Diskussionspapierreihe
Working Paper Series

HELMUT SCHMIDT UNIVERSITÄT
Universität der Bundeswehr Hamburg

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Nr./ No. 150
Juli / July 2014

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Redaktion / Editors

Helmut Schmidt Universität Hamburg / Helmut Schmidt University Hamburg
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Zusammenfassung/ Abstract

Successful innovation is a precondition for economic prosperity. While various potential determinants of innovative activity have been considered, little empirical evidence is yet available for the influence of firm governance issues. This paper aims at filling this gap in the literature by studying whether the relative importance of owner-managed small and medium sized enterprises has an effect on regional innovative capacity. We therefore combine patent data with data from the firm database of Creditreform, containing information on the governance structure of regional operating enterprises. Using a cross section of German NUTS-3-regions, we identify a significantly positive relation between the relative importance of owner-managed SMEs and innovative capacity. This finding is highly robust when controlling for spatial correlations.

JEL-Klassifikation / JEL-Classification: O31; C21; D23

Schlagworte /Keywords: innovation; owner-managed firms; SMEs; Germany

1 Introduction

Innovations contribute essentially to economic prosperity and social welfare. According to growth theory, both process and product innovations promote long-run growth by continuously shifting the production function. Process innovations cause productivity growth and thus upgrade the relation between input and output (Solow 1956). Product innovations might increase economic growth either by horizontal innovations, as in the models by Romer (1987, 1990), or by vertical product innovations, as in the model by Aghion and Howitt (1992). In the Romer (1987, 1990) models, product innovations lead to the creation of new varieties of inputs or intermediate goods. The greater variety of inputs and intermediate goods increases the division of labor and thus the productivity of firms producing final goods. The Schumpeterian growth model by Aghion and Howitt (1992) focuses on quality-improving product innovations making old products obsolete, the well-known process of creative destruction. Whenever there is a love of variety by consumers, an increasing number of final goods also increases welfare (Dixit and Stiglitz 1977).

However, most innovations do not occur by chance. Innovations result from the transformation of generally available knowledge into economically exploitable knowledge. For this process entrepreneurship is needed (Audretsch and Keilbach 2004, Acs et al. 2012, González-Pernía et al. 2012). Obviously the motive behind this sort of entrepreneurial activity is to gain advantages in competition.[1]

Based on theoretical reasoning, the empirical oriented literature has considered numerous factors as possible determinants of the level of regional innovations.[2] Among the most often studied factors are research and development expenditures, population density, industry structure, GDP per capita, the share of highly qualified employees and the regional supply of universities.[3] Little empirical evidence is yet available on the joint influence of governance issues and firm size on innovations. According to principal agent theory, firms have to bear agency costs whenever strategic decisions are not made by the firm owners. In this case, owners have to spend resources on monitoring and disciplining managers. Especially the agency costs connected with innovations tend to be high. Firstly, due to the risky nature of innovation projects, principals need to observe the agents' activities intensively because output is a poor indicator of agents' effort. Secondly, risk averse agents

[1] Since innovations bear the characteristics of a public good and provide nonrival general knowledge themselves (Romer 1990, Grossman and Helpman 1990, Schalk Varga 2004), often patent law is necessary to provide incentives for an efficient level of research and development.

[2] For an overview see Audretsch and Vivarelli (1996), Piergiovanni and Santarelli (2001), Baumert et al. (2010), Franke and Fritsch (2004) as well as Faber and Hesen (2004).

[3] Section two of this paper provides a detailed survey of the related literature.

prefer low-risk tasks instead of working in intrinsically erratic projects. Finally, innovations often are long-term projects whereas agents favor tasks influencing the present value of the firm and thus partially the agents' salaries in the short run (Holmstrom 1989). Owner-managed firms have not to bear these agency costs and might use the referring resources for research and development which finally might result in innovations. Because owners decide themselves, owner-managed firms can make innovation decisions faster, which provides a time advantage in innovative competition (Putterman 2009, Jensen and Meckling 2009, IfM Bonn 2013). Owner-management especially makes sense in small noncomplex firms (Fama and Jensen 1983) and strengthens the advantages of small enterprises of less bureaucracy, short lines of communication and great agility (Parker 2011). Especially bureaucracy might counteract innovations by restricting experimentation as it often struggles with new and extraordinary projects and often does not tolerate failures in the innovation process. Extended bureaucracy might also screen out innovative personalities. Additionally, in expanded hierarchies a larger number of layers decide whether to initiate an innovation. However, innovation projects might counteract the interests of individual layers and thus will not be implemented. Furthermore, small firms often concentrate on few activities and hence promote innovations. The more tasks with different risk characteristics risk averse agents could engage in, the more incentives have to be provided to make them work on the risky innovation project (Holmstrom 1989). Firm size also directly influences the way how firms innovate. SMEs are often active on niche markets and develop individual products together with their customers (Arvanitis 1997, Bizer and Thomä 2013, IfM Bonn 2013a).

Provided this line of argument is correct, we should find that owner-managed SMEs outperform other sorts of enterprises in terms of innovative capacity. In many countries the view that owner-managed SMEs are superior forms of organizing business firms is deeply rooted. This view is especially pronounced in Germany, where owner-managed SMEs are referred to as "*Mittelstand*". Since decades, slogans like "the German *Mittelstand* is the engine of the German economy" are part of the political propaganda, regardless of the concrete political spectrum. Very often, politicians especially refer to the German *Mittelstand*'s enormous innovative capacity (Federal Ministry of Economics and Technology 2013).

Interestingly enough, there is yet almost no empirical evidence on the question whether owner-managed SMEs are in fact promoting innovative activity. This is likely due to the fact that official statistics often do not report on the governance structure of enterprises. Some empirical evidence is available for family firms. Even more evidence is available for SMEs. However, both strands of the literature fail to find a consistent impact on innovative capacity.

This paper aims at filling the described gap in the empirical literature. Due to the fact that the belief in the superior performance of owner-managed SMEs is especially pronounced in Germany, we focus our analysis on Germany. We examine the relation between the relative importance of owner-managed SMEs and innovative capacity on the regional level (NUTS-3) in a cross section approach.[4] In order to do so, we combine patent data with data on firm governance and size from the largest German firm database maintained by the *Creditreform Corporation*. We find a significantly positive and sizeable influence of the relative importance of owner-managed SMEs on relative regional innovative capacity, even when controlling for a large number of potential covariates. Moreover, this finding proves to be highly robust when controlling for various sorts of spatial correlation.

The remainder of this paper is organized as follows. The second section delivers an overview of the related literature. Section three outlines the estimation approach and introduces the employed datasets. Section four presents the empirical results. Section five studies the existence of spatial correlation and delivers further estimation results taking these correlations into account. The final section summarizes the main results and draws some conclusions.

2 Related Literature

To the best of our knowledge, the impact of owner-managed SMEs on innovative capacity has yet not been studied explicitly. This is likely due to the fact that data on the governance structure of enterprises is often unavailable. However, there are two strands of the literature which are concerned with empirical analyses of closely related issues. The first examines whether family firms differ in their innovative capacity from non-family firms. The second analyzes the impact of firm size on innovative activities. Both strands of the empirical oriented literature are quite heterogeneous in measuring innovative capacity. Parts of the literature use input indicators such as research and development expenses. Other studies employ either patents as intermediate output measure or newly commercialized products as output-oriented indicator. Besides using different proxies for innovative capacity, the existing literature also differs in the applied empirical methodologies, the employed control variables and the regional level on which the study is conducted.

