Institut für Wirtschaftsforschung Halle
Halle Institute for Economic Research

Industry Concentration and Regional Innovative Performance – Empirical Evidence for Eastern Germany –

Christoph Hornych and Michael Schwartz

April 2009 Nr. 8

IWH-Diskussionspapiere
IWH-Discussion Papers

Industry Concentration and Regional Innovative Performance – Empirical Evidence for Eastern Germany –

Christoph Hornych and Michael Schwartz

April 2009 Nr. 8

Autoren: *Christoph Hornych*

Department of Urban Economics
E-Mail: Christoph.Hornych@iwh-halle.de
Phone: +49 345 77 53 743

Michael Schwartz

Department of Urban Economics
E-Mail: Michael.Schwartz@iwh-halle.de
Phone: +49 345 77 53 794

Herausgeber:
INSTITUT FÜR WIRTSCHAFTSFORSCHUNG HALLE – IWH
Prof. Dr. Ulrich Blum (Präsident), Dr. Hubert Gabrisch (Forschungsdirektor)
Das IWH ist Mitglied der Leibniz-Gemeinschaft

Hausanschrift: Kleine Märkerstraße 8, 06108 Halle (Saale)
Postanschrift: Postfach 11 03 61, 06017 Halle (Saale)
Telefon: (0345) 77 53-60
Telefax: (0345) 77 53-8 20
Internetadresse: http://www.iwh-halle.de

Industry Concentration and Regional Innovative Performance – Empirical Evidence for Eastern Germany –

Abstract

Regarding technological innovativeness, the transformed economy of the former German Democratic Republic (GDR) clearly lags behind the Western part of the country. To face this weakness, a broad mixture of policy measures was carried out in recent years. Particular attention is drawn to the development of industry concentrations and economic 'clusters'. However, little is known about the effectiveness of these policy measures regarding how industry concentrations in fact promote innovative performance in Eastern Germany. The present study tries to fill this gap by analyzing the relationship between industry concentration in Eastern Germany and regional innovative performance. Our empirical analysis is based upon the number of patent applications of 22 manufacturing industries in 22 Eastern German planning regions. The estimated regression models indicate an inverted U-shaped relationship between the degree of industry concentration and innovative performance. An exceedingly high degree of industry concentration in one region hampers regional innovative output. We discuss policy implications of our findings and give recommendations for future refinement of 'cluster'-supporting policy schemes in Eastern Germany.

Keywords: Industry concentration; Agglomeration; Specialization; Cluster; Innovation; Patents; East Germany

JEL-Classification: R12; O31; O38; P25

Industrielle Konzentration und regionale Innovationskraft – Empirische Ergebnisse für Ostdeutschland –

Zusammenfassung

Sind Regionen mit einer hohen industriellen Konzentration in Ostdeutschland innovativer als weniger spezialisierte Regionen? Dieser Frage geht der vorliegende Beitrag im Rahmen einer empirischen Analyse der regionsspezifischen Patentanmeldungen des Verarbeitenden Gewerbes in den Neuen Bundesländern nach. Eine Antwort ist insbesondere deshalb von hoher Bedeutung, da Ostdeutschland im Hinblick auf seine technologische und innovative Leistungsfähigkeit noch immer hinter Westdeutschland zurückbleibt und wirtschaftspolitische Maßnahmen in hohem Maß auf die Etablierung von Clusterstrukturen abzielen. Eine Einschätzung der Effektivität der in Ostdeutschland vorhandenen Strukturen existiert bislang allerdings nicht. Die Ergebnisse dieser Untersuchung deuten sowohl darauf hin, dass ein gewisses Maß an industrieller Konzentration in einer Region positive Auswirkungen auf das Innovationsgeschehen hat. Darüber hinaus wird aber auch deutlich, dass ein zu hohes Maß an regionaler Konzentration eher einen hinderlichen Einfluss auf die regionalen Innovationsaktivitäten nimmt. Der Beitrag diskutiert aufbauend auf den Studienergebnissen wirtschaftspolitische Empfehlungen für Ostdeutschland.

Stichworte: Industrielle Konzentration; Agglomeration; Spezialisierung; Cluster; Innovationen; Patente; Ostdeutschland

JEL-Klassifikation: R12; O31; O38; P25

Industry Concentration and Regional Innovative Performance – Empirical Evidence for Eastern Germany –

1 Introduction

Regarding technological innovativeness, the German economy still shows major regional disparities. While the western part has a high efficient innovation system, the transformed economy of the former German Democratic Republic (GDR) clearly lags behind. As a recent survey of innovation activities by the German Patent and Trade Mark Office reveals (DPMA 2006), the annual average number of patent applications per inhabitant in Eastern Germany (without Berlin) is 2.1 between 2000 and 2005, in Western Germany, this number is approximately three times higher with 6.2 patent applications per inhabitant during this five-year period. To face this innovative weakness as well as the overall structural weakness, a broad mixture of technology- and innovation-policy measures were carried out since the German reunification. Within this framework, exceptionally high attention is drawn to the initiation and development of new as well as strengthening of existing industry concentrations (e.g. BMBF 2007). Besides an increased effectiveness of innovation activities, the main objective behind those policy-driven attempts to support the Eastern German innovation system is to replicate the success stories of well-known existing industry concentrations or clusters (e.g. Saxenian 1991).

By now, there is only vague knowledge as to whether industry concentrations in Eastern Germany were able to generate agglomeration effects. As prior research suggests, the process of economic transformation is accompanied by disintegration of the organizational structures, the loss of headquarters, the disruption of existing supply chains and the invalidation of formerly valuable network relations (Grabher 1994; Windolf, Brinckmann and Kulke 1999; Blum 2007; Rosenfeld, Franz and Heimpold 2007). Consequently, at least there can be doubt if agglomeration effects have been developed during the last two decades. In a recent study, Rosenfeld, Franz and Heimpold (2007) identified industry concentrations in Eastern Germany. Additionally, they investigate whether these industry concentrations are supported by network activities and innovatice competencences, and therefore have the character of economic clusters. They demonstrate that these 'clusters' are relatively rare and strongly encourage a supporting policy strengthening these industry concentrations. However, the authors admit that they "…have no clues on the effectiveness of this new policy" (2007, p. 86) and recommend that its impact on regional economic growth should be empirically analyzed.

