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ORIGINAL ARTICLE

Interpersonal trust, invention, and innovation across European regions

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Abstract

Many studies in economics and regional science claim a positive link between interpersonal trust and innovation by demonstrating a positive effect of trust on patenting. This contrasts many findings from organization level studies on trust and innovation, who report a variety of findings including inverted-U type relations. A possible explanation is that trust exhibits different roles in invention and innovation, as the former relies on knowledge commons while the latter directly embeds commercialization and the market context. This study attempts to reconcile the two set of findings by studying indicators of invention and innovation in relation to trust at the same unit of observation, by using the regional variation in Europe. I study the relationship between interpersonal trust and patent applications (a measure of invention), trademark applications (a composite indicator) and the share of innovative sales in turnover by SMEs (a direct indicator of commercialization), across European regions. I show that trust positively affects trademark applications with an effect that is comparable to that on patent applications. However, trust exhibits an inverted-U type relationship with innovative sales. Results collectively point to a strong role of trust in

Abbreviations: CCKB, Climate Change Knowledge Portal, World Bank; EPO, European Patent Office; ERI, Eurostat Regional Indicators; EUIPO, European Union Intellectual Property Office; EVS, European Values Survey; GDP, gross domestic product; GISCO, Geographical Information and Maps data service, Eurostat; GMM, generalized method of moments; NUTS, nomenclature of territorial units for statistics; GS2SLS, generalized spatial two-stage least squares; IV, instrumental variables; OECD, the Organisation for Economic Co-operation and Development; OLS, ordinary least squares; QoG, the Quality of Government Index; R&D, research and development; RIS, Regional Innovation Scoreboard; SME, small and medium-sized enterprise.

all three creative activities, including a negative effect at the higher end when the indicator is directly contingent on commercialization and sales. I also estimate the extent of spatial spillovers in the effect of trust on all three creative outcomes.

KEYWORDS
innovation, invention, patents, quality of institutions, social capital, trademarks, trust

1 | INTRODUCTION

This article studies the relationship between interpersonal trust and indicators of invention and innovation. This is undertaken by studying indicators of various creative processes to distinguish the process of technological invention from that of successful commercialization and marketing. Invention refers to the processes by which we improve on existing technological capabilities. Commercialization refers to how technical, design and marketing capabilities are embedded in products and brands and then sold to the public. The Schumpeterian definitions and descriptions of innovation require a step of commercialization to take place, embedding the process of commercialization in its definition of innovation.[1]

The empirical literature in economics on trust and innovation has invariably used patent statistics, which are direct indicators of invention and are related to commercialization only indirectly. Studying innovation indicators above and beyond patent statistics is important since considering commercialization introduces a market context that is not as prominent during earlier stages of the innovation life-cycle. The arguments for the importance of trust on innovation are numerous, but a key and overarching assertion is that interpersonal trust facilitates the creation of knowledge commons, which cultivates more productive knowledge accumulation and cooperation (Bjørnskov, 2009; Bjørnskov & Méon, 2015; Levin & Cross, 2004). This naturally leads to an argument that the effect of trust should be more prominent where knowledge commons and accumulation are critical, which is clearly true for inventive work. However, it isn't immediate why this should readily translate into the context of commercialization and marketing, where knowledge commons may not be as critical, and individual creativity may play a more prominent role.

Previous literature in economics and regional science has established a positive relationship between trust and patenting (Akçomak & Müller-Zick, 2018; Akçomak & ter Weel, 2009; Peiró-Palomino, 2016, 2019) using regional data. I expand this line of work by studying distinct indicators of innovation in relation to interpersonal trust. Namely, I study measures of trademark applications and the share of new-to-market and new-to-firm innovative sales in turnover by small and medium-sized enterprises (SMEs) (henceforth innovative sales), in addition to patents. These are not substitutes or alternative measurements for the same phenomenon, but help distinguish different types of creative activities from one another. Several studies have linked trademarks to observable indicators of innovation (Flikkema et al., 2014; Mendonça et al., 2004; Millot, 2009; Schmoch, 2003). Trademark applications may witness the creation of new products and services, hence are tied to innovation in the sense meant by the Schumpeterian definition. The existing literature argues that trademarks are composite indicators of innovation and can be linked to commodity creation and marketing in the form of service, product, and marketing innovation (De Vries et al., 2017; Flikkema et al., 2014;

Millot, 2009).[2] Finally, the share of innovative sales in turnover is a commonly used measure of innovation in the economics and management of innovation (Belderbos et al., 2004; Evangelista et al., 1997; Mairesse & Mohnen, 2004; Revilla & Rodríguez-Prado, 2018; among others), with the distinguishing feature that it is a direct measure of successful commercialization, encompassing a direct market and sales context that is not present in the remaining two indicators (Kleinknecht et al., 2002).

I use the cultural and creative variation across European regions at the level of nomenclature of territorial units for statistics (NUTS) regional classifications.[3] I use responses to the standard trust question (i.e., percentage of respondents who say "most people can be trusted") in the European Values Survey (EVS), which I aggregate across regional classifications.[4] Sapienza et al. (2013) provide experimental evidence that this question captures the respondent's belief about other people's behavior, hence has meaningful empirical content for the current study.

Comparing counts of patents and trademarks across countries or regions could be problematic since the legal framework in place is a major determinant of both activities. As a result, it is difficult to use these indicators across regions with different legal systems and practices for intellectual property. Using the regional variation in Europe is appealing and meaningful due to the harmonization of the legal framework for patenting and trademarks through the European Patent Office (EPO), the European Union Intellectual Property Office (EUIPO), and the existence of unified data collection practices such as the Community Innovation Survey and the EVS. An important issue is whether the trust indicator merely acts as a proxy for the quality of public institutions in the region, since institutions are clearly important in shaping and conditioning levels of interpersonal trust in a region (Bjørnskov, 2009; Zak & Knack, 2001). I include a measure of the quality of institutions as perceived by inhabitants in the region, the European Quality of Government Index (QoG) (Charron, 2013), to explore the role of interpersonal trust above and beyond the effect of trust in institutions. Finally, I account for the potential endogeneity of trust and research and development (R&D) inputs by using instrumental variables (IVs), and deal with spatial autocorrelation among nearby regions by employing spatial regression methods designed to incorporate endogenous covariates, that is, generalized spatial two-stage least squares, or GS2SLS (Anselin et al., 2012; Arraiz et al., 2010; Drukker et al., 2013; Kelejian & Prucha, 1998, 2010).

My results reveal differences in the extent invention and innovation processes rely on interpersonal trust. As previously demonstrated, patent applications are strongly associated with interpersonal trust. The same is also true for trademark applications, with estimates that are comparable to patents. However, I find that the share of innovative sales is an inverted-U in trust, initially increasing but eventually falling with trust after a threshold. These results collectively indicate that trust exhibits an important role in invention and innovation, but also document a negative effect of trust on innovation, leading to the inverted-U result. Since innovative sales is unique among all three indicators in being a direct measure of commercialization and sales due to new products (Kleinknecht et al., 2002), this indicates that the positive effect on invention and indirect innovation indicators do not readily translate into a direct market context and can be interpreted as a limit on the effect of trust on commercialization efforts. In additional analysis I control for a spatial lag of the trust variable and find that spatial interactions in the effect of all three variables are significant, leading to an analysis of direct and indirect effects of trust.

The rest of the paper is organized as follows. The Section 2 introduces and discusses the related lines of literature. Section 3 introduces the empirical method, key variables, and data sources. Section 4 presents main findings and the related discussion, while Section 5 concludes.