[4] Although both patent and firm data are in principle available on the firm level, the datasets cannot be matched on the firm level. We therefore aggregate both datasets on the regional level.

The first strand of the literature contrasts innovative capacity of family firms with innovative activities in outside managed firms. In family firms ownership and management coincide within the family. While many family firms are owner-managed, this does not necessarily hold true for all family firms.[5] In family firms sometimes one part of the family owns at least parts of the enterprise whereas other family members manage the firm. Although ownership and management are thus combined in one family, they are not conjoint in the same persons. This might lead to the earlier described agency costs. These costs might be lower than the occurring agency costs in outside managed firms, e.g. due to altruism within the family. However, in family firms other agency costs might occur, e.g. when family goals counteract economic goals (Chrisman et al. 2004). Often family members manage the company because of the existing family relationship instead of high competence. Family-owners might tolerate suboptimal performance or even laziness of family-managers and the decision-making hierarchy might be unclear within the family (Kets de Vries 1993, Chu 2009). When studying the relative performance of family and non-family firms, Hülsbeck et al. (2012) find a lower innovative intensity in family firms. They argue this finding to be due to higher risk aversion in family firms because families invest private property. The authors also find that the way how families are involved in strategic decisions is important for innovative capacity. While family members in the directorate have a positive influence on innovative capacity, the opposite holds true when family members are part of the management board.

There is also a number of authors arguing that especially small and medium sized companies can gain from the governance structure of family firms (Chu 2009). According to IfM Bonn (2013), family SMEs have a higher innovative capacity than non-family SMEs due to owner-management.[6] Owner-managers would be familiar with the firm's resources and make innovation decisions on their own. Kraft (1989) finds empirical evidence in favor of a positive influence of owner-management on innovations. However, Czarnitzki and Kraft (2004) do not find a significant impact on innovative activity per se but a significant negative effect on R&D intensity. However, the advantages of owner-management would turn into disadvantages with increasing firm size as a consequence of increasing complexity. Against this background, Classen et al. (2013) examine family and non-family SMEs on different stages of the innovation process. In their study family SMEs turn out to have a

[5]While many owner-managed firms are also family firms, this again does not always hold true. An obvious example is the case where a firm consists of two owner-managers which are unrelated.

[6]Note that this line of argument refers to the organizational principle of owner-management rather than to family firms. As we have argued earlier, not all family firms are necessarily owner-managed. However, in the literature these terms are often used interchangeably.

higher propensity to invest in research and development than non-family SMEs. However, among the innovating firms, family SMEs invest less intensively. The authors attribute this finding to differing strategic goals: While family firms would be primarily interested in their long-term survival, non-family firms would primarily focus on short-term profits. Altogether, Classen et al. (2013) conclude that family SMEs are at least as effective as non-family SMEs in achieving innovations.

The second strand of the literature analyzes the impact of firm size[7] on innovations. However, this literature fails to find a consistent influence of firm size on innovative capacity. Charkrabarti and Halperin (1990) as well as Pfirrmann (1994) detect a negative impact whereas Faber and Hesen (2004) and Cáceres et al. (2011) find a positive effect. Moreover, both relations are not robust when changing the measure of innovative activities or modifying control variables. Acs et al. (2002) detect a significant negative effect of relative firm size on innovations but no significant effect on patents. In Audretsch et al. (2012), increasing firm size promotes innovative capacity only in combination with external knowledge flows from universities to enterprises. Acs and Audretsch (1988) find small firms to be more innovative than their larger counterparts in industries in which small enterprises are underrepresented. They attribute this finding to the prevailing competitive situation. In industries composed predominantly of large firms, small firms might innovate extensively to compete against their larger rivals. Kraft (1989) does not find a significant influence of firm size on the proportion of sales attributed to newly developed products. Furthermore, parts of the literature find non-linear relations between firm size and innovative activity. However, again the findings are far from being clear-cut. While Pavitt et al. (1978) detect an U-shaped impact of firm size on innovations, Schwalbach and Zimmermann (1991), Czarnitzki and Kraft (2004) and Arvanitis (1997) identify an inverse U-shaped influence.

Besides governance structure and firm size, various additional factors can be thought of affecting innovative capacity. Maybe most obvious, firms' expenditures in research and development might have an impact on innovations. Most studies in fact find a significantly positive influence (Cáceres et al. 2011, Audretsch and Vivarelli 1996, Piergiovanni and Santarelli 2001, Baumert et al. 2010, Brenner and Broekel 2011, Jaffe 1986, Franke and Fritsch 2004, Acs and Audretsch 1988). Arvanitis (1997) examines the relation between R&D expenditures and innovative capacity in detail. He considers R&D expenditures also as a quadratic polynomial and detects an inverse U-shaped relation. Expenditures in research and development

[7] Firm size is either measured by sales or by the number of employees, resulting in different classifications of SMEs and large firms.

might also cause spillover effects. Franke and Fritsch (2004) identify a significant positive effect of R&D expenditures, spent by firms of the same industry within the same region, on innovation activities.

Numerous studies have detected knowledge spillovers from universities to enterprises within the same region (Audretsch et al. 2012, Piergiovanni and Santarelli 2001, Baumert et al. 2010, Audretsch and Vivarelli 1996). Research intensive universities turn out to have a significant positive impact on firms' innovative activities. Especially small firms profit from knowledge spillovers, replacing own R&D efforts with external knowledge flows (Audretsch and Vivarelli 1996). However, innovating companies do not only benefit from universities in terms of knowledge spillovers. Additionally, universities provide skilled human capital necessary for innovative activities in firms (Baumert et al. 2010, Audretsch and Vivarelli 1996, Brenner and Broekel 2011).

Furthermore, regional indicators like economic prosperity, population density and industry structure might influence innovative capacity. Economic prosperity may be an indicator for a high level of domestic demand for high quality consumer goods (Baumert et al. 2010) as well as for the availability of capital for investments in innovation processes (Brenner and Broekel 2011). However, the influence of economic prosperity on innovations is yet unclear. Brenner and Broekel (2011), Baumert et al. (2010) and Audretsch et al. (2012) identify a significantly positive impact whereas Faber and Hesen (2004) find a significantly negative effect. The influence of population density on innovative capacity is ambiguous as well. Franke and Fritsch (2004) and Brenner and Broekel (2011) do not find a significant impact, Pfirrmann (1994) detects a negative and Audretsch et al. (2012) a positive effect.

In the case of Germany, innovative capacity might also depend on whether a region is located in the former East or West Germany. However, the impact of the spatial position is unclear (Franke and Fritsch 2004, Audretsch et al. 2012, Czarnitzki and Kraft 2004). In general, direction and significance of regional effects hinge on whether spillover effects are accounted for (Audretsch et al. 2012, Franke and Fritsch 2004, Audretsch and Vivarelli 1996). Additionally, empirical studies of innovative activity should take the structure of the regional industry into account because innovative activities differ considerably between industrial sectors (Audretsch et al. 2012, Schwalbach and Zimmermann 1991, Pavitt et al. 1987, Brenner and Broekel 2011). According to Malerba and Orsenigo (2008), industry structure significantly determines the relation between firm size and innovations.