Partially drawing upon the results of Rosenfeld, Franz and Heimpold (2007), the present study empirically analyzes the relationship between industry concentration in Eastern Germany and regional innovative performance. Innovative performance is measured in terms of patent applications in 22 manufacturing industries in the period from 2000 to 2005. Applying the concordance-approach by Schmoch et al. (2003) we were able to assign patent applications to particular industries, which allows for the investigation of the effects of industry concentration on regional innovations performance. The following section reviews the effects of industry concentration on innovation. Afterwards, Section 3 discusses the conditions for innovation in Eastern Germany. Section 4 illustrates the regional and sectoral distribution of innovation activities in Eastern Germany. Results of an econometric model are presented in Section 5. In the concluding Section 6, the more general implications of our findings will be discussed.

2 The Relationship between Industry Concentration and Innovative Performance

There are two general dimensions of agglomeration economies with both receiving a great deal of attention in the academic world and by governmental policy. While the concept of urbanization economies highlights the variety benefits of a diversified economic activity for the exchange of complementary knowledge between economic actors (Jacobs 1969), by contrast, supporters of the localization economies view emphasize the importance of one spatially concentrated industry for knowledge spillovers, firm competitiveness and innovation (Marshall 1920; Arrow 1962; Romer 1986). Following Marshall, a specialized labor market, specialized suppliers and service firms allowing for intra-industry linkages are key factors determining the advantages of those localization economies. In addition, drawing on these Marshall-Arrow-Romer (MAR) externalities (Glaeser et al. 1992), Porter (1990) emphasizes in his discussion of the 'cluster'-concept the positive effects of intensified local competition, which might be conducive to growth and innovation activities. The general assumption is that the most important knowledge spillovers occur between geographical proximate firms of the same industry.

The literature of geography of innovation offers a large body of concepts supporting the relationship between regional industry concentration and innovative performance. The general assumption is that the most important knowledge spillovers are geographically bounded (e.g. Jaffe, Trajtenberg and Henderson 1993; Zucker, Darby and Brewer 1998), locating in close vicinity to the sources of spillovers becomes crucial for their exploitation (Audretsch and Feldman 1996). Considering innovation efforts in particular, a spatially concentrated industry acts as catalyst for the exchange of experiences, and the transfer of valuable information and knowledge, particularly non-codified tacit knowledge (Baptista and Swann 1998). The transfer of this kind of knowledge requires frequent personal interactions between actors and is difficult to realize over great distances (Malmberg and Maskell 1997). Thus, the homogenous distribution of firms' knowledge and skills within industry concentrations creates a strong basis for intense communication and co-operation processes.

Another important channel for the transfer of innovation-related knowledge and technology within industry concentrations are the effects resulting from higher mobility of skilled workers (Marshall 1920; Krugman 1991). Searching costs for employers and workers as well decline in industry concentrations. Research has shown that knowledge flows from job mobility are limited to a spatially concentrated job market (Saxenian 1991; Almeida and Kogut 1999), and workers with innovation-related knowledge and skills tend to choose their employers locally (Breschi and Lissoni 2001). Thus, knowledge spillovers are generated via the transmission and diffusion of knowledge and skills embodied in individuals (for instance, engineers or researchers). At the same time, they seem to be strongly localized, which implies advantages for firms located within industry concentrations.

Though, there is an extant body of empirical literature regarding the impact of industry concentration, no final conclusion is possible as to whether there are positive, negative or even not any effects of industry concentration on the innovative performance of firms or at the regional level. Some studies do not find evidence for the importance of intra-industry technological spillovers for industry employment growth or innovations at the firm-level (e.g. Glaeser et al. 1992; Feldman and Audretsch 1999). In contrast, results of other empirical investigations (strongly) support the assumption of a positive relationship between industry concentration and innovative performance of firms located within these agglomerations or the respective region (e.g. Audretsch and Feldman 1999; Baptista and Swann 1998; Lobo and Strumsky 2008; Gilbert, McDougall and Audretsch 2008; Folta, Cooper and Baik 2006). A critical survey on the localization versus urbanization debate in general is provided by Beaudry and Schiffauerova (2008). For Germany in particular, there exists little empirical evidence so far. Regarding local employment growth on the NUTS-3-level (districts) between an eight-year span (1993-2001), Suedekum and Blien (2005) find that MAR-externalities (i.e. industry concentration) are present only in the service sector, but not for manufacturing industries. A recent study by Fritsch & Slavtchev (2009) relates industry concentration to the efficiency of regional innovation systems (measured by the number of disclosed patent applications per Planning Region). The authors find an inverse-U relationship, which means regional industry concentration beyond a maximum seems to lower regional innovative performance. No study explicitly examines the effects of industry concentation in Eastern Germany so far.

3 Conditions for Innovation in Eastern Germany

Although, industry concentration is beneficial for innovation from a theoretical point of view and previous empirical work at least partially supports this relationship, with respect to Eastern Germany, important particularities of the innovation system must be taken into account.

Comparable other post-socialist countries in Central and Eastern Europe, the transformation of the former GDR into a free market economy accompanies with a massive program of privatization. While the bigger part of the transition countries realize a voucher privatization (e.g. Pahor, Prašnikar and Ferligoj 2004), the former state-owned conglomerates in Eastern Germany were transformed into a multiplicity of firms and offered to foreign investors (e.g. Blum 2008). While most of these separate plants were taken over by firms from West Germany, overall, foreign direct investments (including West Germany) in Eastern Germany are much higher than in other post-communist economies (Günther 2005). Besides undisputed advantages (e.g. modernization of the capital stock, restructuring and technology transfer), this mode of privatization shows some negative effects. In particular, this development results in a considerable lack of management functions and headquarters along with the relatively low R&D efforts of the companies (Blum 2007). Because the majority of the head offices remain located in Western Germany, subsidiaries/branch plants in East Germany mostly fulfill (rather simple) production or other low-order tasks (Grabher 1994). Important knowledge spillovers may mainly occur between spatially proximate R&D-departments (or headquarters), rather than between production plants (Blum 2007). In addition, assuming that headquarters have already well-established pipelines for knowledge acquisition and to monitor innovations, they generally do not have interest using the surrounding of their (Eastern-German) sub-contractors as a source of knowledge (Dyker et al. 2006). These characteristics of the industrial landscape in eastern Germany may have an influence on the scope of agglomeration economies in the region.