2 | LITERATURE

2.1 | Trust, invention, and innovation

The literature on interpersonal trust emphasizes that trust leads to lower transactions costs, pro-social behavior, improved information flows, easier sharing of critical knowledge, and more productive cooperation (Bjørnskov, 2009; Bjørnskov & Méon, 2015; La Porta et al., 1997; Levin & Cross, 2004; Tsai & Goshal, 1998). Ikeda (2008) argues that trust is necessary for access to resources on networks, while Kwon and Arenius (2010) emphasize that trust allows entrepreneurs to access a wider range of knowledge resources. These arguments indicate that a key role of interpersonal trust is to facilitate the creation of knowledge commons, which cultivates knowledge accumulation, hence performance. Trust also generates positive externalities that can help agents solve social coordination problems (Knack & Keefer, 1997), which positively affect social expectations and behavior (Durlauf & Fafchamps, 2005).

Previous literature in economics and regional science has found a positive relationship between trust and patenting. Akçomak and ter Weel (2009) find that trust positively affects the number of patents (per million inhabitants) across 102 European regions. Earlier work by Dakhli and De Clercq (2004) report similar findings in a cross-country study. Akçomak and Müller-Zick (2018) incorporate possible non-linearity for the same research question and report significant effects of trust under potentially nonlinear and spatial effects. They also consider various trust indicators, but not alternative indicators of innovation. Peiró-Palomino (2019) finds the effect of trust on patents to differ across regions, with stronger effects in less developed regions, while being uniform across periods. I contribute to this literature by studying the effect of interpersonal trust on additional and direct measures of innovation in addition to invention.

A related literature examines the interplay between trust, creativity, and innovation, usually in the form of experimental or survey-based studies at the level of the firm or among team members poised to undertake a certain task. Results from this literature are mixed. Tsai and Goshal (1998) study various departments in a large electronics company. They find that trust increases resource exchange, which in turn increases product innovation. On the other hand, it is also argued that trust may hinder creativity and innovation by suppressing task-related conflicts. Moderate levels of task conflict improve creativity and performance because it is conducive to critical thinking, exploration, and allows the emergence of a group synthesis that can outperform individual perspectives (Jehn & Mannix, 2001). De Clercq et al. (2009) find higher levels of trust to mitigate beneficial effects of task conflict. Similarly, higher levels of trust may induce insufficient monitoring among team members, hindering creativity and innovation (Langfred, 2004). Trust may also increase reliance on existing routines at the cost of experimentation (Molina-Morales & Martínez-Fernández, 2009). Molina-Morales and Martínez-Fernández (2009) find an inverted-U relationship between trust and innovation among firms in a Spanish cluster, while Bidault and Castello (2009) report experimental evidence for an inverted-U relationship between trust and creativity. Chen et al. (2008) find no relationship between trust and the creativity of project teams. It is important to note that these set of results are not produced in the context of invention, but they either use explicit measures of company innovation (De Clercq et al., 2009) or observe creativity or performance in product design processes (Bidault & Castello, 2009). The sample used by Chen et al. (2008) contains R&D teams most of which work in new product and process development rather than in technological research. My results suggests that there are differences to the extent various creative process rely on trust, and it is important for studies to make the exact context of invention or innovation clear, especially in relation to the role of knowledge. Studying regional variation allows observing a rich set of indicators at each location and helps better understand the disparity regarding the role of trust in invention and innovation and helps bridge the gap between the literature in regional science and management. While inverted-U type results have been previously obtained, the current paper is the first one to show this relationship in regional data.

Trust has also been linked to other economic outcomes. In cross-country analysis, trust is shown to be positively related to investment and economic growth (Algan & Cahuc, 2010, 2013; Beugelsdijk et al., 2004; Bjørnskov, 2012; Horváth, 2013; Knack & Keefer, 1997; Zak & Knack, 2001), as well as the level of development (Tabellini, 2010) and productivity (Bjørnskov & Méon, 2015). Dearmon and Grier (2011) link trust to both physical investment and investment in education. Kwon and Arenius (2010) and Kim and Kang (2013) present empirical evidence suggesting that trust is conducive to entrepreneurship. Akçomak and ter Weel (2009) do not find a direct effect of trust on growth, but demonstrate an indirect growth effect due to the link between trust and invention in a simultaneous equations framework. Peiró-Palomino (2016) shows that the relationship between trust and economic growth is heterogenous across regions and exhibits nonlinear effects using nonparametric regression analysis.

The article's focus on interpersonal trust relates it to the literature on the economic consequences of social capital (Putnam et al., 1993). This literature often uses measures of interpersonal trust as a measure of social capital (Westlund & Adam, 2010), but disagreements exist regarding the proper empirical representation of the concept (Sabatini, 2008). Other indicators have been used such as membership to formal institutions or groups (Beugelsdijk and van Schaik, 2005), denseness of networks or the number of relationships (Pucci et al., 2017), the lack of cheating behavior (Knack & Keefer, 1997) and civic associations in the form of voluntary work and blood donations (Crescenzi et al., 2013), among others. Using the latter two indicators, Crescenzi et al. (2013) show that social capital exhibits a positive relationship with invention (patenting) across Italian regions. Miguélez et al. (2011) report a similar finding for Spain. Doh and Acs (2010) report a positive cross-country relation between a composite measure of social capital and patenting. Peiró-Palomino (2016) presents a positive relationship between associational activity and patenting. Pucci et al. (2017) study the effects of local and distant network size on a measure of R&D effectiveness in a sample of Tuscan companies in life sciences. They find a positive effect of distant network size on R&D effectiveness, but an inverted-U relationship for the effect of local network size. Akçomak and Müller-Zick (2018) consider various trust indicators in their study of trust and patenting, showing that only the standard trust indicator and non-egoistic fairness have robust effects on invention across European regions.

2.2 | Trademarks and innovative sales

The article introduces innovation indicators that are contingent on commercialization to varying degrees, that is, trademarks and the share of innovative sales in turnover. The use of trademark data in innovation studies is becoming increasingly common. Several studies have linked trademarks to observable indicators of innovation (Flikkema et al., 2014; Gotsch & Hipp, 2012; Jensen & Webster, 2009; Mendonça et al., 2004; Millot, 2009; Schmoch, 2003; Schmoch & Gauch, 2009). Some trademarks indeed witness the creation of new products and services, hence are natural indicators of innovation in the sense meant by the Schumpeterian definition. Millot (2009) and De Vries et al. (2017) link trademark deposits to commercialization and marketing innovation, noting that they are not confined to these two classifications. Flikkema et al. (2014) studied 660 Benelux trademarks in relation to innovation. Among these, 35% were directly linked to a service innovation, 33% were directly linked to a product innovation, 28% to a process innovation, 25% to a marketing innovation, 20% to an organization innovation, and 17% to a technological innovation, while nearly 60% is linked to some innovation activity. Flikkema et al. (2019) study trademark characteristics that can help relate them to product or service innovation. Findings of this literature lend credence to the claim that trademark statistics are composite indicators that capture innovation in commodity creation and marketing, a later stage in innovation that is captured by patent statistics. However, despite these advantages, trademarks are quite indirect measures of innovation (Blind et al., 2003; Mendonça et al., 2004), especially in comparison to the other innovation indicator used in this study, that is, share of innovative sales in turnover. The exact nature of the connection between trademarks and innovation is also unclear. Since applying for a trademark is primarily a marketing and branding activity, it may be possible to interpret trademark counts as indicators of good business governance, which would suggest a correlative, if not direct, relationship between trademarks and innovation.