3 Methodology and Data

3.1 Methodology

In this paper we aim at studying whether there is a systematic relation between the level of innovations which occurs in a region and the relative importance of owner-managed firms of small or medium size. In order to do so, we basically regress an indicator of regional innovative capacity on a measure of the relative importance of locally operating owner-managed SMEs and a number of additional, potentially meaningful control variables, deduced from the earlier cited literature. As our measure of the relative importance of owner-managed SMEs is available only for the year 2008, we have to concentrate on the analysis of the referring cross section.[8] In order to have enough degrees of freedom for our analysis, we conduct our analysis on the NUTS-3-level. Our empirical approach thus consists of estimating the following regression

$$Inn_i = \alpha + \beta\, OMSME_i + \gamma\, X_i + \epsilon_i \tag{1}$$

with Inn being a proxy for regional innovative capacity, OMSME being a measure of the relative importance of owner-managed SMEs and X being a vector of control variables. The index i denotes the region, an observation comes from, ϵ is the error term and α, β and γ are the parameters to be estimated. In our baseline model we estimate the regression using the OLS technique.[9]

3.2 Regional innovative activity

In line with most of the existing literature (see e.g. Griliches 1990, Lybbert and Zolas 2012, Goto et al. 2010, Moser and Voena 2012), we use patents as intermediate output measure for innovative capacity. In order to measure German regional innovative activity, we employ patent applications to the European Patent Office from applicants located in Germany. The patent data were extracted from the REGPAT database (January 2013 edition) maintained by the OECD. However, using patent

[8] As no obvious instrument variable is available for owner-managed SMEs we thus have little possibilities to control for endogeneity. However, there is neither a credible theoretical argument for reverse causality nor empirical evidence pointing in this direction (see e.g. Czarnitzki and Kraft 2004).

[9] When conducting regressions on the NUTS-3-level, we might be confronted with spatial dependencies as a consequence of commuting behavior and spillover effects. In the first step of our analysis we refrain from taking spatial correlation into account. However, after presenting the results of our baseline regression, we turn to a detailed analysis of spatial correlation (see Section 5).

applications as indicator of regional innovative capacity has several problems to be solved. First, not all inventions are patentable or should be patented according to the will of the inventors (Goto et al. 2010, Griliches 1990). Therefore, the absolute number of patent applications would underestimate the factual number of innovations. Second, the share of inventions, inventors choose to protect by applying for patenting, differs widely across industries. Thus, as Griliches (1990) argues, when evaluating regional innovative activity, industrial structure should be taken into account. Third, the share of patented inventions might change in the course of time (Moser 2013). However, since we only use a cross section of data this problem is obviously absent in our analysis. In order to deal adequately with the first two problems, we proceed as follows. Since we have no reliable information on the share of patented innovations, we refrain from trying to construct an indicator of absolute innovative activity. Instead, we derive a measure of relative innovative capacity. In addition, when doing so, we control for the industrial structure of German regions. However, German NUTS-3-regions do not only differ in their industrial structures, but also in the total number of locally operating enterprises. Therefore, we control for the number of enterprises on the regional level as well. Data on the total number of economically active enterprises per region were extracted from the *Creditreform* database. *Creditreform* is the largest German company information service, collecting data on economically active firms in Germany. The database contains 3,954,721 economically active firms located in Germany at the end of the year 2008.[10] The database includes information on the location of firms' headquarters and on the industrial sector in which an enterprise generates its largest turnover.

Our indicator of relative innovative capacity of German NUTS-3-regions is calculated by comparing the expected number of patents per region with the number that actually occurs.[11] We judge a region to be overly (insufficiently) innovative whenever a region generates more (less) patents per enterprise than an imaginary German region with the same sector structure. Let I be the number of regions, J the number of sectors, $P_{i,j}$ the number of patents in region i and sector j and $N_{i,j}$ the number of firms in region i and sector j. Factual patent density in region i is then given by

$$D_i := \sum_{j=1}^{J} \frac{P_{i,j}}{N_{i,j}} \times \frac{N_{i,j}}{N_i} \qquad (2)$$

[10] For a small number of firms, no information on the location was available. We dropped these observations from our sample.

[11] For a more detailed elaboration see Berlemann and Jahn (2013).

with N_i being the number of firms in region i, i.e.

$$N_i = \sum_{j=1}^{J} N_{i,j} \tag{3}$$

Whenever firms within the same sector perform similarly in terms of generating innovations in all regions, patent density should vary one to one with the structure of the regional economy. Expected patent density can be calculated as

$$D_i^e := \sum_{j=1}^{J} D_j \times \frac{N_{i,j}}{N_i} \tag{4}$$

with D_j being average patent density in sector j over all regions i, i.e.

$$D_j = \frac{\sum_{i=1}^{I} P_{i,j}}{\sum_{i=1}^{I} N_{i,j}} \tag{5}$$

We then define relative innovative performance of region i as

$$R_i := D_i - D_i^e \tag{6}$$

Positive values of R_i go along with overly innovative regions, while negative values indicate underperforming regions. Figure A.1 in the Appendix shows the results on the NUTS-3-level.

3.3 Regional importance of owner-managed SMEs

In order to construct a measure of the relative importance of owner-managed SMEs, we again employ the earlier mentioned *Creditreform* database. The database allows us classifying enterprises by governance structure as well as by firm size. More precisely, the database contains information on the legal form, the owners and the chief operating officers of an enterprise. Moreover, the database reports the companies' turnover and the number of employees which are subject to social security contributions (minijobs are thus excluded). Using this information we can adequately identify owner-managed SMEs. We consider firms to be owner-managed whenever the chief operating officers of an enterprise also own (at least parts of) the enterprise. However, as the advantage of owner-managed firms tends to diminish with an increasing number of decision makers, we restrict the maximum number of chief operating officers, which are considered to be classified as owner-managed firms, to four. Since we are interested in owner-managed SMEs only, we then apply the definition of SMEs to the identified owner-managed firms. We thereby apply the values used in the definition of the *Institut für Mittelstandsforschung Bonn* and classify SMEs as firms with less than 500 employees or an annual turnover of less than 50 million Euros.

By applying this procedure, we identify 3,228,778 German firms, respectively 81.64 percent of total enterprises, as owner-managed SMEs. In order to obtain the relative importance of owner-managed SMEs on the regional level, we divide the number of owner-managed SMEs by the total number of firms on the NUTS-3-level. Figure A.2 in the Appendix shows the regional quotas of owner-managed SMEs.

3.4 Additional control variables

Besides the quota of owner-managed SMEs, various additional factors might influence relative regional innovative capacity.

In line with the existing literature, we expect firms' expenditures for research and development to have a positive impact on innovative activity (Cáceres et al. 2011, Audretsch and Vivarelli 1996, Piergiovanni and Santarelli 2001, Baumert et al. 2010, Brenner and Broekel 2011, Jaffe 1986, Franke and Fritsch 2004, Acs and Audretsch 1988). Therefore, we use internal investments in research and development per enterprise by NUTS-3-regions as control variable. In order to take decreasing marginal returns into account (Arvanitis 1997), we also add investments as a quadratic polynomial. Data on absolute investments in research and development on the regional level were provided on request by *Stifterverband*.[12] In order to calculate investments per enterprise, we use the total number of enterprises on the regional level from the *Creditreform* database.

Moreover, regional knowledge spillovers from universities to enterprises might positively affect innovative capacity (Audretsch et al. 2012, Piergiovanni and Santarelli 2001, Baumert et al. 2010, Audretsch and Vivarelli 1996). Thus, we include the number of universities and universities of applied sciences by NUTS-3-regions into the regression equation to control for knowledge spillovers from research institutions to the local economy. The referring data were provided by the Federal Statistical Office on request.