A further reason which could have substantial impact on potential effects of industry concentration is the missing or limited interconnectedness of economic actors in Eastern Germany. Through the process of transformation, existing business network and formerly valuable supply chains were widely invalid (Windolf, Brinckmann and Kulke 1999; Rosenfeld, Franz and Heimpold 2007). As noted above, large-size manufacturing establishments are often subsidiaries/branch plants. Because these branch plants/subsidiaries were widely integrated into existing networks and production chains of their parent (often Western German) corporations, they have limited interest in the formation of local supply chains (Grabher 1994; Brussig and Dreher 2001). Consequently, although it must be emphasized that empirical results are not consistent, the degree of regional cooperation in Eastern Germany generally is perceived as being low (e.g. Heidenreich 2001; Wölfl and Ragnitz 2001 – for some contrasting results, see Burssig and Dreher 2001; Fritsch 2003; Günther 2004). Interestingly, Günther (2004) shows for Eastern German firms that being engaged in network relationships is not conducive to productivity, whereas this effect is significant and positive for Western German firms.

4 Innovation Activities in Eastern Germany – Spatial and Sectoral Distribution

Before presenting our econometric model, the following sub-sections describe the Spatial (4.1) and the Sectoral (4.2) distribution of innovation activities in Eastern Germany. Subsection 4.3 subsequently describes the innovation performance of Industry-Region-Combinations (IRC).

To measure regional innovative performance we refer to the number of patent applications according to the DPMA (2006). We include all patent applications in a five-year span between 2000 and 2005. This multi-year analysis allows considering the high volatility of the annual number of patent applications in the regions.

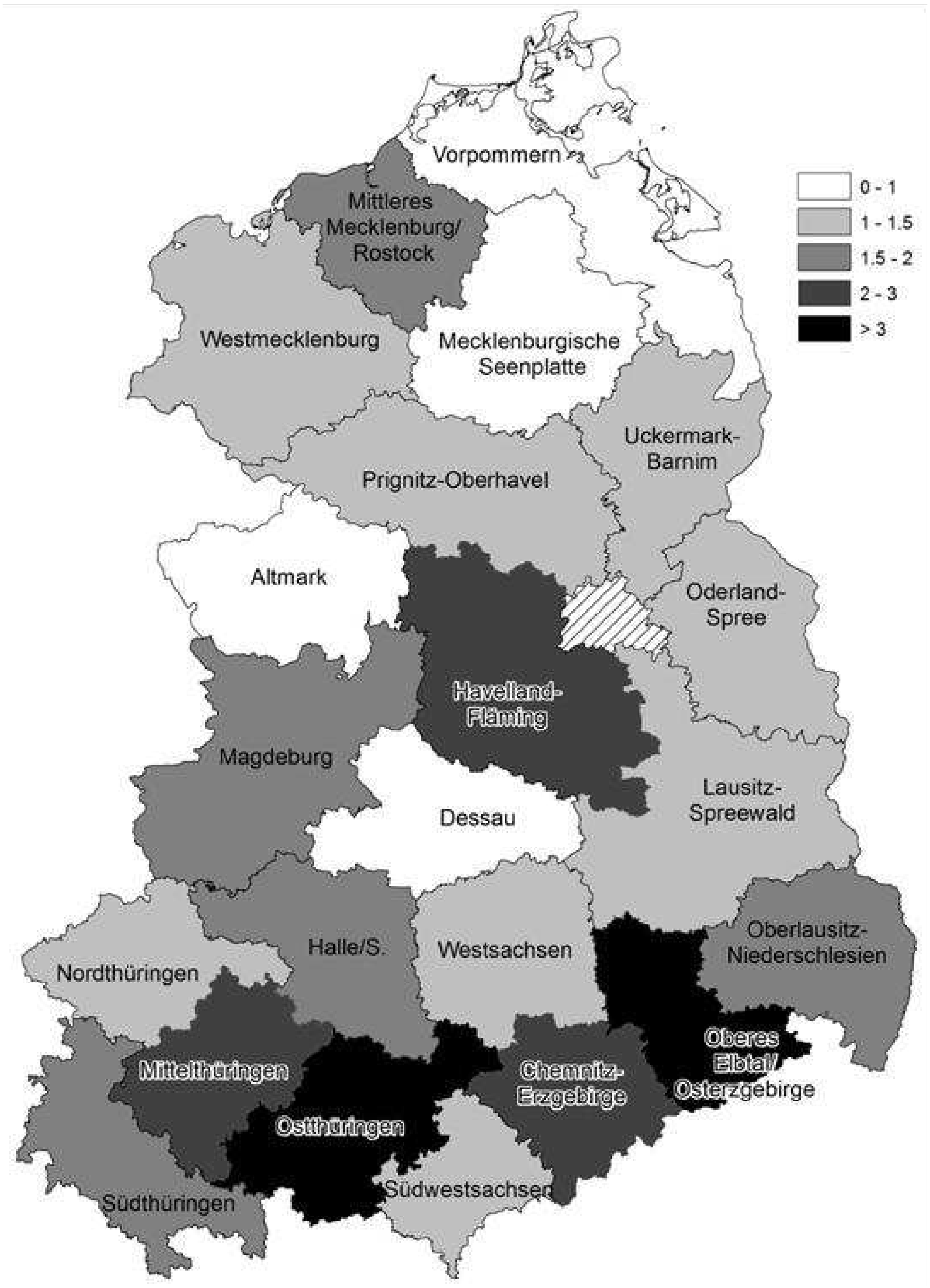
Since patents are primarily used in the manufacturing sector the concordance-approach by Schmoch et al. (2003) is restricted to manufacturing industries, patent applications from the service sector as well as from agriculture are excluded from our analysis. In addition, the Planning Region of Berlin is not included in the investigation, because of Berlins special position as a capital and the missing transition process in the western part of the city.

We are aware that the application of patents as an indicator for innovative performance is criticized for several reasons. For instance, the general increase in the number of patent applications over time and the influence of economic conditions on the affinity to patent are criticized (Griliches 1990; Schmoch 1999). Nevertheless, patents show a strong relationship to R&D expenditures and therefore are a suitable indicator of both, inventive input and output (Griliches 1990). Besides this basic criticism, the use of patent data as a measure of innovative performance in transition countries has its problems. The main critic draws on the fact that these regions are usually far away from the technological frontier and catch up technologically through imitative learning. This process of innovation which takes place when the actors are far away from the technological frontier and move up getting closer to it can not be captured with patent indicators (Radosevic and Kutlaca 1998).

4.1 Spatial Distribution of Innovative Activities

As can be seen from Figure 1, there is a heterogeneous distribution of innovation performance on the level of the planning regions in Eastern Germany. In particular, the map reveals disparities between the northern and the southern part. Among all (Eastern) German planning regions; ‘Mecklenburgische Seenplatte’, ‘Vorpommern’, ‘Altmark’ and ‘Uckermark-Barnim’ are the four least innovative planning regions.