Trademarks are also linked to the degree of product differentiation and product quality (Block et al., 2015; Mangani, 2007; Mendonça et al., 2004; von Graevenitz, 2007), and are related to firm survival, especially among young SMEs (Helmers & Rogers, 2010; Jensen et al., 2008; Srinivasan et al., 2008). Lyalkov et al. (2019) provide cross-country evidence that link trademarks to measures of Kirznerian type entrepreneurship that is based on finding and exploiting market opportunities, rather than the creativity based entrepreneurship of the Schumpeterian type. Castaldi and Dosso (2018) argue that trademarks do not have a direct growth effect for firms, but an indirect one through their mediating role between R&D and growth. Several studies report positive effects of trademarks on market value and productivity (above and beyond the effects of R&D and patents) (Greenhalgh & Rogers, 2012; Krasnikov et al., 2009; Sandner & Block, 2011). de Grazia et al. (2020) propose aggregate trademark applications as a leading indicator for forecasting business cycles. Schautschick and Greenhalgh (2015) and Castaldi (2020) offer reviews of the empirical literature on trademarks.

The share of innovative sales in turnover is a standard measure of innovation in the economics and management of innovation and is commonly used for studying innovation within the coverage of the Community Innovation Survey (Belderbos et al., 2004; Evangelista et al., 1997; Mairesse & Mohnen, 2004; Revilla & Rodríguez-Prado, 2018; among others). The distinguishing feature and advantage of this indicator is that it is a direct measure of successful innovation, measuring innovations that have already been introduced to the market, fully integrating the commercialization step (Kleinknecht et al., 2002). This direct market context is neither present in patents, which measure inventive activity, nor trademarks, which measure innovation indirectly despite their strong linkages with different types of innovative activity.

3 | METHOD AND DATA

I employ regression analysis, using invention and innovation indicators as dependent variables, and interpersonal trust as the key independent variable. I control for inputs to the inventive and innovative processes (share of R&D expenditures in gross domestic product (GDP), and share of business R&D in total R&D), as well as tertiary education, population, geographic area, and a measure of the quality of institutions. I use IVs to account for potential endogeneity of trust and R&D, and estimate main specifications using GS2SLS with spatial error dependence (Arraiz et al., 2010; Kelejian & Prucha, 1998) to control for spatial dependence between nearby regions as well as to introduce spatial lags of the trust variable.

3.1 | Interpersonal trust

The trust variable is taken from the fourth wave of the EVS conducted between years 2008 and 2010.[5] I use the wave four integrated file that gives access to all four waves. The survey includes the Yes/No

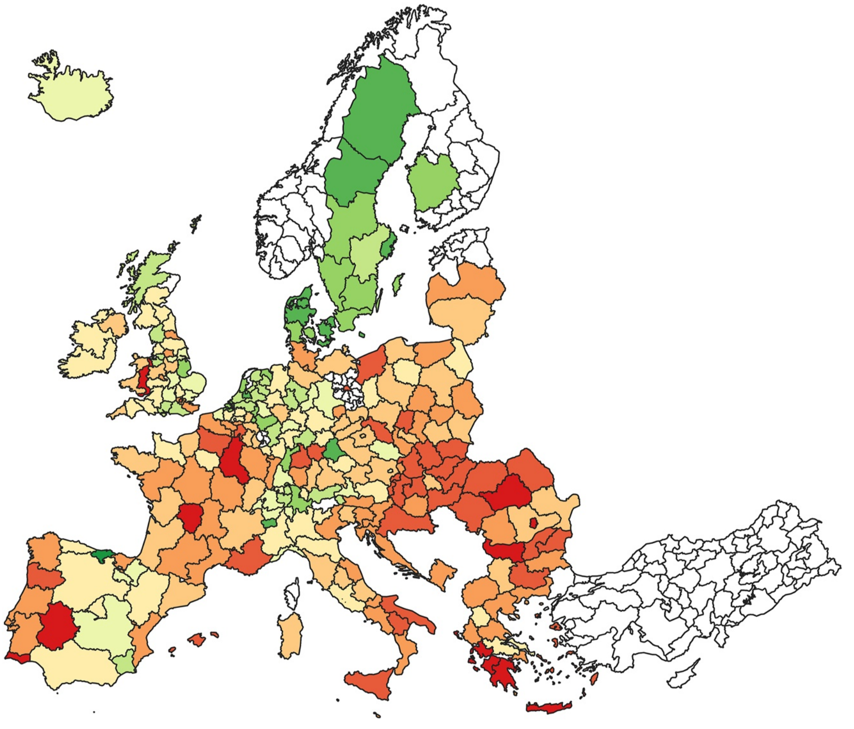

FIGURE 1 The geography of trust in continental Europe, on color spectrum green (high) to red (low).

question "Most people can be trusted." My measure of regional trust is computed as the ratio of respondents (using sampling weights) that respond "Yes" to this question aggregated for each region. Figure 1 depicts the geographical distribution of the trust variable in continental Europe where green (red) represents higher (lower) trust on the color spectrum. Regions for which the variable is missing are depicted in white.

3.2 | Dependent variables

Three dependent variables are chosen to study invention and innovation in relation to trust. I use patent applications (per million inhabitants) in each region as a measure of invention. I use trademark applications (per million inhabitants) and innovative sales (sales of new-to-market and new-to-firm innovations as ratio of turnover by SMEs) as indicators of innovation. Patent and trademark applications are taken from Eurostat Regional Indicators (henceforth ERI) of Eurostat, and are from year 2011, or 2012 if data for the former year is missing. Innovative sales variable is taken from the 2017 edition of the Regional Innovation Scoreboard (henceforth RIS) (Hollanders & Es-Sadki, 2017). Since 2010 is the final year in which trust data is collected from the field, it is preferred to use measurements after 2010 for dependent variables to alleviate endogeneity concerns.[6] The original source of RIS for this variable is the Community Innovation Survey.[7]

For variables that are available in ERI, I use the regional variable at the NUTS 2 level. The organization of RIS data requires using a combination of NUTS 1 and NUTS 2 regions, since RIS reports at a specific combination of NUTS 1 and NUTS 2 regional codes.[8] Analysis of dependent variables taken from RIS are undertaken by aggregating all relevant variables at this precise combination of codes. Few small countries are represented as single data points.

3.3 | Independent variables

The formation and evolution of interpersonal trust is potentially related to the quality of institutions (Akçomak & ter Weel, 2009; Bjørnskov, 2009; Knack, 2002; Zak & Knack, 2001). A generalized lack of trust in social institutions could affect economic outcomes as well as shape levels of interpersonal trust in the region. Therefore, whether the trust index acts merely as a proxy for institutions is of importance. I control for a direct measure of the quality of regional institutions, so that the coefficient of trust can be interpreted while holding constant institutional quality. My measure of the quality of institutions come from the QoG(Charron, 2013). QoG combines 16 regional indicators of (i) quality (of public education, public health, law enforcement, fairness of elections, fairness of media), (ii) impartiality (of education, health and law), and (iii) corruption (of education, health and law, including perceived and witnessed bribery). It can be considered as a measure of the quality of governance, but also of people's trust in institutions, as the index is constructed using survey responses. I use the 2010 index values for this variable.

In addition, I also control for R&D expenditures as percentage of GDP, business R&D as fraction of total R&D, percentage of population with tertiary education, population, and geographic area at the regional level. All these variables are taken from ERI. Similar to patents and trademarks, these variables are from year 2011, or from 2012 in case of missing-data for 2011. Few observations of business R&D are taken as their 2009 values since this was the closest year to 2011 with available data. Table 1 gives summary information and descriptive statistics for all variables, including the instruments that will be introduced in the next subsection. Table 2 provides correlations among all variables. In Table 2, variables are presented in the order of trust, then dependent variables, then remaining independent variables, to highlight the correlations of trust with dependent variables.