Additionally, regional supply of skilled human capital might have a positive influence on innovative activity (Baumert et al. 2010). Therefore, we also control for the regional share of employees with a degree in professional schools, universities of applied sciences or universities in all employees subject to social insurance

[12] *Stifterverband* is a community initiative of the German economy supporting academic institutions in Germany.

Table 1: Description of employed variables

Variable	Description	Source
Inn	Relative regional innovative capacity by NUTS-3-regions, Germany, 2008	Calculations from Berlemann and Jahn (2013) based on the OECD REGPAT database, January 2013 edition, and on the *Creditreform* database (2008)[a]
OMSME	Number of owner-managed SMEs relative to all enterprises by headquarters by NUTS-3-regions in percent, Germany, December 31, 2008	*Creditreform* database (2008)[a]
RD	Internal investments in research and development per enterprise in thousand Euros by headquarters by NUTS-3-regions, Germany, average over 2007 and 2009[b]	*Stifterverband*[a], *Creditreform* database (2008)[a]
RD^2	Squared RD in billion Euros	
Univ	Number of universities, university hospitals and universities of applied siences by NUTS-3-regions, Germany, 2008. If establishments are located in several NUTS-3-regions, they are proportionately divided to these regions according to their revenues and spendings at each location.	German Federal Statistical Office[a]
Edu	Share of employees with degree in professional school, university of applied sciences or university in all employees subject to social insurance contribution at place of work by NUTS-3-regions in percent, Germany, June 30, 2008	Statistical Office of Lower Saxony (2010)
GDP	GDP per capita at current prices in thousand Euros by NUTS-3-regions, Germany, 2008	Statistical Offices of the Länder (2010)
Urban	Urban district dummy variable[c]	German Federal Agency for Cartography and Geodesy
East	East Germany dummy variable (including Berlin)	

[a] Special analysis on request.

[b] Value for 2007 of Schweinfurt is missing.

[c] Region Hannover and Regionalverband Saarbrücken are treated as rural districts.

contribution. The necessary data was provided by the Statistical Office of Lower Saxony.

In line with the existing literature (Audretsch et al. 2012, Baumert et al. 2010, Pfirrmann 1994), we include regional indicators like economic prosperity and population density in our regression analysis. Regional economic prosperity is measured by GDP per capita. Data were extracted from the databases of the Statistical Offices of the Länder. Population density is taken into account via a dummy variable, indicating whether a region is urban or rural. The referring data were extracted from the database of the Federal Agency for Cartography and Geodesy.

In the case of Germany, the spatial position of a region might influence its innovative capacity as well (Audretsch et al. 2012, Franke and Fritsch 2004). Thus, we use a dummy variable expressing whether a region is located in the former East or West Germany.

Numerous empirical studies on innovative activity also control for the regional industrial structure (Audretsch et al. 2012, Schwalbach and Zimmermann 1991, Pavitt et al. 1987, Brenner and Broekel 2011). However, we refrain from doing so as our dependent variable already accounts for the regional industry structure. For a detailed description and some descriptive statistics of the employed variables see Table 1 and Table 2.

Table 2: Descriptive statistics of dataset

Variable	Min	1st Quantile	Median	Mean	3rd Quantile	Max	Width	Standard deviation
Inn	-0.0345	-0.0169	-0.0112	-0.0116	-0.00779	0.0875	0.1219	0.01053
OMSME	58.3	80.9	84.1	83.1	86.3	91.1	32.83	4.809
RD	0.0	1.0	2.8	9.1	6.8	589.0	588.9	34.28
Univ	0.0	0.0	0.0	0.761	1.0	24.000	23.96	1.781
Edu	2.81	5.35	6.97	7.82	9.17	25.30	22.52	3.652
GDP	13.3	21.6	25.8	28.5	31.6	85.4	72.14	10.86

N = 413
N Urban = 112
N East = 87

4 Results

In Table 3 we report the results of our baseline regression approach, explaining relative innovative capacity (Inn) of German NUTS-3-regions[13] by the share of owner-managed SMEs (OMSME) and a number of control variables in the 2008 cross section. The second column displays the estimated coefficients, the third column

[13] According to the territorial boundaries of 31.12.2008, Germany consisted of 413 NUTS-3-regions.

the resulting standard errors, the fourth column the p-values. The fifth column informs on the standardized coefficients. The coefficients are estimated using the OLS method. We report White-corrected standard errors. The regression explains 52.6 percent of the observed variation in relative regional innovative capacity.

Table 3: Determinants of relative regional innovative capacity (Inn)

Explanatory variables	Coefficients	Standard errors	p-values	Standardized coefficients
(Intercept)	-0.1244	0.0098	0.0000	
OMSME	0.0012	0.0001	0.0000	0.5511
RD	0.0003	0.0001	0.0132	
RD^2	-0.0004	0.0002	0.0199	
Univ	0.0006	0.0002	0.0051	0.1078
Edu	0.0007	0.0002	0.0019	0.2328
GDP	0.0002	0.0001	0.0251	0.1699
Urban	0.0021	0.0010	0.0430	0.0894
East	-0.0024	0.0013	0.0586	-0.0930
N	413			
adj. R^2	0.526			
F-value	58.2 (0.0000)			

The employed set of control variables turns out to perform well in our sample. All estimated coefficients turn out to be significant at least on the 90-percent confidence level, most of them on even higher levels. Moreover, all coefficients turn out to have the expected sign. An analysis of bivariate correlations and variance inflation factors indicate that our estimations do not suffer from any multicollinearity problems.[14]

Concerning firms' investments in research and development, we find an inverse U-shaped impact on innovative capacity. This result confirms the empirical findings of Arvanitis (1997). However, just as in Arvanitis (1997) the decreasing part of the parabola is practically irrelevant. In our analysis, only the district of Wolfsburg lies in the descending part. Additionally, Wolfsburg is identified as an outlier with respect to investments in research and development. Running the regression without Wolfsburg, the coefficient of RD^2 is no longer significant while the remaining estimates remain virtually unchanged (see Table A.3 in the Appendix). One might therefore argue that research and development expenditures in general have a significantly positive influence on innovative capacity. This result is in line with most of the existing literature.

According to our estimation results, the total number of universities and universities of applied sciences in a region tends to promote regional innovative activity.

[14]The correlation matrix and the variance inflation factors are presented in Table A.1 and A.2 in the Appendix.

This result is consistent with the existing literature, indicating knowledge spillovers from universities to enterprises within the same region.

Furthermore, we detect a significantly positive impact of the regional supply of skilled human capital on innovative capacity. This influence is the second largest among the explanatory variables. This finding indicates skilled employees to be a necessary input factor to innovative activities in firms.

Moreover, we find a significantly positive impact of economic prosperity and population density on regional innovative activity. Urban regions on average tend to be more innovative than rural regions. We also find regions in the former East Germany to be less innovative on average than their West German counterparts. More than 20 years after reunification this finding is still significant on the 90-percent confidence level.

The variable of central interest, the share of owner-managed SMEs (OMSME) turns out to have a positive impact on a region's relative innovative capacity. Hence, regions possessing a relatively large amount of owner-managed SMEs tend to be more innovative than regions having a relatively small number of owner-managed SMEs. The estimated coefficient is highly significant and sizeable as it has a larger standardized coefficient than all other included control variables. A regression without the quota of owner-managed SMEs as independent variable delivers an adjusted R-squared of only 33.2 percent. Thus, the quota of owner-managed SMEs explains a considerable part of relative regional innovative capacity.

