any, these ties might contribute to innovation resilience.

While insightful, the study is not free of limitations. Firstly, its focus on Italian provinces restricts the generalizability of findings. Extending research to other countries would bolster the robustness of conclusions. Secondly, the analysis centers on a specific crisis, potentially limiting applicability to other economic downturns. Future investigations should explore the transferability of results to crises of varying natures, such as the unique challenges posed by the COVID-19 pandemic. Future research might also benefit from a sector-specific analysis to determine whether the impact of social capital on innovation varies across industries, particularly those more susceptible to or resilient against economic fluctuations.

Appendix 1

See Tables 8, 9, 10, 11, 12

Table 8 List of Variables and Data Sources

Depvars	Description	Source
lnPatents	Log of (Patent Applications)	EUROSTAT (NUTS3) + ISTAT 2003–2012 (NUTS3)
lnPatPop	Log of (Patent Applications / Population)	EUROSTAT (NUTS3) + ISTAT 2003–2012 (NUTS3)
lnPatFir	Log of (Patent Applications / Number of Firms)	EUROSTAT (NUTS3) + ISTAT 2003–2012 (NUTS3)
lnPatGDP	Log of (Patent Applications / GDP)	EUROSTAT (NUTS3) + ISTAT 2003–2012 (NUTS3)
lnPatRD	Log of (Patent Applications/ R&D Expenditure)	EUROSTAT (NUTS3) + ISTAT 2003–2012 (NUTS3)
Indepvars	*Description*	*Source*
Bridging SC	Non-profit Associations per 100 Inhabitants	ISTAT 2001 Census (NUTS3)
Bonding SC	Share of 'Olson group' members / Resident Families	EVS 1999 (NUTS2) + ISTAT 2001 (NUTS3)
Alternative Bridging SC	CONI Associations per 100 Inhabitants	ISTAT 2001 (NUTS3)
Alternative Bonding SC	Frequency Meetings with Friends / resident families	ISTAT 2001 + ISTAT 2001 (NUTS3)
Controls	*Description*	*Source*
lnRDFir	Log of (R&D Firms)	Italian Chamber of Commerce 2003–2012 (NUTS3)
pop_den	Population Density (in km^2)	ISTAT 2003–2012 (NUTS3)
lnGVA	Log if (GVA)	ISTAT 2003–2012 (NUTS3)
unjrate	Unemployment Rate	ISTAT 2003–2012 (NUTS3)
big_banks	Number of Big Banks	Bank of Italy 2003–2012 (NUTS3)
trial	Average Duration of Bankruptcy Trials	ISTAT 2003–2012 (NUTS3)
newspapers	Newspapers sold per 1000 inhabitants	Italian National Press Agency 2003–2012 (NUTS3)
exp_GDPjratio	Exports / GDP	ISTAT 2003–2012 (NUTS3)
TerEdu	Proportion of inhabitants with Tertiary Education	ISTAT 2003–2012 (NUTS2)
PosSec Edu	Proportion of inhabitants with Secondary Education	ISTAT 2003–2012 (NUTS2)

The Bank of Italy defines big banks as those with a total value of traded funds greater than EUR 26 billion

Table 9 List of Provinces in Top Terciles of Social Capital

Bridging Social Capital	Bonding Social Capital
Alessandria	Ancona
Ancona	Ascoli Piceno
Arezzo	Bari
Belluno	Bologna
Biella	Bolzano/Bozen
Bologna	Campobasso
Bolzano/Bozen	Catania
Cagliari	Catanzaro
Cuneo	Cosenza
Ferrara	Firenze
Forli-Cesena	Genova
Gorizia	Isernia
Grosseto	Macerata
Imperia	Matera
L'Aquila	Milano
Macerata	Modena
Oristano	Napoli
Perugia	Padova
Pesaro e Urbino	Palermo
Pisa	Perugia
Pistoia	Pesaro e Urbino
Pordenone	Pordenone
Ravenna	Potenza
Rieti	Reggio di Calabria
Savona	Roma
Siena	Savona
Sondrio	Torino
Terni	Trento
Trento	Trieste
Trieste	Udine
Udine	Valle d'Aosta/Vallee d'Aoste
Valle d'Aosta/Vallee d'Aoste	Venezia
Verbano-Cusio-Ossola	Verona
Vercelli	Vicenza