3.4 | Functional form

I use a logarithmic transformation for all main variables except QoG, which obtains negative index values. To test for the presence of nonlinear effects, I estimate additional regressions in which a quadratic form for trust is used instead of the logarithmic transform. The log-linear form can be obtained via the use of a knowledge production function framework (see, for instance, Rodríguez-Pose & Di Cataldo, 2014), but this is avoided to save space. Whenever its use is appropriate, I prefer the log-linear form so that estimated coefficients can be interpreted as elasticities. Having unitless coefficients is desirable as well, since some variables (patents and trademarks) are measured in numbers per million inhabitants, but innovative sales is measured as fractions of totals.

3.5 | Endogeneity and instrumental variables

Previous authors have argued that the trust variable is endogenous to various economic and inventive outcomes (Akçomak & ter Weel, 2009; Bjørnskov, 2012; Bjørnskov & Méon, 2015; Tabellini, 2008). I seek the effect of interpersonal trust that has been measured using survey data between 2008 and 2010 in each region, on dependent variables measured at the same region at year 2011 or after. Hence, there is no reason to expect reverse causality from dependent variables to trust. However, trust may be endogenous to inventive and innovative activity due to omitted variables. A key concern is the mutual relationship between trust and institutional quality, which is mitigated by controlling for a measure of the latter. However, it is not possible to argue that all potential sources of omitted variables

TABLE 1 Variable descriptions and descriptive statistics.

Source	Description	Dependent variables	Mean	St. dev.	Min	Max
ERI	Patent applications at EPO (per million inhabitants)	Patents	104.35	126.98	0.233	716.44
ERI	Trademark applications at EUIPO (per million inhabitants)	Trademarks	129.44	165.20	2.89	2119.8
RIS	Sales of new-to-market and new-to-firm innovations as ratio of total turnover, by SMEs	Innovative sales	0.3809	0.1352	0.0342	0.8952
Source	**Description**	**Independent variables**	**Mean**	**St. dev.**	**Min**	**Max**
EVS	Fraction of respondents who say "most people can be trusted," EVS wave 4	Trust	0.3584	0.1872	0.0	0.9139
QoG	The quality of goverment index	Quality of government	0.2992	0.9398	−2.719	1.899
ERI	Total intramural R&D expenditure (as % of GDP)	R&D as % of GDP	1.561	1.248	0.11	7.97
ERI	Business R&D expenditure (as fraction of total R&D)[a]	Business R&D as fraction of total	0.5325	0.2456	0.0233	1
ERI	% Of tertiary education attainment in population aged 25–64	Tertiary education	26.29	8.846	9.9	55.7
ERI	Population on Jan 1st of year	Population	1,989,577	1,589,495	28,007	11,852,851
ERI	Area of the region in square kilometers	Area	18,497.53	28,578.72	161	226,782.8
Source	**Description**	**Instrumental variables**	**Mean**	**St. dev.**	**Min**	**Max**
EVS	Fraction of respondents who say "most people can be trusted," EVS waves 1 through 3 combined	Past trust	0.3464	0.1323	0.0549	0.7571
CCKB	Temperature (°C) during the coldest month of the year, 1901–1990	Minimum temperature	−0.3875	4.461	−13.135	11.859
GISCO	Latitude coordinate of the region in degrees	Latitude	48.515	6.177	28.353	66.439
ERI	R&D expenditures by government in 2002 as PPS per inhabitant, constant 2005 prices	Government R&D (2002)	40.475	56.766	0	323
ERI	Total intramural R&D expenditure (as % of GDP), 2002	R&D as % of GDP (2002)	1.333	1.170	0.07	8.37

Abbreviations: CCKB, Climate Change Knowledge Portal, World Bank; ERI, Eurostat Regional Indicators; EVS, European Values Survey; GISCO, Geographical Information and Maps data service, Eurostat; QoG, the Quality of Government Index; RIS, Regional Innovation Scoreboard.

[a]The maximum value of 1 for business R&D as fraction of total comes from the NUTS 2 region "Cornwall and the Isles of Scilly" in the UK, where the values of both total and business R&D as percentage of GDP are 0.2%, due to rounding.

TABLE 2 Correlation matrix.

		Trust	Pat	TM	Inn S	QoG	RD	B RD	TED	Pop	Area	Past trust	Min temp	LAT	Past G RD	Past RD
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Trust	1	–														
Patents	2	0.404	–													
Trademarks	3	0.206	0.444	–												
Innovative sales	4	0.185	0.127	0.206	–											
Quality of government	5	0.588	0.513	0.312	0.372	–										
R&D as % of GDP	6	0.349	0.660	0.316	0.214	0.483	–									
Business R&D, fraction of total	7	0.323	0.440	0.201	0.291	0.488	0.390	–								
Tertiary education	8	0.409	0.315	0.345	0.378	0.511	0.520	0.214	–							
Population	9	−0.079	0.087	0.098	0.295	−0.149	0.102	0.013	0.078	–						
Area	10	0.110	−0.057	−0.162	0.031	0.044	0.094	−0.004	0.038	0.088	–					
Instruments																
Past trust	11	0.614	0.287	0.325	0.284	0.455	0.253	0.215	0.442	−0.101	0.082	–				
Minimum temperature	12	−0.261	−0.270	−0.026	0.238	−0.109	−0.235	−0.199	−0.054	0.113	−0.388	−0.151	–			
Latitude	13	0.549	0.333	0.093	0.101	0.536	0.362	0.378	0.453	−0.108	0.292	0.469	−0.682	–		
Past government R&D	14	0.156	0.269	0.301	0.078	0.210	0.539	−0.026	0.393	0.211	−0.074	0.091	−0.055	0.132	–	
Past R&D	15	0.381	0.654	0.317	0.171	0.480	0.908	0.344	0.491	0.109	0.052	0.306	−0.248	0.374	0.571	–

Note: All correlations are calculated using the largest mutual sample with non-missing values for both variables.

are accounted for. To address endogeneity concerns fully, I employ IV methods to seek robustness of results to endogeneity.

I work with many instruments that have been applied in the previous literature for trust in similar contexts. Bjørnskov and Méon (2015) and Peiró-Palomino (2016) use the (i) average temperature during the coldest month of the year in the country as an instrument for trust (henceforth "minimum temperature"). Bjørnskov and Méon (2015) argue that in regions where the minimum temperature over the year is lower, survival through the winter depended more strongly on cooperation, hence trusting anonymous people is more common. This variable is available at the country level and was previously used in cross-country analysis. Country-level instruments reduce the resolution of the regional analysis since all results are obtained after projecting the data to the instrument in question. However, instruments for trust are difficult to obtain at the level of regions (Tabellini, 2008). Geographical features have naturally been considered, (ii) the latitude of the region in particular (Horváth, 2013; Peiró-Palomino, 2016). Latitude is correlated with temperature, with the advantage that it is available for all regional classifications. I use both (i) and (ii) as instruments for trust. Minimum temperature is constructed as the 1901–1990 average of the minimum temperature (in Celsius) during the year, using monthly historical data obtained from the Climate Change Knowledge Portal (CCKB) of the World Bank. In addition, I also use (iii) a lagged measure of trust as an additional instrument, that is, the trust variable constructed from waves 1 through 3 of the EVS. The Survey includes the NUTS codes of respondents on wave 4, while previous waves contain the original region codes of the EVS (variable ×048). I manually match these region codes in prior waves to the NUTS classification on wave 4, which allows aggregating responses for any of the 120 NUTS 1 and 326 NUTS 2 regions in the European geography for the period 1981–2004 to construct this lagged instrument.[9]

I also use additional instruments to deal with the endogeneity of R&D inputs with respect to invention and innovation indicators by employing additional instruments. I use (iv) the lagged share of government R&D expenditures (year 2002), as well as (iv) lagged R&D (year 2002) as instruments for R&D expenditures in the region. Instruments for R&D expenditures are difficult to obtain (Griliches et al., 1991; Pakes & Griliches, 1984), but lagged values offer a means of instrumentations in the vein of generalized method of moments (GMM) (e.g., Crépon & Duguet, 1997). Lags of (flow) R&D expenditures can prove to be good instruments for the level variable since R&D expenditures are relatively persistent and can be affected by past government and total R&D, while their effects on innovation outcomes are unlikely to reach too far into the future due to knowledge obsolescence. Correlations between endogenous variables and instruments can also be seen in Table 1. Note that all correlations have the expected theoretical relationships with the relevant IVs. Trust is positively correlated with its past value (0.61) as well as latitude (0.55), while being negatively correlated with minimum temperature (−0.26), as expected. Total R&D is highly correlated with both instruments intended for it, while business R&D is correlated with past R&D.