Figure 1
Average annual number of patent applications (2000-2005) per inhabitant (2005) in Eastern German planning regions

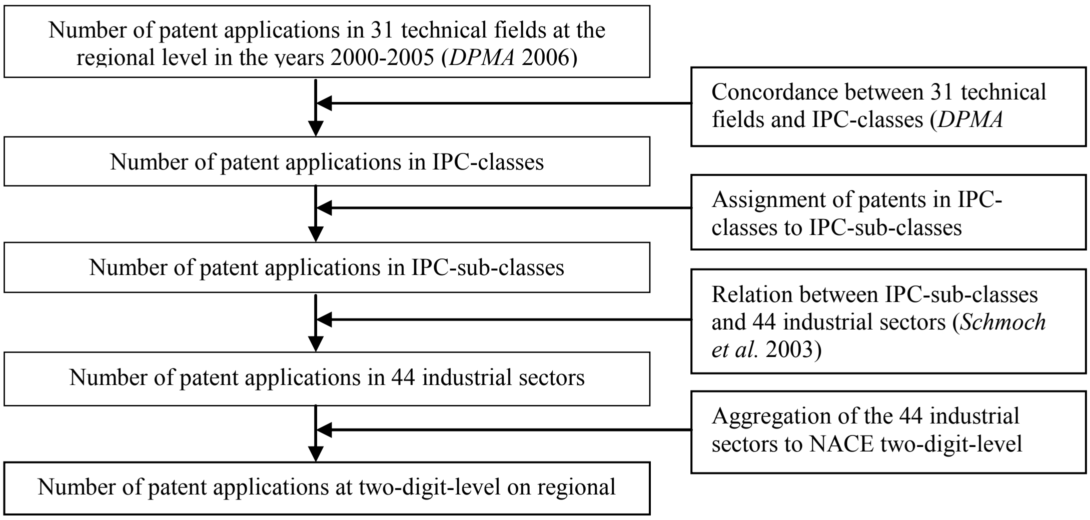


Source: DPMA (2006); authors calculation and illustration.

4.2 Sectoral Distribution of Innovative Activities

A more detailed analysis of innovation performance in Eastern Germany on the sectoral level requires the assignment of patent applications to specific sectors or industries. Because, patent application data do not contain specific information with respect to the sector of the applicant, but regarding the technical field of the invention, several approaches were developed since the 1980s to link technical fields and industry classification. The first satisfying solution was provided by Schmoch et al. (2003). Based upon an extensive analysis of more than 150 000 patent applications, they develop a concordance between the technological field of an application and the two-digit level of the NACE classification of economic activities. Applying this approach requires detailed information about the technical field of the patents, namely at the level of sub-classes of the International Patent Classification (IPC)

Figure 2:
Method to identify the number of patent application of industries



Source: Authors illustration.

Unfortunately, our primary data source (DPMA 2006) does not provide this information directly. However, on the regional level (the level of planning regions) it includes information of patent applications with respect to 31 technical fields (defined by DPMA 2006), and provides a concordance between these 31 technical fields and the IPC-classes. So we were able to compute the number of patent applications at the level of IPC-classes in each (planning) region. To assign patent applications in IPC-classes to related IPC sub-classes, equal frequencies of each sub-class must be assumed. This is quite restrictive assumption and may bias our results by leading to and over- or underestimation of the actual number of patens of an industry. Following the concordance by Schmoch et al. (2003), each resulting patent application at the level of IPC-sub-classes in each region was distributed to one (or more) of 44 industries, which can be aggregated to a consistent two-digit level without problems. Figure 2 below summaries the approach. Of course, the described method is controversial. A principal weakness is the implicit assumption, that the relation between technological fields and industrial sectors is not only valid on the average of all regions, but also in any specific region. Moreover, the possible variation of this relation in time might be a problem.

Applying this approach by Schmoch et al. (2003) enables us to analyze the sectoral distribution of innovative activity in Eastern Germany. The number of the patent applications of the different industries is given in Appendix 1. A total of 15 848 patent applications were observed for all 22 two-digit manufacturing industries in the five-year period under observation. Most patent applications in Eastern Germany between 2000 and 2005 are allotted to the 'chemical industry' (NACE Code 22), the 'machinery industry' (NACE Code 29) and 'radio and television industry' (NACE Code 32).

4.3 A two-dimensional Analysis: Innovation Performance of Industry-region Combinations

The combination of both the spatial and the sectoral dimension of innovative activity allows for the analysis of specific (what we might term) industry-region combinations (IRCs). A detailed overview with respect to the five most/least innovative IRCs is pro-

Table 1
Innovation activities in Eastern Germany: Top-performing and low-performing IRCs (according to cumulated patent applications; 2000 – 2005).

Planning region	Industry (NACE code)	Patent applications			*Specialisation rate*
		Overall	Industry share	Regions share	
Five Most Innovative					
Oberes Elbtal/Osterzgebirge	(32)	604.97	30.1%	17.1%	*5.31*
Oberes Elbtal/Osterzgebirge	(29)	555.86	23.0%	15.7%	*1.16*
Oberes Elbtal/Osterzgebirge	(24)	509.65	19.0%	14.4%	*1.37*
Oberes Elbtal/Osterzgebirge	(30)	421.91	28.0%	11.9%	*0.97*
Ostthüringen	(24)	320.20	11.9%	20.3%	*1.31*
Five Least Innovative					
Mecklenburgische Seenplatte	(18)	0.17	1.5%	0.1%	*0.15*
Altmark	(19)	0.15	0.7%	0.2%	*0.04*
Vorpommern	(18)	0.14	1.2%	0.1%	*0.04*
Uckermark-Barnim	(18)	0.14	1.2%	0.1%	*0.18*
Altmark	(18)	0.09	0.8%	0.1%	*0.13*

Source: Authors calculations.

vided in Table 1. The most common region among the five most innovative IRCs is 'Oberes Elbtal/Osterzgebirge', which is the planning region including the city of Dresden. The respective industries (NACE codes 24, 29, 30, and 32) yield almost 60% of this regions' overall patent applications. Moreover, the more innovative industries in Eastern Germany seem to be more regionally concentrated than low performing industries, as suggested by a comparison of the specialisation rate (last column in Table 1, description below). This descriptive result might be a first indication for positive effects of industry concentration on regional innovative performance in the Eastern German innovation system.