Provinces in each list are reported in alphabetical order

Appendix 2

See Figs. 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22

Table 10 Moran's I Spatial Correlogram

	Bridging Social Capital		Bonding Social Capital	
Distance bands	*I*	*p*-value	*I*	*p*-value
(0–25000]	0.585	0.093	0.244	0.286
(25,000–50000]	0.398	0.001	0.211	0.044
(50,000–100000]	0.318	0.000	0.032	0.255
(100,000–200000]	0.085	0.014	0.018	0.260
(200,000–400000]	0.015	0.175	−0.026	0.275

Table 11 Robustness Checks: Alternative Threshold (Quartiles) as High Social Capital Indicators

	lnPatents	lnPatPop	lnPatFir	lnPatGDP	lnPatRD
High bridging social capital X Crisis	0.14**	0.13*	0.15**	0.12*	0.15**
	(0.06)	(0.07)	(0.07)	(0.06)	(0.07)
High bridging social capital X Crisis	0.06	0.06	0.08	0.05	0.05
	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)
Province fixed effects	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes
L1.Depvar	Yes	Yes	Yes	Yes	Yes
Observations	1030	1030	1030	1030	1030
Clusters	103	103	103	103	103
Adjusted_R2	0.94	0.90	0.90	0.87	0.85

Bridging social capital is proxied by the number of non-profit associations per 100 inhabitants in a province. Bonding social capital is computed following the approach proposed by Antonietti and Boshma (2021). Standard errors are robust and clustered at the province level. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively

Table 12 Robustness checks: alternative threshold (quartiles) as high social capital indicators & correction for cross sectional spatial dependence and serial correlation

	lnPatents	*lnPatPop*	*lnPatFir*	*lnPatGDP*	*lnPatRD*
High bridging social capital X crisis	0.13**	0.11**	0.14**	0.11**	0.13**
	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)
High bonding social capital X crisis	0.08	0.08	0.10	0.08	0.08
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Province fixed effects	Yes	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	Yes	Yes	Yes
L1.Depvar	Yes	Yes	Yes	Yes	Yes
Observations	1030	1030	1030	1030	1030
Clusters	103	103	103	103	103
AdjustecLR2	0.02	0.02	0.02	0.02	0.18

Bridging social capital is proxied by the number of coni associations per 100 inhabitants in a province. Bonding social capital is proxied by the number of people aged 6 and older meeting friends at least once a week, for every 100 people in the same area. Standard errors are robust and clustered at the province level. *, **, and *** denote significance at the 10, 5, and 1 percentage level, respectively

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References

Abi Younes G, Ayoubi C, Ballester O, Cristelli G, de Rassenfosse G, Foray D, Zhou L (2020) COVID-19: insights from innovation economists. Sci Public Policy 47(5):733–745

Aghion P, Saint-Paul G (1998) Virtues of bad times interaction between productivity growth and economic fluctuations. Macroecon Dyn 2(3):322–344

Akçomak IS, Ter Weel B (2009) Social capital, innovation and growth: evidence from Europe. Eur Econ Rev 53(5):544–567

Alvarez R, Benavente JM, Crespi G (2010) Economic crisis and organizational change in developing countries: evidence from Chile. Int J Technol Learn, Innovation Dev 3(1):67–86

Amore MD (2015) Companies learning to innovate in recessions. Res Policy 44(8):1574–1583

Antonelli C (1997) The economics of path-dependence in industrial organization. Int J Ind Organ 15(6):643–675

Antonietti R, Boschma R (2021) Social capital, resilience, and regional diversification in Italy. Ind Corp Chang 30(3):762–777

Antonioli D, Montresor S (2021) Innovation persistence in times of crisis: an analysis of Italian firms. Small Bus Econ 56(4):1739–1764

Archibugi D, Filippetti A, Frenz M (2010) Economic crisis and innovation: is destruction prevailing over accumulation? Res Policy 42(2):303–314

Archibugi D, Filippetti A, Frenz M (2013) The impact of the economic crisis on innovation: evidence from Europe. Technol Forecast Soc Chang 80(7):1247–1260

Arundel A, Kabla I (1998) What percentage of innovations are patented? empirical estimates for European firms. Res Policy 27(2):127–141