Using multiple instruments allows addressing key issues in proper instrument use for the analysis at hand, using overidentifying restrictions of instrument validity (i.e., exclusion restrictions). While exclusion restrictions for instruments cannot be tested directly, overidentifying restrictions allows testing the validity of the instrument set conditional on at least one instrument being valid. Rejection of overidentifying restrictions provide evidence that at least one instrument is not exogenous. In addition, if instruments are only weakly related to endogenous regressors, standard results on the consistency of IV estimators break down even if instruments are truly exogenous (Andrews et al., 2019; Bound et al., 1995; Staiger & Stock, 1997; Stock & Yogo, 2005). A large literature in econometrics has developed various tests for weak instruments and underidentification to address this problem (Hahn & Hausman, 2003; Sanderson & Windmeijer, 2016; Stock & Yogo, 2005; Stock et al., 2002; among others). I select the set of instruments used in each specification by analyzing tests of underidentification and weak identification, in addition to testing the validity of the set of instruments using the Sargan test of overidentifying restrictions. The resulting instrument selection procedure is summarized in Table 3. The relevance of the instrument set is demonstrated using Sanderson–Windmeijer First-Stage χ^2 and F-Tests, which test the null hypotheses that the endogenous variable in question is underidentified and weakly identified, respectively (Sanderson & Windmeijer, 2016). I also report the F-test version of the Cragg–Donald test statistic (Cragg & Donald, 1993) formulated by Stock and Yogo (2005), which tests for the null hypothesis that instruments are weak, that is, that the bias of the IV estimator relative to the ordinary least squares estimator is above a specified threshold, or that the conventional Wald test size exceeds a given threshold. The critical values for different potential bias for IV coefficients and Wald test sizes are computed by Stock and Yogo (2005). Finally, I also report Wu–Hausman tests of exogeneity for each specification, which tests the null hypothesis that no correlation exists between endogenous variables and the error term, conditional on the validity of the instrument set.

For the specification for patent applications, the null hypothesis that the specification is underidentified and weakly identified are both strongly rejected (columns 1 and 2) at all reasonable levels of statistical significance. The Cragg–Donald F-test rejects the null that IV bias is higher than 5% at 5% significance (column 3). The Sargan test (column 4) does not reject the null that overidentifying restrictions are satisfied up to 10% significance ($\chi^2_3 = 6.27$, $p = 0.10$), and the Wu–Hausman test rejects the exogeneity of the variable set (column 5), indicating the necessity of the IV specification. For the trademark specification, Sargan test rejects the validity of the complete instrument set ($\chi^2_3 = 40.08$, $p = 0.00$), but does not reject when latitude is removed from the instrument list ($\chi^2_2 = 0.933$, $p = 0.63$). As a result, latitude is removed from the instrument list for this specification. Tests for under- and weak identification (columns 1–3) indicate that this instrument set satisfies corresponding identification criteria as well, while the Wu–Hausman test rejects exogeneity. Finally, neither the full instrument set ($\chi^2_3 = 34.53$, $p = 0.00$), nor the set excluding latitude ($\chi^2_2 = 36.65$, $p = 0.00$) appear to satisfy exclusion criteria for the innovative sales specification according to the Sargan test. For this variable, I only use the lagged value (EVS waves 1–3) of trust as an instrument for the variable, including the instruments used for R&D expenditures. Remaining instrument set satisfies overidentifying restrictions for this specification ($\chi^2_1 = 0.78$, $p = 0.38$) and is selected for subsequent analysis. For this case, critical values are not available for a given maximum IV bias, but only for a given maximum Wald test size. Finally, the Wu–Hausman test rejects the exogeneity of variables that are treated as endogenous for this specification as well[10].

3.6 | Generalized spatial 2SLS

Regional data is likely to exhibit spatial autocorrelation due to geographic dependencies. I account for such dependencies by estimating regression specifications using GS2SLS (Anselin et al., 2012; Arraiz et al., 2010; Drukker et al., 2013; Kelejian & Prucha, 1998, 2010). I use shapefiles provided by the Geographical Information and Maps data service, Eurostat (GISCO) data distribution service of Eurostat at the NUTS 1 and NUTS 2 levels. A spatial lag of the dependent variable is not included since the goal of analysis is not to estimate the effect of trust above and beyond spatial spillovers in invention/innovation indicators, but to control for spatial autocorrelation that could bias standard errors. I also estimate additional specifications that include a spatial lag of trust in order to identify direct and indirect effects, that is, regional spillovers for this variable. All spatial weight matrices are constructed using queen contiguity with 10 km precision.[11]

TABLE 3 Instrument selection.

Dependent variable	Instrument set	Sanderson–Windmeijer chi-square tests 1	Sanderson–Windmeijer *F*-tests 2	Cragg–Donald/Stock–Yogo Wald *F*-test for weak identification 3	Sargan test for overidentifying restrictions 4	Wu–Hausman test for variable exogeneity 5
Patents	Full instrument set:	Trust: 86.94 (4) ($p = 0.000$)	Trust: 20.49 (4; 181) ($p = 0.000$)	16.39 (5% critical value for 5% maximum IV bias: 13.97)	6.27 (3) ($p = 0.10$)	5.19 (2, 182) ($p = 0.006$)
	Minimum temperature					
	Latitude					
	Past trust (EVS waves 1–3)					
	Past government R&D (2002)	R&D: 425.17 (4) ($p = 0.000$)	R&D: 100.2 (4; 181) ($p = 0.000$)			
	Past R&D (2002)					
Trademarks	Full instrument set	(Above)	(Above)	(Above)	40.08 (3) ($p = 0.000$)	0.767 (2, 182) ($p = 0.466$)
	Without latitude (chosen instrument set)	Trust: 86.25 (3) ($p = 0.000$)	Trust: 27.25 (3; 182) ($p = 0.000$)	20.43 (5% critical value for 5% maximum IV bias: 11.04	0.933 (2) ($p = 0.627$)	6.56 (2, 182) ($p = 0.002$)
		R&D: 408.3 (3) ($p = 0.000$)	R&D: 129.0 (3; 182) ($p = 0.000$)			
Innovative sales	Full instrument set	(Above)	(Above)	(Above)	34.53 (3) ($p = 0.000$)	2.90 (2, 142) ($p = 0.059$)
	Without latitude	(Above)	(Above)	(Above)	35.65 (2) ($p = 0.000$)	2.26 (2, 142) ($p = 0.108$)
	Without latitude and tempcold (chosen instrument set)	Trust: 95.89 (2) ($p = 0.000$)	Trust: 45.11 (2; 143) ($p = 0.000$)	29.60 (5% critical value for 10% test size: 13.43)	0.783 (1) ($p = 0.376$)	3.66 (2, 142) ($p = 0.028$)
		R&D: 266.5 (2) ($p = 0.000$)	R&D: 125.3 (2; 143) ($p = 0.000$)			