5 Econometric Model

To further analyze the impact of industry concentration on regional innovative performance in Eastern Germany, an econometric model was estimated. The innovative performance of the IRCs (as dependent variable) was identified as described in Section 3. We estimate a pooled model including all 22 manufacturing industries in 22 planning regions, leading to a sample size of 484 IRCs. Because of missing data for some IRCs (for instance, the tobacco industry is only present in a few regions), the sample was reduced to 377 observations.

5.1 Measures of Industry Concentration

It is unclear, which of the many possible indicators might be most effective to capture the degree of industry concentration and MAR externalities respectively, and empirical support varies according to the indicator utilized (Beaudry and Schiffauerova 2008). To avoid potential bias and to ensure the widest possible comparability of our results with previous studies, we use three different variables to measure industry concentration. For the calculation of all three indicators, we rely on employment data from the German Social Insurance Statistics for the year 2003. This database meets with the NACE Rev.1 classification of economic activities and contains the number of employees for each firm at the NUTS-3 level (see Fritsch and Brixy 2004 for a description). While this database has the huge benefit of recording separate locations of multi-establishment enterprises, a disadvantage is that only employees participating in the German social insurance system are recorded. Freelancers or self-employed persons are not considered.

First, we use the rather simple and frequently used (Beaudry and Schiffauerova 2008) indicator of absolute industry size, that is own industry employment in the respective region, to measure the degree of industry concentration. Secondly, as stated in the introduction, a more recent study of Eastern German economic 'clusters' by Rosenfeld, Franz and Heimpold (2007) introduces the concept of spatially concentrated industries (SCIs). Drawing on this concept, we specify an alternative dummy variable SCI. Similar to Rosenfeld, Franz and Heimpold (2007), a SCI is assigned to an IRC, if this industry in the planning region is one of the three most important locations in Eastern Germany (in terms of absolute industry employment). Third, we employ the well-known measure of industry specialization (e.g. Glaeser et al. 1992; Feldman and Audretsch 1999). This relative measure (also known as location quotient) is the most frequently used indicator to capture the degree of industry concentration (Beaudry and Schiffauerova 2008). Industry specialization is defined as the share of total regional employment accounted for by one particular industry employment in that region relative to this share in the Eastern German economy. The higher the resulting value for a given IRC, the more concentrated is the respective industry in the corresponding (planning) region. Statistically significant positive coefficient of the corresponding variables would imply that industry concentration is positively associated with IRC innovative performance.

5.2 Further Determinates of Innovation Performance

Besides variables measuring the degree of industry concentration, we include further determinants of IRCs innovation performance. First, prior research has emphasized the decisive role inter-firm networks play for successful innovation processes (e.g. DeBresson and Amesse 1991; Freeman 1991; Hagedoorn and Schakenraad 1994). Effective networking provides valuable opportunities for the exchange of knowledge and ideas, technology transfer and collective learning. To identify innovation-related network relationships, Rosenfeld, Franz and Heimpold (2007) focus on networks showing a certain degree of formalization. They screen public available data sources (e.g. internet platforms about networks that receive public funding) and conduct a survey among governmental administrations, regional development agencies and chambers of industry and commerce. The resulting networks were assigned to particular IRCs (see Rosenfeld, Franz and Heimpold 2007 for a description of the data). We employ these data and generate a dummy variable business networks, which takes the value one, if at least one formalized network can be identified in the particular IRC. Second, employment data from the German Social Insurance Statistics (see above) is used to capture the number of R&D-employees in the IRCs. Specifically, employees holding a university degree and that are labeled as 'engineer', 'chemist', physician', 'mathematician' or as 'other natural scientist' are defined as R&D-employees. Industry R&D employment is used as a proxy for the input in the innovation process. Besides these IRCs' characteristics, we include two variables that describe the respective planning regions and control for more general economic conditions. We expect that a high GDP per capita indicates favorable conditions for innovation activities. Moreover, since agglomerated areas provide a wide range of knowledge and ideas (Jacobs 1969), we expect that population density (as proxy for urbanization effects) promotes innovation success. The data of both variables for the year 2003 were taken from the German Federal Statistical Office (‘Statistisches Bundesamt’). The correlations as well as descriptive statistics of the included variables can be found in the Appendix.

5.3 Regression Results

Model I includes industry size as indicator of industry concentration, Model II refers to the alternative concept of spatially concentrated industries (SCIs) and Model III uses the measure of industry specialization. Table 2 shows the estimation results. Each model is estimated with 21 industry controls (‘manufacture of chemicals and chemical products’, NACE-Code 24 serves as reference category). However, the respective variables are omitted in Table 4, but the complete regression results can be found in the Appendix 3. An in depth-discussion of the findings is held in the concluding section of this article.

With respect to the central research question of this article as to whether industry concentration in Eastern Germany promote innovative performance, regression results are twofold. First, for industry size as well as for SCIs, statistically significant positive effects on innovative performance can be found. This result suggests that industry concentration per se (measured in terms of absolute industry employment in one region) is associated with higher patenting activity in Eastern Germany. More remarkably, the regression result of Model III also gives some evidence of a non-linear relationship between the degree of industry specialization and innovation. While the results indicate that higher industry concentration in Eastern Germany positively affects innovation output on the regional level (Ind_Spec), the 'minus' of the coefficient of the square of this variable (Ind_Spec (square)) provides evidence for an inverted-U relationship.

Table 2:
Regression results of the determinants of innovative performance of manufacturing industries in Eastern German planning regions (standard errors in parentheses)

Dependent variable: Number of industry patent applications in planning region (ln)						
	I		II		III	
Indicators of industry concentration						
Industry size (IRC employment) (ln)	0.182	(0.026)***	-	-	-	-
SCI (dummy)	-	-	0.169	(0.066)**	-	-
Ind_SPEC	-	-	-	-	0.079	(0.028)***
Ind_SPEC (square)	-	-	-	-	- 0.003	(0.001)***
Characteristics of IRC						
Business networks (dummy)	0.100	(0.054)*	0.150	(0.057)***	0.153	(0.056)***
Industry R&D employment (IRC share) (ln)	0.077	(0.030)**	0.082	(0.031)***	0.087	(0.031)***
Regional characteristics						
GDP per capita (ln)	1.281	(0.148)***	1.280	(0.156)***	1.332	(0.159)***
Population density (ln)	1.023	(0.051)***	1.156	(0.049)***	1.175	(0.048)***
Industry controls (output omitted)						
Constant	- 5.365	(0.485)***	- 4.805	(0.510)***	- 5.087	(0.517)***
Observations (IRCs)	377		377		377	
R-square / R-square adjusted	0.934 / 0.929		0.926 / 0.921		0.926 / 0.921	
F (Prob > F)	189.86 (0.000)***		168.35 (0.000)***		162.35 (0.000)***	

*, **, *** indicates statistical significance on 10%, 5%, 1%-level.