Altogether, the results of our baseline regression are thus supportive to the hypothesis that owner-managed SMEs generate above-average levels of innovations. Interestingly enough, our results remain almost unchanged when extending the analysis to all owner-managed firms, regardless of their sizes. However, this finding can be attributed to the fact that there are only very few large owner-managed firms. Thus, the relative importance of owner-managed companies almost equals the one of owner-managed SMEs.

In order to check the stability of our results, we checked for possible outliers. Three regions might be classified as outliers: First, the urban district Ludwigshafen exhibits a relatively high regional innovative activity. In Ludwigshafen (hosting the large chemical producer *BASF*) the relative number of patent applications per enterprise exceeds the German average by 0.0875. Second, the urban region Wolfsburg in Lower Saxony shows a relatively large GDP per capita as well as a relatively high amount of investments in research and development. These findings can be attributed to the large *Volkswagen Company* located in Wolfsburg. Third, the German capital Berlin hosts a relatively large number of universities and universities of applied sciences. However, Berlin is not only Germany's capital but also the largest German city. Running regressions without these three potential outliers leads to similar outcomes as in the analysis including all 413 German regions, at least with respect to direction and significance of the OMSME-coefficient.[15] Therefore, we keep all regions in our sample even within the following empirical analyses.

5 Spatial correlations

While using data on the NUTS-3-level allows us estimating the relationship between innovative capacity and the importance of owner-managed SMEs on the basis of 413 observations, this comes at the price that the underlying data might exhibit a significant degree of spatial correlation. In the presence of spatial correlation, OLS in many cases does not deliver best linear unbiased estimators (Keilbach 2000, Lerbs and Oberst 2012, Eckey et al. 2007). Since we relied on the OLS procedure in our baseline regression, it is necessary to study whether our estimations are suffering from spatial correlation. Moreover, whenever we find indications of spatial correlations, it is necessary to study whether the results from our baseline regression hold even when controlling for the relevant form of spatial correlation.

The idea of spatial correlation goes back to Tobler's first law of geography, stating that everything is interacting but interaction weakens with increasing space (Anselin 1988). Three types of spatial dependencies might occur in linear regressions.

First, the error terms might be correlated in space. In the presence of spatial residual autocorrelation, OLS no longer leads to efficient estimates (Lerbs and Oberst 2012). Hence, spatial error models of the type

$$Y = \alpha + \beta X + u, \;\; u = \lambda W u + \epsilon, \;\; \epsilon \sim N(0, \sigma^2) \tag{7}$$

have to be used. Y is the dependent variable, X is a vector of independent variables, W is the contiguity matrix describing the spatial arrangement of the relevant area, u is the spatially dependent and ϵ a normally distributed error term. The parameters to be estimated are α, β and λ.

Second, there might be some spatial autocorrelation in the dependent variable. In our research context, innovative capacity of a region might be influenced by innovative activities of the neighboring regions. In the presence of spatial autocorrelation in the dependent variable, OLS estimators are biased (Lerbs and Oberst 2012, Keilbach 2000). In this case, a spatial lag model of the form

[15] Regression results without outliers are presented in Table A.3 in the Appendix.

$$Y = \rho W Y + \alpha + \beta X + \epsilon, \quad \epsilon \sim N(0, \sigma^2) \tag{8}$$

should be implemented. Here, the parameters to be estimated from the data are α, β and ρ.

Third, the explanatory variables might exhibit spatial correlation. As an example, innovative capacity of a region might also be related to the number of universities located in neighboring regions. In the presence of spatially lagged independent variables, the appropriate spatial lag model to be estimated becomes

$$Y = \alpha + \theta W X + \beta X + \epsilon, \quad \epsilon \sim N(0, \sigma^2) \tag{9}$$

with θ being the vector of coefficients of the spatial lags of the explanatory variables to be estimated from the data.

However, the three described forms of spatial correlation might also occur in combination. The spatial Durbin model allows for spatially autocorrelated dependent variables together with spatially lagged independent variables. The Kelejian-Prucha model deals with spatial autocorrelation in the dependent variable as well as in the residual. The spatial Durbin error model includes spatially lagged independent variables as well as spatial autocorrelation in the error term. The Manski model combines all three types of spatial dependencies (Elhorst 2010).

In the following we study whether and which of the described forms of spatial correlation turn out to exist in our dataset. We thereby follow the general-to-specific approach and start with the OLS model. We then test whether the model needs to be extended with spatial interaction terms (Elhorst 2010). In order to test for spatial dependence, we first have to define the contiguity matrix. As this type of contiguity matrix is recommended in the literature (see e.g. Keilbach 2000 and Dormann et al. 2007), we use a row standardized contiguity matrix of style *queen* including only regions next to the one under consideration. Row standardization means that a neighbor's impact on the referring region is equal to the average of all neighbors' influences.

In order to test whether spatial interactions exist, we first use a Moran's I-test (Keilbach 2000, Anselin 1988). Moran's I identifies spatial autocorrelation in the OLS residuals.[16] As the OLS baseline regression does not explicitly control

[16] Moran's I is positive (0.1891) and highly significant (0.0000). Figure A.3 shows Moran scatterplot.

for spatial dependencies, they are reflected in the residuals. In order to extend the OLS model by spatial correlations, we estimate a model with spatially lagged independent variables (Elhorst and Vega 2013).[17] However, Moran's I still shows highly significant spatial autocorrelation in the residuals (0.1776). Therefore, we apply Lagrange-Multiplier-tests to discover whether a spatial error model or a model with a spatially lagged dependent variable might be appropriate to capture the existing spatial dependencies (Eckey et al. 2006). The Lagrange-Multiplier-tests find both models to be potentially adequate and therefore robust Lagrange-Multiplier-tests should be used. The robust tests support the spatial error model and reject the spatial lag model (Anselin and Florax 1995).[18] Hence, we estimate a spatial error model and refrain from estimating a model with spatially lagged dependent variable. However, the spatial error model might suffer from omitted variable bias since it does not contain spatially lagged dependent and explanatory variables. In order to protect against omitted variable bias, we also estimate a spatial Durbin model. The spatial Durbin model nests the spatial error model and produces unbiased coefficient estimates even when the data generating process follows another spatial regression specification (LeSage and Pace 2009, Elhorst and Vega 2013).[19] The results from these estimations are shown in Table 4.[20] Again, we report White-corrected standard errors in the OLS approach as well as in the spatial lag model of the independent variables.

Interestingly enough, the spatial error as well as the spatial lag model show nearly the same results as the simple OLS approach employed in the baseline regression. Even the spatial Durbin model, combining spatial correlations in various variables, lead to very similar findings. Especially the coefficient of the quota of owner-managed SMEs turns out to perform highly robust across all applied esti-

[17]Due to multicollinearity problems we exclude the spatial lag of the East Germany dummy variable.

[18]The referring results are summarized in Table A.4 in the Appendix.

[19]Although the Kelejian-Prucha model and the spatial Durbin error model nest the spatial error model as well, we refrain from estimating a Kelejian-Prucha model and a spatial Durbin error model because both models produce biased estimates if the true data generating process follows another spatial regression specification. However, the spatial Durbin model only suffers from this problem if the true data generating process is of the Manski type (Elhorst 2010). Therefore, we estimate a Manski model as well. The only difference between the Manski model and the spatial Durbin model is the spatially lagged error term. Since λ turns out to be insignificant, we do not report the results of the Manski model and stick to the spatial Durbin model (Elhorst and Vega 2013). However, the regression results of the Manski model are available from the authors on request.