Note: Test statistics in Columns 1 and 4 are distributed chi-square, remaining tests statistics are distributed *F*. Degrees of freedom and *p*-values are given in subsequent parentheses. Null hypotheses for the Sanderson–Windmeijer chi-square (resp., *F*) tests are that the endogenous variable is underidentified (resp., weakly identified); the null for Cragg–Donald is that the instrument set is weak in the sense that the IV bias is above a specified threshold, or the size of the Wald test is above a threshold; the null for the Sargan test is that the instrument set is uncorrelated with the error term; and the null for the Wu–Hausman test is that the variables treated as endogenous are in fact exogenous. Sargan and Wu–Hausman tests are conducted using 2SLS estimates before controlling for spatial dependence. Innovative sales use a smaller sample that gives similar results for the full instrument set and the set without latitude. Results for this sample are not reported due to space considerations.

4 | ANALYSIS AND RESULTS

Basic correlations between trust and dependent variables on Table 2 indicate that all three indicators correlate positively with trust.[12] Figure 2 displays plots of (log) trust against all three dependent variables (in logs). The positive relationships between trust and dependent variables are evident here as well. A double-log specification appears as a good approximation for patents and trademarks. However, the plot for innovative sales indicates that this variable may exhibit a non-linear relationship with trust. To account for such potential nonlinearities, I estimate additional specifications that include a quadratic specification for trust, instead of the log transform. Remaining variables are unaltered in these additional estimations.

Table 4 presents results from GS2SLS regressions. The dependent variable is patent applications in columns 1 through 3, trademark applications in columns 4 through 6, and innovative sales in columns 7 through 9. For each variable, the first two columns report results from the log-linear specification, with the second specification including QoG (quality of government) as an additional control, while the first specification does not. The third specification for each dependent variable replaces the logarithmic transformation for trust and introduces a quadratic specification instead. The trust variable is centered around its mean for this specification (and its square taken afterward) in order to avoid collinearity between trust and its square.

For patent application regressions (columns 1–3), the coefficient of trust in all specifications are positive and significant. The inclusion of QoG reduces the coefficient of trust significantly, from 1.28 (column 1) to 0.91 (column 2). Both coefficients are elasticity measurements, hence a 10% increase in interpersonal trust leads to a 9.1% increase in patent applications in the region, holding fixed trust in institutions. The corresponding coefficients for the trust variable are also positive and significant in trademark specifications. For this variable, the inclusion of QoG introduces only a minor change in the estimated effect of trust. The point estimate for trust in column 5 indicates that a 10% increase in interpersonal trust in the region is expected to increase trademark applications in the same region by 8.8%. These estimates also lead to the conclusion that interpersonal trust exhibits effects on patent and trademark applications in the region that are of similar magnitudes.

For the innovative sales specification, the log-linear form produces a positive and significant coefficient only at 10% significance in column 7 where QoG is excluded from the list of controls. The point estimate drops little with the inclusion of institutional quality in the list of regressors, but the resulting coefficient estimate is not significant at any reasonable level. However, it was noted before that innovative sales may exhibit nonlinearities in its dependence with institutional trust. This is in line with the plot of innovative sales against trust in Figure 2, and also with much previous evidence (Bidault & Castello, 2009; Molina-Morales & Martínez-Fernández, 2009) that was discussed in Section 2. In

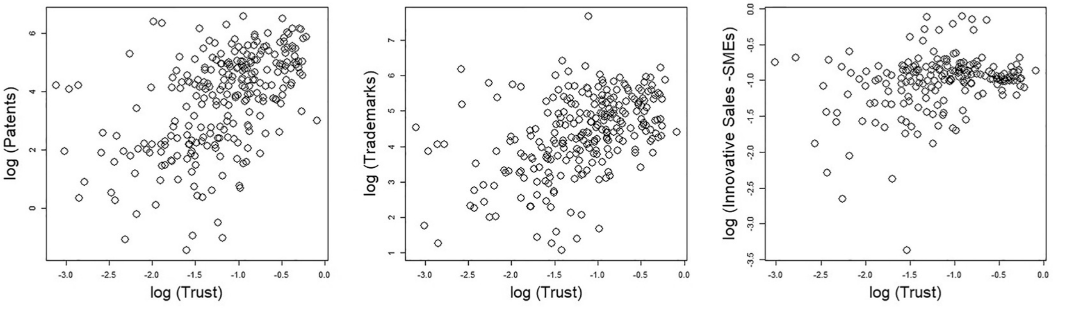

FIGURE 2 Scatterplots of trust against dependent variables. All variables are in logs.

TABLE 4 Generalized spatial two-stage least squares (GS2SLS) regressions with spatially autocorrelated errors.

	Patent applications (per million inhabitants)			Trademark applications (per million inhabitants)			Innovative sales by SMEs		
	1	2	3	4	5	6	7	8	9
(log) Trust	1.2815*** (0.3989)	0.9099** (0.3909)		0.8872*** (0.3320)	0.8847** (0.3574)		0.5110* (0.2773)	0.4854 (0.3012)	
Trust			1.0256** (0.5075)			1.2230*** (0.3749)			0.6947*** (0.2602)
Trust squared			1.3775 (2.1559)			−0.8023 (1.5981)			−4.7164*** (1.0681)
Quality of government (QoG)		0.4392*** (0.1385)	0.5206*** (0.1109)		0.0355 (0.1190)	0.1123 (0.0839)		0.0387 (0.0768)	0.0858* (0.0499)
(log) R&D as % of GDP	1.0298*** (0.1552)	0.9058*** (0.1383)	0.9608*** (0.1195)	0.2135* (0.1165)	0.1984* (0.1162)	0.2489*** (0.0884)	−0.0198 (0.0893)	−0.0322 (0.0844)	0.0802 (0.0591)
(log) Business R&D as % of total	0.5235*** (0.1532)	0.4254*** (0.1336)	0.4984*** (0.1135)	0.2086* (0.1139)	0.1963* (0.1118)	0.2475*** (0.0821)	0.0020 (0.0832)	−0.0047 (0.0786)	0.0348 (0.0506)
(log) Tertiary education	−0.0587 (0.3243)	−0.3081 (0.2856)	−0.2597 (0.2619)	0.4382* (0.2453)	0.4092* (0.2412)	0.5000** (0.2040)	0.0560 (0.1591)	0.0260 (0.1506)	0.0452 (0.1192)
(log) Population	0.0895 (0.1180)	0.2225** (0.1070)	0.1917** (0.0936)	0.2859*** (0.0885)	0.3009*** (0.0893)	0.2635*** (0.0679)	0.0947 (0.0762)	0.1046 (0.0706)	−0.0021 (0.0420)
(log) Area	−0.1335* (0.0829)	−0.1625** (0.0729)	−0.1633** (0.0657)	−0.2957*** (0.0610)	−0.2991*** (0.0611)	−0.2940*** (0.0495)	−0.0444 (0.0443)	−0.0491 (0.0424)	−0.0001 (0.0299)
Spatial autocorrelation coefficient	0.4023*** (0.0854)	0.4156*** (0.0807)	0.4720*** (0.0723)	0.4259*** (0.0985)	0.4336*** (0.1006)		0.5812*** (0.1028)	0.5932*** (0.1110)	0.5698*** (0.0793)
Constant	5.6144*** (1.7304)	4.1457*** (1.6025)	3.3881** (1.4032)	2.8252** (1.2658)	2.7111** (1.3448)	1.9211* (1.0456)	−1.5799** 0.7998	−1.6253** (0.7875)	−1.0296* (0.6116)
Pseudo *R*-squared	0.6285	0.7086	0.7560	0.4716	0.4732	0.5960	0.1011	0.1119	0.3939
# Of regions	192	192	192	192	192	192	152	152	152