Arvanitis S, Woerter M (2014) Firm characteristics and the cyclicality of R&D investments. Ind Corp Chang 23(5):1141–1169

Asheim BT, Coenen L (2005) Knowledge bases and regional innovation systems: comparing Nordic clusters. Res Policy 34(8):1173–1190

Banfield EG (1958) The Moral Basis of a Backward Society. Free Press, New York

Barlevy G (2007) On the cyclicality of research and development. Am Econ Rev 97(4):1131–1164

Baycan T, Pinto H (2018) Resilience, crisis and innovation dynamics: emerging challenges Resilience, crisis and innovation dynamic. In: Baycan T, Pinto H (eds) Resilience crisis and innovation dynamics. Edward Elgar, Camberley

Bell M, Pavitt K (1995) The development of technological capabilities. Trade, Technol Int Compet 22(4831):69–101

Beugelsdijk S, Smulders S (2009) Bonding and bridging social capital and economic growth. SSRN Elect J. https://doi.org/10.2139/ssrn.1402697

Blau PM (1964) Justice in social exchange. Sociol Inquiry 34(2):193–206

Boschma, R. (2017). Towards an evolutionary perspective on regional resilience. In *Evolutionary Economic Geography*. Routledge. London, pp 29–47
Bristow G, Healy A (2018) Innovation and regional economic resilience: an exploratory analysis. Ann Reg Sci 60(2):265–284
Burt RS (2000) The network structure of social capital. Res Organ Behav 22:345–423
Candido AC, Wielewicki PF, Zimmermann RA (2016) Barriers and drivers for innovation in times of crisis. Revista De Negocios 20(4):1–10
Cappelli R, Montobbio F, Morrison A (2021) Unemployment resistance across EU regions: the role of technological and human capital. J Evol Econ 31:147–178
Caragliu A, Landoni P (2024) Firm cooperation policies: the impact of territorial spillovers. Ann Reg Sci 73:363–396
Cartocci, R. (2007). *Mappe del tesoro. Atlante del capitale sociale in Italia*. Il mulino.
Chen J, Wang L, Li Y (2020) Natural resources, urbanization and regional innovation capabilities. Resour Policy 66:101643
Cincera M, Cozza C, Tübke A, Voigt P (2012) Doing R&D or not (in a crisis), that is the question. Eur Plan Stud 20(9):1525–1547
Cohen, W. M., Nelson, R., & Walsh, J. P. (2000). Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent (or not).
Cohen WM, Levinthal DA (1989) Innovation and learning: the two faces of R & D. Econ J 99(397):569–596
Coleman JS (1988) Social capital in the creation of human capital. Am J Sociol 94:S95–S120
Conley TG (2010) Spatial econometrics. In Microeconometrics. Palgrave Macmillan UK, London, pp 303–313
Correa, P., & Iootty, M. (2011). R&D decisions during the crisis: firm-level evidence for selected eastern countries.
Cortinovis N, Xiao J, Boschma R, van Oort FG (2017) Quality of government and social capital as drivers of regional diversification in Europe. J Econ Geogr 17(6):1179–1208
Crescenzi R, Gagliardi L, Percoco M (2013a) Social capital and the innovative performance of Italian provinces. Environ Plan A 45(4):908–929
Crescenzi, R., Gagliardi, L., & Percoco, M. (2013b). The 'bright'side of social capital: How 'bridging'makes Italian provinces more innovative. *Geography, institutions and regional economic performance*, Springer, Berlin 143–164.
Cruz-Castro L, Sanz-Menéndez L (2016) The effects of the economic crisis on public research: Spanish budgetary policies and research organizations. Technol Forecast Soc Chang 113:157–167
Dekker P, Uslaner EM (2001) Introduction. In: Uslaner EM (ed) Social capital and participation in everyday life. Routledge, London, pp 1–8
Dellisanti R (2023) Spatial patterns of cultural and creative industries: creativity and filière behind concentration. Pap Reg Sci 102(3):533–565
Di Caro P, Fratesi U (2018) Regional determinants of economic resilience. Ann Reg Sci 60:235–240
Donoghue EM, Sturtevant VE (2007) Social science constructs in ecosystem assessments: Revisiting community capacity and community resiliency. Soc Nat Resour 20(10):899–912. https://doi.org/10.1080/08941920701561114
Dosi G (1982) Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. Res Policy 11(3):147–162
Faggian, A., Modrego, F., & McCann, P. (2019). Human capital and regional development. *Handbook of regional growth and development theories*, 149–171.
Fassio C (2018) Export-led innovation: the role of export destinations. Ind Corp Chang 27(1):149–171
Filippetti A, Archibugi D (2011) Innovation in times of crisis: national systems of innovation, structure, and demand. Res Policy 40(2):179–192
European Central Bank (2008). Financial Stability Review. Frankfurt, June 2008. https://www.ecb.europa.eu/pub/pdf/fsr/financialstabilityreview200806en.pdf
Flammer C, Ioannou I (2021) Strategic management during the financial crisis: how firms adjust their strategic investments in response to credit market disruptions. Strateg Manag J 42(7):1275–1298
Francois P, Lloyd-Ellis H (2003) Animal spirits through creative destruction. Am Econ Rev 93(3):530–550
Fukuyama F (1995) Trust: the social virtues and the creation of prosperity. Free Press, New York
Geraci A, Nardotto M, Reggiani T, Sabatini F (2022) Broadband internet and social capital. J Public Econ 206:104578