[20]The presented spatial models are based on a contiguity matrix including only regions with direct borders. Additionally, we estimated spatial models based on a contiguity matrix of second order as robustness check. Again, the empirical findings are very similar to the reported. The results are available from the authors on request.

mation approaches both in direction and size. Hence, although spatial dependence seems to exist, we find a significantly positive relation between the relative importance of owner-managed SMEs and regional innovative capacity.

Table 4: OLS and spatial models of regional innovative capacity (Inn)

	OLS	Spatial lag (independent)	Spatial error	Spatial Durbin
(Intercept)	-0.1244***	-0.1336***	-0.1228***	-0.0863***
OMSME	0.0012***	0.0012***	0.0012***	0.0012***
RD	0.0003**	0.0003**	0.0003***	0.0003***
RD	-0.0004**	-0.0004**	-0.0004***	-0.0004***
Univ	0.0006***	0.0007***	0.0007***	0.0007***
Edu	0.0007***	0.0007***	0.0008***	0.0008***
GDP	0.0002**	0.0002*	0.0001***	0.0002***
Urban	0.0021**	0.0017*	0.0014	0.0014
East	-0.0024*	-0.0010	-0.003**	-0.0034
OMSME.lag		0.0001		-0.0003*
RD.lag		0.0000		-0.0001*
RD.lag		0.0001		0.0002
Univ.lag		-0.0005		-0.0006
Edu.lag		-0.0003		-0.0005
GDP.lag		0.0002		0.0001
Urban.lag		0.0057		0.0040
East.lag				0.0032
adj. R	0.526	0.527		
F-value	58.2***	31.6***		
Nagelkerke			0.5705	0.5766
ρ				0.3761***
λ			0.3901***	

***1%, **5%, *10%

6 Summary and Conclusions

According to principal agent theory, owner-managed firms have not to bear agency costs in order to monitor and discipline managers. Hence, they might use more of their resources for research and development, potentially resulting in more innovations. On average, SMEs are characterized by less bureaucracy, short lines of communication and great agility. Moreover, SMEs often act on niche markets and develop innovations in order to meet individual customers' needs. Hence, especially the combination of owner-management with a small firm size should make sense. This combination might, amongst others, provide a time advantage in innovative competition. Consequently, owner-managed SMEs might potentially outperform other sorts of firms with regard to innovative capacity. However, this issue has yet not been examined empirically. This is likely due to the fact that most official statistics do not report on the governance structure of enterprises. We fill this gap in the empirical literature employing a unique firm dataset, containing information on the governance structure of enterprises as well as on firm size. After combining this dataset with patent data we find a sizable and significant influence of the regional importance of owner-managed SMEs on relative regional innovative capacity. This finding is highly robust even when controlling for spatial correlations.

Altogether, our empirical analysis indicates that in fact owner-managed SMEs tend to be highly innovative. This finding supports the view of most politicians, owner-managed SMEs being a superior form of organizing business. This view is especially pronounced in German politics, where owner-managed SMEs often are regarded as the driver of the German economy. Interestingly enough, although robust supporting empirical evidence was yet unavailable, this view survives our empirical tests at least in as far as innovative capacity is concerned. Whether owner-managed SMEs are also a superior form of organizing business in additional respects, as it is often claimed, remains open for further research.

References

Acs, Z. J., Anselin, L., Varga, A., 2002. Patents and Innovation Counts As Measures of Regional Production of New Knowledge. Research Policy 31 (7), 1069-1085.

Acs, Z. J., Audretsch, D. B., 1988. Innovation in Large and Small Firms: An Empirical Analysis. American Economic Review 78 (4), 678-690.

Acs, Z., Audretsch, D., Braunerhjelm, P., Carlsson, B., 2012. Growth and Entrepreneurship. Small Business Economics 39, 289-300.

Aghion, P., Howitt, P., 1992. A Model of Growth Through Creative Destruction. Econometrica 60 (2), 323-351.

Anselin, L., 1988. Spatial econometrics: methods and models. Studies in operational regional science. Kluwer Academic Publishers, Dordrecht.

Anselin, L., Florax, R. 1995. Small Sample Properties of Tests for Spatial Dependence in Regression Models: Some Further Results. In: Anselin, L., Florax, R. (Eds.), New Directions in Spatial Econometrics, Springer, Berlin and Heidelberg, 21-74.

Arvanitis, S., 1997. The Impact of Firm Size on Innovative Activity – an Empirical Analysis Based on Swiss Firm Data. Small Business Economics 9, 473-490.

Audretsch, D. B., Hülsbeck, M., Lehmann, E. E., 2012. Regional Competitiveness, University Spillovers, and Entrepreneurial Activity. Small Business Economics 39 (3), 587-601.

Audretsch, D. B., Keilbach, M., 2004. Entrepreneurship and Regional Growth: An Evolutionary Interpretation. Journal of Evolutionary Economics 14, 605-616.

Audretsch, D., Vivarelli, M., 1996. Firm Size and RD Spillovers: Evidence From Italy. Small Business Economics 8, 249-258.

Baumert, T., Buesa, M., Heijs, J., 2010. The Determinants of Regional Innovation in Europe: A Combined Factorial and Regression Knowledge Production Function Approach. Research Policy 39, 722-735.

Berlemann, M., Jahn, V., 2013. Relative innovative capacity of German regions: Is East Germany still lagging behind?. CESifo Forum 14 (4), 42-50.

Bizer, K., Thomä, J., 2013. To Protect or Not to Protect? Modes of Appropriability in the Small Enterprise Sector. Research Policy 42, 35-49.

Brenner, T., Broekel, T., 2011. Regional Factors and Innovativeness: an Empirical

Analysis of Four German Industries. The Annals of Regional Science 47 (1), 169-194.

Cáceres, R., Guzmán, J., Rekowski, M., 2011. Firms as Source of Variety in Innovation: Influence of Size and Sector. International Entrepreneurship and Management Journal 7 (3), 357-372.

Chakrabarti, A. K., Halperin, M. R., 1990. Technical Performance and Firm Size: Analysis of Patents and Publications of U. S. Firms. Small Business Economics 2 (3), 183-190.

Chrisman, J. J., Chua, J. H., Litz, R. A., 2004. Comparing the Agency Costs of Family and Non-Family Firms: Conceptual Issues and Exploratory Evidence. Entrepreneurship Theory and Practice 28 (4), 335-354.

Chu, W., 2009. The influence of family ownership on SME performance: evidence from public firms in Taiwan. Small Business Economics 33 (3), 353-373.

Classen, N., Carree, M., Van Gils, A., Peters, B., 2013. Innovation in Family and Non-Family SMEs: an Explanatory Analysis. Small Business Economics 42 (3), 595-609.

Czarnitzki, D., Kraft, K., 2004. Management Control and Innovative Activity. Review of Industrial Organization 24, 1-24.

Dixit, A. K., Stiglitz, J. E., 1977. Monopolistic Competition and Optimum Product Diversity. American Economic Review 67, 297-308.

Dormann, C. F., McPherson, J. M., Araújo, M. B., Bivand, R., Bolliger, J., Carl, G., Davies, R. G., Hirzel, A., Jetz, W., Kissling, W. D., Kühn, I., Ohlemüller, R., Peres-Neto, P. R., Reineking, B., Schröder, B., Schurr, F. M., Wilson, R., 2007. Methods to account for spatial autocorrelation in the analysis of species distributional data: a review. Ecography 30 (5), 609-628.