Note: Standard errors are in parentheses. Significance levels: (1%)***, (5%)**, (10%)*.

accordance with this, columns 3, 6, and 9 introduce a quadratic term for trust in each specification instead of the baseline log transformation. The outcome highlights the importance of considering the possibility of a nonlinear effect, producing coefficients for both the level and the square of the trust variable that are significant at the 1% level. According to coefficient estimates in column 9, innovative sales initially rise with increasing interpersonal trust in the region, but fall after a threshold. Noting that the trust variable is mean-centered for the quadratic specification, innovative sales attains a maximum value when the trust variable takes value 0.432, that is, when 43.2% of individuals in the region agree with the statement "most people can be trusted." While the marginal effect of trust varies along the inverted-U, one can still obtain useful elasticities for comparison. For instance, the implied elasticity when the existing trust level is 0.2 is 0.438, much lower than estimated elasticities for patents and trademarks. The same elasticity equals 0.249 at the sample mean of the trust variable (trust = 0.358).

These results document an additional negative effect of trust on innovative sales at the higher end of its distribution, and indicates that the uniform positive effect of trust on patents and trademarks do not translate into all innovation indicators. Reasons to expect a potential negative effect of trust on innovation were discussed in Section 2. Note that innovative sales variable is unique among indicators in its direct measurement of successful commercialization in a sales context. On the other hand, the quadratic form does not detect a nonlinear relationship between trust and the remaining two dependent variables. Results lead to the conclusion that the negative effect of trust is not observed in indirect indicators, but is clearly observed in direct market and sales contexts. The squared term is positive (resp. negative) for patent (resp. trademark) application regressions in column 3 (resp. column 6). One could conclude that these coefficients point to the presence of increasing returns to trust for patents, and of decreasing returns to trademarks, but these effects do not achieve any reasonable level of statistical significance. I take the results in columns 2 and 5 as the baseline results for patents and trademarks, respectively.

In terms of additional results, note that the inclusion of QoG as a control significantly reduces the trust coefficient for patents, but not for trademarks or innovative sales. The effect of institutions are large and significant for patents, indicating an implied elasticity value of 0.156 at the mean value of QoG. Therefore, a 10% increase in trust in institutions leads to a 1.56% rise in patent applications in the region, for a region obtaining the mean value of QoG. The coefficient of QoG is much smaller for trademarks and produces an insignificant coefficient (column 5), while the corresponding coefficient is significant only at the 10% level in innovative sales regressions (column 9). This set of results indicate that institutional quality affects invention to a much larger extent that innovation, producing much smaller, insignificant (trademarks), or barely significant (innovative sales) effects for the latter.

Total R&D (as % of GDP) is positively associated with patents (column 1–3) and trademarks (columns 4–6), with much lower coefficients for the latter. As expected, the R&D elasticity of patents are much larger, up to about an order of magnitude, compared to the same elasticity for trademarks. This variable has an insignificant coefficient for all innovative sales specifications (columns 7–9). Business R&D (as ratio of total R&D) positively affects patents and trademarks as well. It is worth noting that the effect of business R&D on patents is about half of the effect of total R&D for patents, but is comparable to the effect of total R&D for trademarks. Again, business R&D produces insignificant coefficients in innovative sales regressions.

The coefficient of tertiary education is insignificant except for trademark applications. Coefficients of population and area are such that both are significant in most specifications, except in specifications for innovative sales. Population has a positive, and area has a negative coefficient in most columns. The signs of the two variables together indicate a positive effect of population density for all indicators except innovative sales, which is consistent with the benefits of spatial agglomeration and within-region spillovers.

4.1 | Spatial spillovers

Table 5 reports results from regressions that include a spatial lag of the (log) trust variable in addition to the baseline results in Table 4. The spatial lag is added to the preferred specification in Table 4 for each variable, that is, column 2 for patents, column 5 for trademarks, and column 9 for innovative sales. The table reports coefficients only for trust and its spatial lag, but all controls in the respective column in Table 4 included. These give similar coefficients to those in Table 4 and are not reported. Since a spatial lag of the dependent variable is not included, direct and indirect effects of trust are measured directly by the regression coefficients of the variable and its spatial lag, respectively (Elhorst, 2010). These effects correspond to the effect of neighboring regions on the dependent variable for a particular region averaged over all regions, which equals the effect of trust in one region to its neighboring regions, averaged over all regions. For patent applications (column 1) the direct effect of trust produces an elasticity value 0.798, while the indirect elasticity due to regional spillovers is 0.283. For trademarks, the estimated direct effect is somewhat smaller compared to patents, at 0.712, while the indirect effect is considerably larger, with an elasticity of 0.350. For innovative sales, the inclusion of the spatial lag reduces the coefficient of trust, while increasing the magnitude of the coefficient of the squared term. This introduces a slight change in the trust value at which this variable attains maximum value, that is, 43.6% (compared to 43.2 in the baseline specification). The implied direct elasticity at trust level 0.2 becomes 0.426 (compared to 0.438), while the same elasticity is 0.228 at mean trust level (compared to 0.249). The coefficient of the spatially lagged term is 0.156, indicating a spillover effect that is about an order of magnitude smaller than the corresponding spillover effect for patents and trademarks.

4.2 | Robustness analysis

Here I perform additional analysis on the main specifications used in Table 4 for robustness checks. These results are presented in Table 6. First, note that the samples used in Columns 1–6 and 7–9 of Table 4 uses different samples due to the different data sources for patents and trademarks on the one hand (ERI) and innovative sales on the other (RIS). In particular, innovative sales regressions use a smaller sample with different data points, that is, NUTS 1 level instead of NUTS 2 for some countries. Since data from ERI is available at both levels, it is possible to estimate the main specifications for patents and trademarks in Table 4 for the RIS sample. Columns 1 and 2 of Table 6 reports estimates for the specifications in Column 3 (patents) and Column 6 (trademarks), respectively for the smaller-

TABLE 5 Spatial spillovers in trust, direct and indirect effects (GS2SLS).

	Patent applications	Trademark applications	Innovative sales
	1	2	3
(log) Trust	0.7984** (0.3809)	0.7106** (0.3328)	
Trust			0.6351*** (0.2538)
Trust squared			−4.8079*** (1.0563)
Spatial lag of (log) trust	0.2826* (0.1697)	0.3503** (0.1376)	0.1562** (0.0752)
Remaining controls in Table 4	Included	Included	Included
Pseudo R-squared	0.7197	0.5178	0.4072
# Of regions	192	192	152

Note: All additional variables included in Table 4 are also included in all specifications, including quality of government, which obtain similar coefficients to those in Table 4. Standard errors are in parentheses. Significance levels: (1%)***, (5%)**, (10%)*.

and different- RIS sample. It is seen that main results replicate with the alternative sample. The effect of trust on patents is a bit larger, white that on trademarks are a bit smaller, compared to baseline estimates.

Another potential issue is whether the inverted-U result in Column 9 of Table 4 is a construct of a few very influential data points. A close analysis of Figure 2 may suggests the possibility that the result is driven by the few observations with low values for the innovative sales variable. To address this possibility, I estimate the main specification for innovative sales with these observations removed. Column 3 of Table 6 presents estimates for the sample with log(trust) > −2, to see whether the remaining data points provide a similar result. Results confirm the inverted-U relationship between trust and innovative sales, while the coefficient on the first-order quadratic term, hence the estimate of the marginal effect is lower, with a smaller significance level (5% instead of 1%).