Giannakis E, Bruggeman A (2017) Determinants of regional resilience to economic crisis: a European perspective. Eur Plan Stud 25(8):1394–1415
Gong H, Hassink R, Tan J, Huang D (2020) Regional resilience in times of a pan- demic crisis: the case of COVID-19 in China. Tijdschr Econ Soc Geogr 111(3):497–512
Granovetter M (1992) Economic institutions as social constructions: a framework for analysis. Acta Sociologica 35(1):3–11
Griliches, Z. (1998). Patent statistics as economic indicators: a survey. In *R&D and productivity: the econometric evidence* University of Chicago Press. pp. 287–343
Grindley PC, Teece DJ (1997) Managing intellectual capital: licensing and cross-licensing in semiconductors and electronics. Calif Manage Rev 39(2):8–41
Guiso L, Sapienza P, Zingales L (2004) The role of social capital in financial development. Am Econ Rev 94(3):526–556
Guiso L, Sapienza P, Zingales L (2008) Social capital as good culture. J Eur Econ Assoc 6(2–3):295–320
Hall BH (1994) Corporate restructuring and investment horizons in the United States, 1976–1987. Bus Hist Rev 68(1):110–143
Hall BH, Ziedonis RH (2001) The patent paradox revisited: an empirical study of patenting in the US semiconductor industry 1979–1995. Rand J Econ 32:101–128
Hall, B. H. (1992). Investment and research and development at the firm level: does the source of financing matter?. https://doi.org/10.3386/w4096
Hasan I, Hoi CKS, Wu Q, Zhang H (2020) Is social capital associated with corporate innovation? evidence from publicly listed firms in the US. J Corp Finan 62:101623
Hauser C, Tappeiner G, Walde J (2007) The learning region: the impact of social capital and weak ties on innovation. Reg Stud 41(1):75–88
Himmelberg CP, Petersen BC (1994) R and D and internal finance: a panel study of small firms in high-tech industries. Rev Econ Statistics 76(1):38–51
Holl. A. & Rama, R. (2015). "Economic crisis and innovation: Do regions matter?," ERSA conference papers, European regional science association.
Iglič H, Rözer J, Volker BG (2021) Economic crisis and social capital in European societies: the role of politics in understanding short-term changes in social capital. Eur Soc 23(2):195–231
Jaffe AB, Trajtenberg M (2002) Patents, citations, and innovations: A window on the knowledge economy. MIT press, Cambridge
Kanerva–MERIT M, Hollanders–MERIT H (2009) The impact of the economic crisis on innovation
Kang T, Baek C, Lee JD (2017) The persistency and volatility of the firm R&D investment: revisited from the perspective of technological capability. Res Policy 46(9):1570–1579
Kobeissi N, Hasan I, Wang B, Wang H, Yin D (2023) Social capital and regional innovation: evidence from private firms in the US. Reg Stud 57(1):57–71
Laursen K, Masciarelli F, Prencipe A (2012) Regions matter: how localized social capital affects innovation and external knowledge acquisition. Organ Sci 23(1):177–193
Lewin AY, Massini S, Peeters C (2011) Microfoundations of internal and external absorptive capacity routines. Organ Sci 22(1):81–98
Liang J (2017) Trade shocks, new industry entry and industry relatedness. Reg Stud 51(12):1749–1760
Lien L, Timmermans B (2024) Crisis-induced innovation and crisis-induced innovators. Ind Innov 31(2):183–217
Malerba F, Orsenigo L (1996) Schumpeterian patterns of innovation are technology-specific. Res Policy 25(3):451–478
Martin R, Sunley P (2015) On the notion of regional economic resilience: conceptualization and explanation. J Econ Geogr 15(1):1–42
Maskus KE, Neumann R, Seidel T (2012) How national and international financial development affect industrial R&D. Eur Econ Rev 56(1):72–83
McPherson M, Smith-Lovin L, Cook JM (2001) Birds of a feather: homophily in social networks. Ann Rev Sociol 27(1):415–444
Miller DJ, Fern MJ, Cardinal LB (2007) The use of knowledge for technological innovation within diversified firms. Acad Manag J 50(2):307–325
Miroshnychenko I, De Massis A (2020) Three decades of research on corporate governance and R&D investments: a systematic review and research agenda. R and D Manag 50(5):648–666
Montresor S, Quatraro F (2017) Regional branching and key enabling technologies: evidence from European patent data. Econ Geogr 93(4):367–396