Eckey, H.-F., Kosfeld, R., Tuerck, M., 2006. Räumliche Ökonometrie. Wirtschaftswissenschaftliches Studium (WiSt) 35 (10), 548–554.

Eckey, H.-F., Kosfeld, R., Tuerck, M., 2007. Regionale Entwicklung mit und ohne räumliche Spillover-Effekte. Jahrbuch für Regionalwissenschaft (27), 23-42.

Elhorst, J. P., 2010. Applied spatial econometrics: Raising the bar. Spatial Econometric Analysis 5 (1), 9-28.

Elhorst, J. P., Vega, S. H., 2013. On Spatial Econometric Models, Spillover Effects, and W. ERSA conference papers No. ersa13p222.

Faber, J., Hesen, A. B., 2004. Innovation Capabilities of European Nations Cross-national Analyses of Patents and Sales of Product Innovations. Research Policy 33, 193-207.

Fama, E. F., Jensen, M. C., 1983. Separation of Ownership and Control. Journal of Law and Economics 26, 301-325.

Federal Ministry of Economics and Technology, 2013. German Mittelstand: Engine of the German economy. Facts and Figures About Small and Medium-sized German firms, Berlin.

Franke, G., Fritsch, M., 2004. Innovation, Regional Knowledge Spillovers and RD Cooperation. Research Policy 33, 245-255.

González-Pernía, J. L., Peña-Legazkue, I., Vendrell-Herrero, F., 2012. Innovation, Entrepreneurial Activity and Competitiveness at a Sub-national Level. Small Business Economics 39, 561-574.

Goto, A., Motohashi, K., Nagaoka, S., 2010. Patent Statistics as an Innovation Indicator. In: Hall, B. H., Rosenberg, N. (Eds.), Handbook of the Economics of Innovation, Vol. 2, North-Holland, Amsterdam et al., 1083-1127.

Griliches, Z., 1990. Patent Statistics as Economic Indicators: A Survey. Journal of Economic Literature 28 (4), 1661-1707.

Grossman, G. M. , Helpman, E. , 1990. Trade, Innovation, and Growth. The American Economic Review 80, 86-91.

Holmstrom, B., 1989. Agency Costs and Innovation. Journal of Economic Behavior and Organization 12 (3), 305-327.

Hülsbeck, M., Lehmann, E. E., Weiß, D., Wirsching, K., 2012. Innovationsverhalten in Familienunternehmen. Journal of Business Economics 82 (3), Supplement, 71-91.

IfM Bonn, 2013. Innovationstätigkeit von Familienunternehmen, IfM-Materialien Nr. 225, Bonn.

IfM Bonn, 2013a. Der deutsche Mittelstand: Ein Konglomerat verschiedenartiger Unternehmen, IfM Standpunkt 1, Bonn.

Jaffe, A. B., 1986. Technological Opportunity and Spillovers of RD: Evidence from Firms' Patents, Profits, and Market Values. American Economic Review 76 (5), 984-1001.

Jensen, M., Meckling W., 2009. Theory of the Firm: Managerial Behavior, Agency

Costs, and Ownership Structure. In: Kroszner, R. S., Putterman, L. (Eds.), The Economic Nature of the Firm, 3rd edition, Cambridge University Press, New York, 283-303.

Kraft, K., 1989. Market Structure, Firm Characteristics and Innovative Activity. The Journal of Industrial Economics 37 (3), 329-336.

Keilbach, M. C., 2000. Spatial knowledge spillovers and the dynamics of agglomeration and regional growth. Physica Verlag, Heidelberg.

Kets de Vries, M. F. R., 1993. The Dynamics of Family Controlled Firms: The Good and the Bad News. Organizational Dynamics 21 (3), 59-71.

Lerbs, O., Oberst, C., 2012. Explaining the spatial variation in homeownership rates: Results for German regions. CESifo working paper no. 3377.

LeSage, J., Pace, R. K., 2009. Introduction to Spatial Econometrics. CRC Press, Boca Raton.

Lybbert, T. J., Zolas, N. J., 2012. Getting Patents and Economic Data to Speak to Each Other: An "'Algorithmic Links with Probabilities"' Approach for Joint Analyses of Patenting and Economic Activity. WIPO Economic Research Working Paper No. 5.

Malerba, F., Orsenigo, L., 2008. Schumpeterian Patterns of Innovation. In: Antonelli, C. (Ed.), Innovation and Competition: The Schumpeterian Legacy, Routledge, London et al., 294-316.

Moser, P., 2013. Patents and innovation: evidence from economic history. Journal of Economic Perspectives 27, 23-44.

Moser, P., Voena, A., 2012. Compulsory Licensing: Evidence from the Trading-with-the-Enemy-Act. American Economic Review 102, 396-427.

Parker, S. C., 2011. Small Firms and Innovation. In: Audretsch, D. B., Falck, O., Heblich, S.,Lederer, A. (Eds.), Handbook of Research on Innovation and Entrepreneurship, Edward Elgar, Cheltenham (UK), 357-364.

Pavitt, K., Robson, M., Townsend, J., 1987. The Size Distribution of Innovating Firms in the UK: 1945-1983. The Journal of Industrial Economics 35 (3), 297-316.

Pfirrmann, O., 1994. The Geography of Innovation in Small and Medium-Sized Firms in West Germany. Small Business Economics 6 (1), 41-54.

Piergiovanni, R., Santarelli, E., 2001. Patents and the Geographic Localization of

RD Spillovers in French Manufacturing. Regional Studies 35 (8), 697-702.

Putterman, L., 2009. Ownership and the Nature of the Firm. In: Kroszner, R. S., Putterman, L. (Eds.), The Economic Nature of the Firm, 3rd edition, Cambridge University Press, New York, 353-361.

Romer, P. M., 1987. Growth Based on Increasing Returns Due to Specialization. American Economic Review 77 (2), 56-62.

Romer, P. M., 1990. Endogenous Technological Change. Journal of Political Economy 98, S71-S102.

Schalk, H. J., Varga, A., 2004. Knowledge Spillovers, Agglomeration and Macroeconomic Growth: An Empirical Approach. Regional Studies 38 (8), 977-989.

Schwalbach, J., Zimmermann, K. F., 1991. A Poisson Model of Patenting and Firm Structure in Germany. In: Acs, Z. J., Audretsch, B. (Eds.), Innovation and Technological Change. An International Comparison, University of Michigan Press, Ann Arbor, 109-120.

Solow, R. M., 1956. A Contribution to the Theory of Economic Growth. Quarterly Journal of Economics 70, 65-94.