Source: Authors calculations.

Considering business networks, we find significant positive effects in all three models. We also find a statistically significant positive relationship between regional innovative performance and the share of IRCs' R&D employment. Accordingly, this result highlights the importance of private sectors R&D inputs for successful innovation processes in Eastern Germany. Furthermore, region with a high GDP and a dense population seem to favor the number of patent applications.

6 Conclusions

Recently, Rosenfeld, Franz and Heimpold (2007) recommend a regional economic policy for Eastern Germany that strongly supports and strengthens industry concentrations. They presume that as a result of agglomeration economics such concentrated policy measures will be more effective than area-wide measures to stimulate economic growth and innovation. But empirical evidence that investigates this relationship is missing so far. Therefore, the present study poses the research question(s): Do concentrations of manufacturing industries promote innovative performance in Eastern Germany?

Absolute measures of industry concentration unequivocally notice a statistically positive relationship between innovation performance of East German planning regions and the extent to which industries are concentrated in that region. Therefore, our findings seem to be in line with more general findings on the effects of MAR externalities on innovation (see section 2.1). However, using a relative measure of industry concentration and relating it to innovative performance of Eastern German (planning) regions yields a remarkable result. Specifically, we find that industry concentration in Eastern German regions beyond a certain maximum level seems to decrease regional innovative performance. This result reinforces prior research, where such an inverse-U relationship has been detected (Folta, Cooper and Baik 2006; Fritsch and Slavtchev 2009). In other words, if manufacturing industries in Eastern Germany exhibit an exceedingly high degree of concentration in a specific region, this has negative effects on the innovative performance of that region.

And what do our empirical findings imply for the concrete design and future refinement of supporting policy schemes in Eastern Germany? It seems likely that our results seem to confirm the concerns of Blum (2007) and Rosenfeld, Franz and Heimpold (2007): The Eastern German economy widely lacks important headquarters and R&D departments and, therefore, huge industry concentrations primarily are based on agglomerations of pure production tasks/facilities. For instance, consider the industry 'Manufacturing of motor vehicles' in the planning region of 'Südwestsachsen' (see Figure 1). This industry has one of the highest specialization rates of all Eastern German IRCs with 5.15. However, approximately 75% of all IRCs employees (over 8 000) are working in one local production plant (Volkswagen in the city of Zwickau). Although there is no empirical justification for this point, it is questionable to what extent (MAR-) agglomeration economies can occur in this surrounding.

In this respect, policy-makers (not only in Eastern Germany) should keep in mind that the formation of successful 'cluster' structures is a long term and particularly path-dependent process which involves continues efforts on all governmental levels (Boschma and Lambooy 1999). According to our results, the more/ most innovative IRCs (see Table 2) can look back on a long tradition in specific industries accompanied with the regional accumulation of human capital, knowledge and institutions. For instance, the planning region 'Oberes Elbtal/Osterzgebirge' has a history in microelectronics and semiconductors (belonging to NACE-Code 32 'radio, television and communication equipment'), which can be traced back to the efforts of the formerly central planned GDR to establish Dresden as worldwide competitive industry location.

This path-dependency is further emphasized by the regression results regarding the effects of business networks. For considerable time, the support of regional networks is a common tool, to foster the economic development in Germany (e.g. Eickelpasch and Fritsch 2005). Those IRCs in Eastern Germany that could not develop formalized networks yet perform significantly weaker in terms of innovative output. Therefore, following Rosenfeld et al. (2007) we strongly recommend intensifying policy support for regional networking. This is important because the simple co-location of potential partners in (close) proximity (e.g. firms, universities, R&D organizations, governmental institutions, trade associations) might be insufficient for the transfer of knowledge/technology (Boschma 2005). Governmental support programs in Eastern Germany should not only aim to initiate 'clusters'. Rather such policies should recognize the network dimension and build on existing preconditions (i.e. specific technological trajectories). Ignoring the local- or regional-specific strengths may be a wasting of valuable resources for successful economic re-structuring.

Literature

Almeida, P.; Kogut, B. (1999): Localization of Knowledge and the Mobility of Engineers in Regional Networks. Management Science 45 (7), pp. 905-917.

Arrow, K. J. (1962): The economic implications of learning by doing. The review of economic studies 29, pp. 155173.

Audretsch, D. B.; Feldman, M. P. (1996): R&D spillovers and the geography of innovation and production. American economic review 86, pp. 630-640.

Baptista, R.; Swann, P. (1998): Do firms in clusters innovate more? Research Policy 27, pp. 525-540.

Beaudry, C.; Schiffauerova, A. (2008): Who's right, Marshall or Jacobs? The localization versus urbanization debate, Research Policy, doi:10.1016/j.respol.2008.11.010.

Blum, U. (2007): Der Einfluß von Führungsfunktionen auf das Regionaleinkommen: eine ökonometrische Analyse deutscher Regionen, in: IWH, Economy in Change 6/2007, pp. 187-194.

Blum, U. (2008): Institutions and Clusters, in: B. Johansson; C. Karlsson. (eds), Handbook on Research on Innovation and Clusters. Edward Elgar: Cheltenham, pp. 361-373.

Breschi, S.; Lissoni, F. (2001): Knowledge Spillovers and Local Innovation Systems: A Critical Survey, in: Industrial and Corporate Change 10 (4), pp. 975-1005.

Boschma, R. A. (2005): Proximity and innovation: a critical assessment. Regional Studies 39, pp. 61-74.

Boschma, R. A.; Lamnbooy, J. G. (1999): Evolutionary economics and economic geography. Journal of Evolutionary Economics 9, pp. 411-429.

Brussig, M.; Dreher, C. (2001): Wie erfolgreich sind Kooperationen? Neue Ergebnisse zur Kooperationspraxis in Ostdeutschland. WSI-Mitteilungen. No. 9 2001, pp. 566-572.

BMBF (2007): Deutschlands Spitzencluster – Mehr Innovation, Mehr Beschäftigung, Mehr Wachstum. Bundesministerium für Bildung und Forschung. Bonn, Berlin, 2007.

DeBresson, C.; Amesse, F. (1991): Networks of innovators: a review and introduction to the issue. Research Policy 20 (5), pp. 363-379.