5 | CONCLUSION

The economic literature on trust has examined the relationship between trust and invention (patents), but overlooked the importance of commercialization in innovation. In this article I introduce measures of innovation to the study of the relationship between trust, invention and innovation across European regions, taking care to distinguish indicators of invention and innovation from one another. The key contribution of the article is to bring more direct indicators of innovation into the analysis, which enriches the discussion on the relationship between trust and creative processes.

My results reveal differences in the extent invention and innovation processes rely on interpersonal trust. While patent and trademark applications are strongly associated with interpersonal trust, the relationship between innovative sales and trust is estimated as an inverted-U. These results point to an important role of interpersonal trust in all three indicators, reporting that trust has an important role in innovation as well as in invention. However, the positive association that has been previously observed between trust

TABLE 6 Robustness of results.

	Patent applications, smaller sample	**Trademark applications, smaller sample**	**Innovative sales by SMEs, log(trust) > −2**
	1	2	3
(log) Trust	1.2099*** (0.3512)	0.7005*** (0.2478)	
Trust			0.4835** (0.2292)
Trust squared			−3.9311*** (0.8830)
Quality of government (QoG)	0.2659** (0.1339)	−0.0227 (0.0939)	0.0877** (0.0395)
(log) R&D as % of GDP	0.9938*** (0.1525)	0.2591** (0.1054)	0.0552 (0.0507)
(log) Business R&D as % of total	0.4042*** (0.1344)	0.3081*** (0.0924)	0.0064 (0.0454)
(log) Tertiary education	−0.2318 (0.2946)	0.7821*** (0.2114)	−0.0067 (0.0815)
(log) Population	0.2339** (0.1104)	0.2210*** (0.0770)	0.0158 (0.0345)
(log) Area	−0.2097*** (0.0750)	−0.3091*** (0.0532)	0.0225 (0.0226)
Spatial autocorrelation coefficient	0.4270***	0.5109***	0.6727***
Constant	4.4791*** (1.5378)	2.7145** (1.0863)	−1.3302*** (0.4679)
Pseudo R-squared	0.7801	0.7040	0.2349
# Of regions	152	152	147

Note: Standard errors are in parentheses. Significance levels: (1%)***, (5%)**, (10%)*.

and invention does not readily translate into all innovation indicators. While results report a uniformly positive and significant effect of trust on trademarks, they also establish a negative effect at the higher end of the trust distribution for innovative sales. Since the innovative sales variable is unique among the three indicators in being a direct measure of successful commercialization and sales, it can be argued that the effect of trust on successful commercialization is not uniformly positive, but can be hindered by excessively high values of trust. Importantly, my results also raise caution for the study of invention and innovation at large, pointing out the necessity of making explicit the context given by the precise set of indicators. My analysis also include the identification of direct and indirect effects of trust on all three indicators, showing that the effect of trust on creative outcomes is also mediated by regional spillover effects.

As a policy implication, results advice against the over-emphasis of trust-building in contexts that are in direct contact with commercialization, marketing, and sales. This final stage of the innovation life-cycle seems to benefit from an intermediate level of trust. Investments to build trust are better suited to contexts where shared and cumulative knowledge is of critical importance, such as inventive work in engineering, or otherwise when mutual trust is significantly low.

The regional context offers observations for a rich set of creative outcomes at each location. Future work may attempt observing creative outcomes and trust at a more disaggregated level, perhaps at the level of the firm, or at the level of individuals. More detailed data, or carefully designed experimental settings may help further understand the role of trust in inventive and innovative outcomes.

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CONFLICT OF INTEREST STATEMENT
The author does not report any conflict of interest.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are available from the corresponding author upon reasonable request.

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[1] "In fact, it is precisely the existence of market risk that distinguishes product innovation from product invention" (Barlet et al., 1998).

[2] Despite these findings, the exact nature of the link between trademarking and innovation is unclear. Since trademarking is mainly a marketing activity- hence is indirectly linked to new products-, trademark counts can also be treated as a joint index of good management, including marketing but also innovation efforts. The current article makes use of this correlative relationship in order to gain insight into later stages of the innovation life-cycle than patents.

[3] I primarily use the regional variation at the NUTS 2 level. Some analyses use a combination of NUTS 1 and NUTS 2 regional classifications due to data availability (see Section 3).

[4] I have preferred the EVS over the European Social Survey since the former contained higher resolution regional information (NUTS 2 instead of NUTS 1) for Germany and United Kingdom.

[5] The first four waves of the EVS are conducted between years (1) 1981–1984, (2) 1989–1993, (3) 1999–2004, and (4) 2008–2010. The latest year the survey is administered for wave 4 is 2008 or 2009 for most countries in the sample, with only Great Britain, Iceland, and Sweden including responses from year 2010. Fieldwork for wave 5 (2017–2021) was completed during the writing of this article.

[6] The 2012 edition of RIS gives similar results, but the 2017 report is used in final analysis due to its finer and wider coverage. The 2012 edition may seem like a better match due to being the first edition after 2010 -the final year trust data is collected in the field-, 2017 is preferred for the current study due to the finer regional classification used by the latter for Germany and Greece, as well as including Serbia. This is also a better choice for innovative sales for two reasons. While there is extensive evidence suggesting that the R&D-patenting relationship is mostly contemporaneous, the same cannot be argued for innovative sales, hence the additional time lag should be preferred. This also allows better instrumentation of R&D expenditures for innovative sales due to the longer time interval between lagged (total and government) R&D (which are used as instruments for current R&D, see Section 3.5) and innovative sales.

[7] A potential criticism is that patent and trademark applications are mostly made by large firms, while the share of innovative sales in turnover is measured only for SMEs. While this criticism cannot be fully addressed, I note that empirical evidence points to complementarities in small and large firm innovation (Agrawal et al., 2014; Glaeser & Kerr, 2009; Helsley & Strange, 2002), which suggests that SME innovation is indicative of the larger innovative capability of the region.

[8] RIS data is aggregated at the NUTS 2 level, except for Belgium, Bulgaria, France, Austria, and United Kingdom, which are reported at the level of NUTS 1.

[9] For France, Germany, and UK, this produces a match only at the NUTS 1 regional level, while information on all other variables, including trust obtained from wave 4, are available at the level of NUTS 2 regions. For these countries, corresponding NUTS 1 observations are used for the value of the instrument to limit the loss of observations to a minimum.

[10] I also analyzed variables indicating key properties of the predominant language spoken in the region as instruments for trust (Licht et al., 2007; Tabellini, 2008). These are whether the main language in the country exhibits pronoun-drop characteristics, and whether it has second-person (Tu-Vous) differentiation. Tabellini (2008) uses a variable that subtracts the latter from the former, which correlates more strongly with the trust variable than its individual constituents. While this variable correlates highly with trust, its conditional validity is rejected by the test of overidentifying restrictions in the current sample. A similar situation exists with the longitude coordinate of the region, which correlates negatively with trust but is rejected. For R&D inputs, I used a measure of tax incentive support for R&D across European countries as instruments, taken from the OECD R&D Tax Incentive Database. This variable is available at the level of countries and is also rejected by a test of overidentifying restrictions in the current sample.

[11] Spatial analyses are performed on QGis and GeoDa, including the restriction of the shapefiles to the sample at hand, while regression results are obtained using GeoDaSpace.

[12] All correlations are statistically significant, with $p < 0.000$.

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