Appendix

Figure A.1: Relative regional innovative capacity by NUTS-3-regions in Germany, 2008

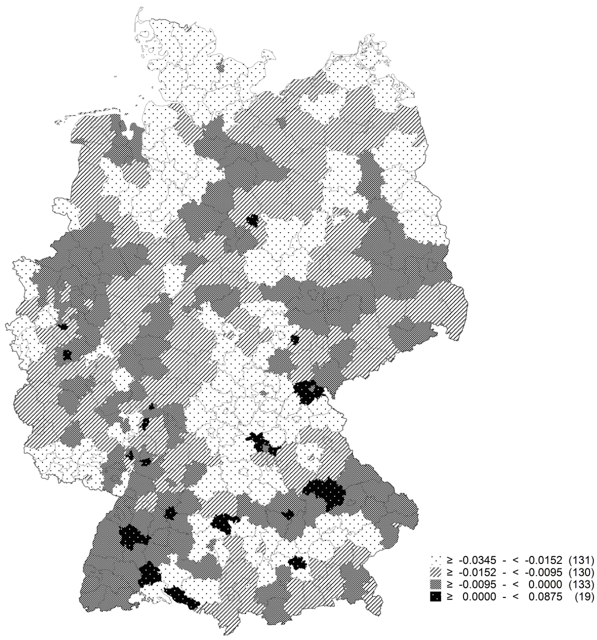


Figure A.2: Quotas of owner-managed SMEs by NUTS-3-regions in Germany in percent, 2008

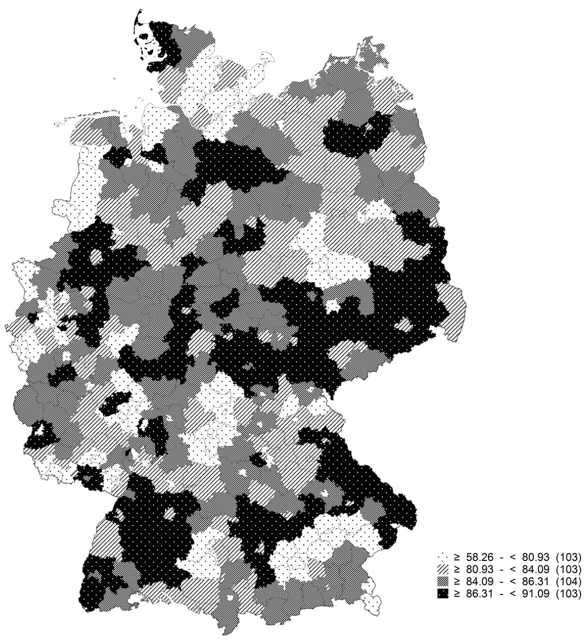


Table A.1: Correlation matrix for employed control variables

	OMSME	RD	Univ	Edu	GDP	Urban	East
OMSME	1.0000	-0.0548	-0.3199	-0.4000	-0.5456	-0.3859	0.1522
RD		1.0000	0.0741	0.2744	0.3945	0.1622	-0.1028
Univ			1.0000	0.5292	0.3441	0.4035	0.0451
Edu				1.0000	0.5268	0.5210	0.2071
GDP					1.0000	0.5893	-0.3194
Urban						1.0000	-0.0079
East							1.0000

Table A.2: Variance inflation factors

Variables	VIF
OMSME	1.581
RD	7.848
Univ	1.464
Edu	2.516
GDP	2.911
Urban	1.801
East	1.506

Table A.3: Determinants of relative regional innovative capacity (Inn) without potential outliers

without Ludwigshafen

Explanatory variables	Coefficients	Standard errors	p-values
(Intercept)	-0.1217	0.0088	0.0000
OMSME	0.0012	0.0001	0.0000
RD	0.0002	0.0001	0.0229
RD^2	-0.0003	0.0001	0.0367
Univ	0.0007	0.0003	0.0099
Edu	0.0009	0.0001	0.0000
GDP	0.0001	0.0001	0.0362
Urban	0.0015	0.0010	0.1197
East	-0.0033	0.0010	0.0008
N	412		
adj. R^2	0.514		
F-value	55.3 (0.0000)		

without Wolfsburg

Explanatory variables	Coefficients	Standard errors	p-values
(Intercept)	-0.1239	0.0104	0.0000
OMSME	0.0012	0.0001	0.0000
RD	0.0003	0.0001	0.0236
RD^2	-0.0008	0.0011	0.4384
Univ	0.0006	0.0002	0.0038
Edu	0.0006	0.0002	0.0061
GDP	0.0002	0.0001	0.0439
Urban	0.0023	0.0011	0.0424
East	-0.0022	0.0013	0.0921
N	412		
adj. R^2	0.521		
F-value	56.8 (0.0000)		

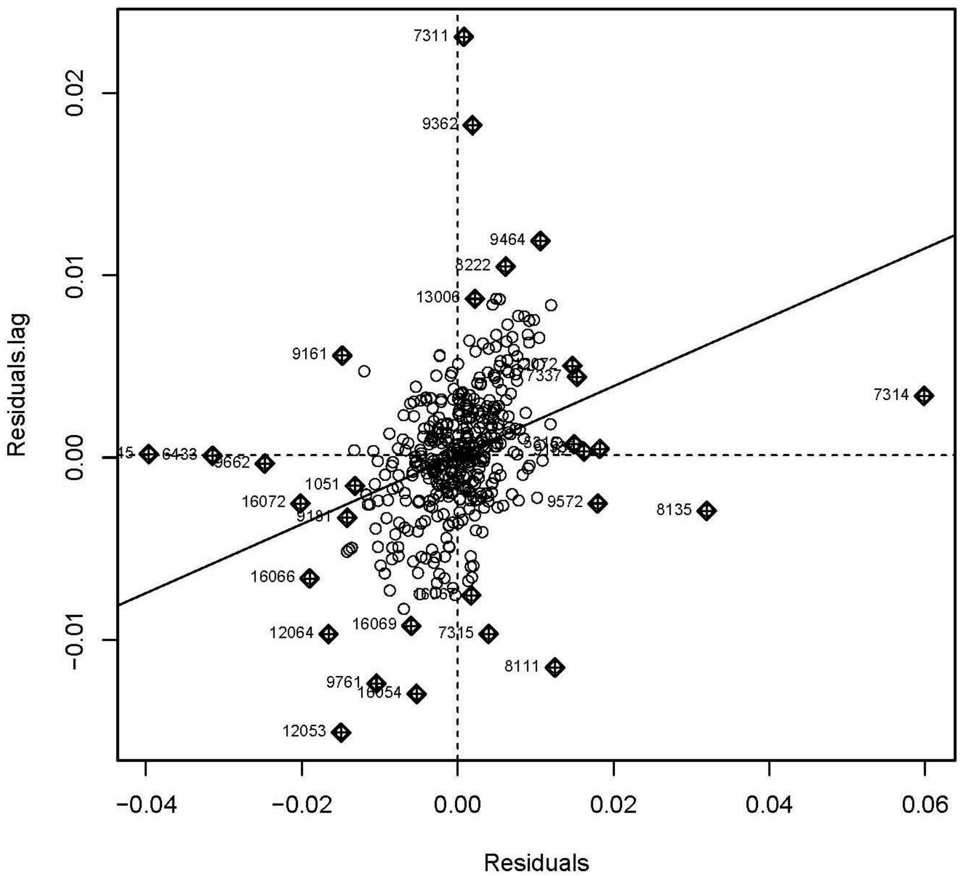
without Berlin

Explanatory variables	Coefficients	Standard errors	p-values
(Intercept)	-0.1238	0.0098	0.0000
OMSME	0.0012	0.0001	0.0000
RD	0.0003	0.0001	0.0121
RD^2	-0.0004	0.0002	0.0194
Univ	0.0009	0.0004	0.0329
Edu	0.0006	0.0002	0.0031
GDP	0.0002	0.0001	0.0303
Urban	0.0021	0.0011	0.0501
East	-0.0023	0.0012	0.0678
N	412		
adj. R^2	0.527		
F-value	58.2 (0.0000)		

Table A.4: Results of Lagrange-Multiplier-tests

	LM test	p-values
LMerr	32.17	0.0000
LMlag	21.24	0.0000
RLMerr	10.92	0.0010
RLMlag	0.0008	0.9776

Figure A.3: Moran scatterplot



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