DPMA (2006): Patentatlas Deutschland – Regionaldaten der Erfindertätigkeit. German Patent and Trade Mark Office. Munich.

Dyker, D.; Higginbottom, K.; Kofoed, N.; Stolberg, C. (2006): Analyzing FDI in Central-East Europe through case studies, in: D. Dyker, (ed.), Closing the EU East-

West Productivity Gap – Foreign direct Investment, Competitiveness, and Public Policy. Imperial College Press: London, pp. 71-92.

Eickelpasch, A.; Fritsch, M. (2005): Contents for cooperation – A new approach in German innovation policy. Research Policy 34, pp. 1269-1282.

Feldman, M. P.; Audretsch, D. B. (1999): Innovation in cities: Science-based diversity, specialization and localized competition. European Economic Review 43, pp. 409-429.

Folta, T. B.; Cooper, A. C.; Baik, Y.-S. (2006): Geographic cluster size and firm performance, in: Journal of Business Venturing 21, pp. 217-242.

Freeman, C. (1991): Networks of Innovators: A synthesis of research issues. Research. Policy (20), pp. 499 - 514.

Fritsch, M. (2003): Does R&D-Cooperation Behavior Differ Between Regions? Industry and Innovation 10 (1), pp. 25-39.

Fritsch, M.; Brixy, U. (2004): The Establishment File of the German Social Insurance Statistic. Journal of Applied Social Science Studies, 124, pp. 183-190.

Fritsch, M., Slavtchev, V. (2009): How Does Industry Specialization Affect the Efficiency of Regional Innovations Systems? Annals of Regional Science, forthcoming.

Gilbert, B. A.; McDougall, P. P.; Audretsch, D. B. (2008): Clusters, knowledge spillovers and new venture performance: An empirical examination. Journal of Business Venturing 23, pp. 405-422.

Glaeser, E. L.; Kallal, H. D.; Scheinkman, J. A.; Shleifer, A. (1992): Growth in cities. Journal of political economy 100 (6), pp. 1126-1152.

Grabher, G. (1994): The Disembedded Regional Economy: The Transformation of East German Industrial Complexes into Western Enclosures, in A. Ash; N.hrift (eds.), Globalization, Institutions, and Regional Development in Europe. Oxford University Press: Oxford, pp. 177-195.

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

Günther, J. (2004): Innovation cooperation: experiences from East and West Germany. Science and Public Policy 31 (2), pp. 151-158.

Günther, J. (2005): Investment of foreign companies significantly higher in East Germany than in Central Eastern Europe, in: IWH, Economy in Change 2/2005, pp. 44-50.

Hagedoorn, J.; Schakenraad, J. (1994): The Effect of Strategic Technology Alliances on Company Performance. Strategic Management Journal 15 (4), pp. 291-309.

Heidenreich, M. (2001): Regionale Netzwerke. Ein Weg zur Stärkung der Innovationstätigkeit ostdeutscher Betriebe?, in: J. Wolf; H. Mattfeldt; H. Giebel (eds), Jahrbuch für Politik und Gesellschaft in Sachsen-Anhalt. Mitteldeutscher Verlag:, Halle (Saale), pp. 222-243.

Jacobs, J. (1969): The economy of cities. Random House. New York.

Jaffe, A. B.; Trajtenberg, M.; Henderson, R. (1993): Geographic localization of knowledge spillovers as evidenced by patent citations. Quarterly Journal of Economics 63, pp. 577-598.

Krugman, P. (1991a): Geography and Trade. MIT Press: Cambridge.

Lobo, J.; Strumsky, D. (2008), Metropolitan patenting, inventor agglomeration and social networks: A tale of two effects. Journal of Urban Economics 63, pp. 871-884.

Malmberg, A.; Maskell, P. (1997): Towards an Explanation of Regional Specialization and Industry Agglomeration. European Planning Studies 5 (1), pp. 25-42.

Marshall, A. (1920): Principles of Economics. Eighth Edition. McMillan: London, reprinted 1962.

Pahor, M.; Prašnikar, J.; Ferligoj, A. (2004): Building a corporate network in a transition economy: The case of Slovenia. Post-Communist Economies 16 (3), p. 307-331.

Porter, M. E. (1990): The Competitive Advantage of Nations. MacMillan: London.

Romer, P. M. (1986): Increasing Returns and Long Run Growth. Journal of Political Economy 94 (5), pp. 1002-1037.

Rosenfeld, M. T. W.; Franz, P.; Heimpold, G. (2007): Economic ‚Clusters' in East Germany: Evidence on the Characteristics of Spatially Concentrated Industries. Post-Communist Economics 19 (1), p. 73-92.

Radosevic, S. and Kutlaca, D. (1998): Assessing the Basis for 'Catching-Up' of Eastern Europe – An Analysis Based on US Foreign Patenting Data. STEEP Discussion Paper No. 42.

Saxenian, A. (1991): The origins and dynamics of production networks in Silicon Valley. Research Policy 20 (5), pp. 423-437.

Schmoch, U. (1999): Impact of International Patent Applications on Patent Indicators. Research Evaluation 8 (2), pp. 119-131.

Schmoch, U.; Laville, F.; Patel, P.; Frietsch, R. (2003): Linking Technology Areas to Industrial Sectors. Forschungsbericht, Fraunhofer ISI, 2003.

Suedekum, J.; Blien, U. (2005): Local Economic Structure and Industry Development in Germany, 1993-2001. Economics Bulleting 15 (17), pp. 1-8.

Windolf, P.; Brinckmann, U.; Kulke, D. (1999): Warum blüht der Osten nicht? Zur Transformation ostdeutscher Betriebe. Forschung aus der Hans-Böckler-Stiftung 13. Edition Sigma: Berlin.

Wölfl, A.; Ragnitz, J. (2001): Netzwerkaktivitäten und die Produktivitätslücke Ostdeutschlands: Die Rolle von Agglomerationsvorteilen, in: IWH, Economy in Change 13/2001, pp. 315-319.

Zucker, L. G.; Darby, M. R.; Brewer, M. B. (1998): Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises. American Economic Review 88 (1), pp. 290-306.