Mu J, Peng G, Love E (2008) Interfirm networks, social capital, and knowledge flow. J Knowl Manag 12(4):86–100
Muštra V, Šimundić B, Kuliš Z (2020) Does innovation matter for regional labour resilience? the case of EU regions. Reg Sci Policy Pract 12(5):955–970
Nannicini T, Stella A, Tabellini G, Troiano U (2013) Social capital and political accountability. Am Econ J Econ Pol 5(2):222–250
Nelson RR, Winter SG (1982) The Schumpeterian tradeoff revisited. Am Econ Rev 72(1):114–132
Paunov C (2012) The global crisis and firms' investments in innovation. Res Policy 41(1):24–35
Putnam R (1995) Bowling alone: America's declining social capital. J Democr 6:65–78. https://doi.org/10.1353/jod.1995.0002
Rafferty M, Funk M (2008) Asymmetric effects of the business cycle on firm-financed R&D. Econ Innov New Techn 17(5):497–510
Saint-Paul G (1993) Productivity growth and the structure of the business cycle. Eur Econ Rev 37(4):861–883
Schobert M, Orru K, Gabel F, Nero K, Windsheimer P, Klaos M, Nævestad TO (2023) The three ''s of social capital in crises: Challenges with the availability, accessibility and activatability of social support. Int J Disaster Risk Reduct 92:103704
Schuller T, Baron S, Field J (2000) Social capital: A review and critique. In S. Baron, J. Field, & and T. Schuller (Eds.) Social capital: Critical perspectives. Oxford University Press. Oxford pp. 1–38
Schumpeter JA (1950) The march into socialism. Am Econ Rev 40(2):446–456
Schumpeter, J. A. (1939). Business cycles New York: Mcgraw-hill. 1: 161–174
Spagnolo G (1999) Social relations and cooperation in organizations. J Econ Behav Organ 38(1):1–25
Tavassoli S, Karlsson C (2018) The role of regional context on innovation persistency of firms. Pap Reg Sci 97(4):931–955
Tebaldi E, Elmslie B (2008) Do institutions impact innovation?
Terzo G (2021) Social capital, social economy and economic resilience of Italian provinces. Pap Reg Sci 100(5):1113–1135
Trichet JC (2010) State of the union: the financial crisis and the ECB's response between 2007 and 2009. J Common Mkt Stud 48:7
Tsiapa M (2023) Social capital and characteristics of economic dualism as determinants of regional resilience. Eur Plann Stud 31(12):1–22
Varsakelis NC (2006) Education, political institutions and innovative activity: a cross-country empirical investigation. Res Policy 35(7):1083–1090
Ziedonis RH (2004) Don't fence me in fragmented markets for technology and the patent acquisition strategies of firms. Manag Sci 50(6):804–820