Appendix 1:
Manufacturing industries in Eastern Germany; ordered by the number of patent applications between 2000 and 2005

Code	Industry	Patent applications
(24)	Manufacture of chemicals and chemical products	2688.4
(29)	Manufacture of machinery and equipment n.e.c.	2417.7
(32)	Manufacture of radio, television and communication equipment and apparatus	2011.7
(34)	Manufacture of motor vehicles, trailers and semi-trailers	1607.1
(30)	Manufacture of office machinery and computers	1508.5
(33)	Manufacture of medical, precision and optical instruments, watches and clocks	1231.6
(31)	Manufacture of electrical machinery and apparatus n.e.c.	656.2
(28)	Manufacture of fabricated metal products (except machinery and equipment)	612.2
(35)	Manufacture of other transport equipment	601.9
(27)	Manufacture of basic metals	453.4
(26)	Manufacture of other non-metallic mineral products	364.4
(15)	Manufacture of food and beverages	357.7
(25)	Manufacture of rubber and plastic products	316.2
(23)	Manufacture of coke, refined petroleum products and nuclear fuel	313.8
(36)	Manufacture of furniture; manufacturing n.e.c.	291.8
(21)	Manufacturing of pulp, paper and paper products	195.4
(17)	Manufacture of textiles	72.5
(22)	Publishing, printing and reproduction of recorded media	45.3
(16)	Manufacture of tobacco products	40.9
(20)	Manufacture of wood and of products of wood and cork; articles of straw and plaiting materials	27.7
(19)	Tanning and dressing of leather; manufacture of luggage, handbags, sadlery, harness and footwear	21.5
(18)	Manufacture of wearing apparel, dressing and dying of fur	11.7

Source: Authors calculations.

Appendix 2:

Descriptive statistics and bivariate correlation matrix

Variable		Mean	Std. Deviation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	Patents (*ln*)	2.683	1.555							
(2)	Industry size *(ln)*	6.927	1.288	0.292						
(3)	SCI *(dummy)*	0.172	0.378	0.094	0.326					
(4)	Ind_SPEC	1.261	1.888	-0.086	0.204	0.456				
(5)	Business networks *(dummy)*	0.520	0.500	0.363	0.370	0.101	-0.045			
(6)	Industry R&D employment *(ln)*	-4.103	1.130	0.557	-0.082	0.084	0.082	0.106		
(7)	GDP per capita *(ln)*	3.036	0.149	0.222	0.084	0.050	-0.136	0.111	0.026	
(8)	Population density *(ln)*	4.855	0.510	0.354	0.318	0.334	0.020	0.152	0.050	0.187

Source: Authors calculations.

Appendix 3:

Complete regressions results including industry dummies

	Model I		Model II		Model III	
Indicators of industry concentration						
Industry size (IRC employment) *(ln)*	0.182	(0.026) ***	-	-	-	-
SCI *(dummy)*	-	-	0.169	(0.066) **	-	-
Ind_SPEC	-	-	-	-	0.079	(0.028) ***
Ind_SPEC (square)	-	-	-	-	- 0.003	(0.001) ***
Characteristics of IRC						
Business networks *(dummy)*	0.100	(0.054) *	0.150	(0.057) ***	0.153	(0.056) ***
Industry R&D employment (IRC share) *(ln)*	0.077	(0.030) **	0.082	(0.031) ***	0.087	(0.031) ***
Regional characteristics						
GDP per capita *(ln)*	1.281	(0.148) ***	1.280	(0.156) ***	1.332	(0.159) ***
Population density *(ln)*	1.023	(0.051) ***	1.156	(0.049) ***	1.175	(0.048) ***
Industry controls (reference industry 24) a						
(15) Food and beverages	- 2.133	(0.151)	- 1.830	(0.153)	- 1.827	(0.153)
(16) Tobacco products	- 3.625	(0.263)	- 4.009	(0.278)	- 4.182	(0.297)
(17) Textiles	- 3.373	(0.152)	- 3.500	(0.161)	- 3.510	(0.161)
(18) Wearing apparel, dressing and dying of fur	- 4.970	(0.205)	- 5.222	(0.217)	- 5.234	(0.217)
(19) Tanning and dressing of leather…	- 4.346	(0.218)	- 4.632	(0.231)	- 4.656	(0.232)
(20) Wood and of products of wood and cork…	- 4.301	(0.139)	- 4.305	(0.147)	- 4.308	(0.147)
(21) Pulp, paper and paper products	- 2.419	(0.139)	- 2.522	(0.147)	- 2.522	(0.147)
(22) Publishing, printing…	- 4.067	(0.156)	- 4.001	(0.165)	- 3.988	(0.164)
(23) Manufacture of coke…	- 1.708	(0.215)	- 2.073	(0.225)	- 1.974	(0.244)
(25) Rubber and plastic products	- 2.103	(0.133)	- 2.008	(0.139)	- 2.018	(0.139)
(26) Other non-metallic mineral products	- 2.001	(0.132)	- 1.875	(0.138)	- 1.876	(0.138)
(27) Manufacture of basic metals	- 1.840	(0.129)	- 1.795	(0.136)	- 1.796	(0.136)
(28) Fabricated metal products…	- 1.702	(0.135)	- 1.425	(0.136)	- 1.426	(0.136)
(29) Machinery and equipment n.e.c.	- 0.370	(0.130)	- 0.171	(0.134) †	- 0.171	(0.134) †
(30) Office machinery and computers	- 0.035	(0.168) †	- 0.478	(0.166)	- 0.501	(0.166)
(31) Electrical machinery and apparatus n.e.c.	- 1.485	(0.130)	- 1.470	(0.138)	- 1.470	(0.138)
(32) Radio, television…	- 0.377	(0.133)	- 0.489	(0.140)	- 0.482	(0.140)
(33) Medical, precision and optical instruments…	- 0.894	(0.129)	- 0.825	(0.136)	- 0.826	(0.136)
(34) Motor vehicles, trailers and semi-trailers	- 0.393	(0.128)	- 0.457	(0.135)	- 0.451	(0.135)
(35) Other transport equipment	- 1.389	(0.129)	- 1.428	(0.136)	- 1.444	(0.136)
(36) Furniture; manufacturing n.e.c.	- 2.013	(0.141)	- 1.969	(0.149)	- 1.971	(0.149)
Constant	- 5.365	(0.485)	- 4.805	(0.510)	- 5.087	(0.517)
Observations (IRCs)	377		377		377	
R-square / R-square adjusted	0.934 / 0.929		0.926 / 0.921		0.926 / 0.921	
F (Prob > F)	189.86 (0.000) ***		168.35 (0.000) ***		162.35 (0.000) ***	

*, **, *** indicates statistical significance on 10%, 5%, 1%-level. – [a] All industry controls are statistically significant on 1%-level unless denoted (†).

Source: Authors calculations.