CHAPTER 4

Historical Legacies of Regional Innovation Activity: The Case of East and West Germany

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1 Tracing the Legacies of German Division and Reunification

The 40 years of German separation into a capitalist West and a communist East after the Second World War (WWII) and the sudden reunification have left deep traces in many respects. Our contribution deals with these effects on innovation activity. To this end, we compare the innovation

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activity in East and West Germany before WWII, at the end of the socialist East German regime, and particularly in the period after German reunification in the year 1990. This comparison includes the level, the technological profiles, and the development of the regional structure of innovation activity. Our analysis demonstrates strong effects of the German separation and reunification on the regional innovation landscape within East Germany as well as rather pronounced repercussions for innovation activities in the West.

The empirical analysis in this paper is largely based on patents for several reasons. A main advantage is that patent data are available over relatively long periods of time. Patents also represent inventions of a certain minimum quality, which makes them comparable across countries, regions, and time periods. Patent data also provide important information such as the names and addresses of the applicants and the inventors, the knowledge fields (International Patent Classification, IPC class) of inventions, and information regarding specific knowledge input (citations) and the impacts of patented inventions on subsequent patents (for an overview, see Griliches 1990; Nagaoka et al. 2010).[1]

The remainder of this chapter is organized as follows. We begin with a brief overview of the history of innovation activity in Germany since the late nineteenth century (Sect. 2) and then analyze the development of the level of patenting in East and West Germany in this period (Sect. 3). Section 4 presents similarities in the technological profiles of patenting activity in both parts of the country and chronicles their developments. Section 5 describes shifts in the regional structures, and Sect. 6 concludes.

2 A Short History of Innovation Activity in Germany

At the end of the nineteenth century, Germany became one of the world's leading industrial powers, advancing in technological fields that were characteristic of the second industrial revolution, such as chemicals, pharmaceuticals, automobiles, and electricity (Grupp et al. 2002). The country

[1] A disadvantage of patents is that they represent only the first stage of the innovation process. Therefore, one does not know if, when, or how an invention is applied in a new process or product (Feldman and Kogler 2010). Another critical issue is that not all inventors and firms use patents to protect their intellectual property (Cohen et al. 2000; Blind et al. 2006). Hence, not all inventions are patented. Moreover, some inventors obtain multiple related patents for basically the same invention to block follow-up patents from rivals.

lost its leading position during the Nazi era with the expulsion of Jewish scientists (e.g., Waldinger 2012) and the devastation of WWII, which led to its separation into a communist East German state that was integrated into the Communist Bloc (the German Democratic Republic, GDR) and a Western-style capitalist market economy in the West (the Federal Republic of Germany, FRG), both founded in the year 1949.

In contrast to West Germany, East Germany, which came under Soviet occupation after WWII, faced substantial dismantling of industrial and innovative structures that were largely relocated to the Soviet Union (Ritschl and Vonyó 2014; Steiner 2010). The innovative potential of the GDR also massively declined because many innovative firms relocated from the East to the West in order to escape the communist regime. Likewise, East Germany experienced a considerable exodus of population, particularly of well-qualified and entrepreneurial-minded people, up until the closure of its western border in August 1961 (Ritschl 2010; Falck et al. 2013; Ritschl and Vonyó 2014; Becker et al. 2020).

The Soviet-style innovation system established in the GDR proved relatively inefficient (Mayntz 1998; Radosevic 1998; Kotz et al. 2002; Augustine 2007). A main deficiency of this system was that research and development (R&D) activities were organized according to a linear model of innovation that is particularly inattentive to feedback loops (for a schematic overview of actors and linkages, see Meske 1993). As a result of this rigid organization, the GDR innovation system failed to adapt its industrial and innovative capacities to global developments such as the oil crises of the 1970s (Blum and Dudley 2000). Another obstacle to innovation activities faced by the GDR was the closed border to the technologically more-advanced West, which hindered connections to global knowledge flows (Grupp et al. 2002). Moreover, the Western countries introduced an embargo on the Eastern Bloc for the export of innovative goods, which hampered these countries' access to modern Western technology.

The communist East German regime collapsed quickly and unexpectedly after the fall of the Berlin Wall in November 1989. In July 1990, the two German states introduced a currency union, followed by formal reunification in early October, whereby the formal institutional framework of West Germany was transferred to East Germany practically overnight (Brezinski and Fritsch 1995; Hall and Ludwig 1995). This sudden shock transition in East Germany involved a massive decline in the industrial sector. Many formerly state-owned enterprises could not compete effectively and were shut down (Burda and Hunt 2001). Only a few viable firms

survived (Mergele et al. 2020), sometimes as extended workbenches of West German and international companies, without any significant individual innovation activities. Most large state-owned enterprises were split off and transformed into unrelated small and medium-sized firms (e.g., Radosevic 2022).

Since the beginning of the transformation process in 1990, there has been a persistent East–West gap in innovation activities. Despite massive subsidies for private sector R&D activity and considerable investment in universities and public research institutes, the average level of innovation activity in East Germany is consistently lower and less productive than in West Germany (Fritsch and Slavtchev 2011; Rammer et al. 2020).

3 Patenting Activity Before, During, and After German Separation, 1877–2015

Our basic approach to identifying the effect of 40 years of the East German socialist regime is to compare patenting activity before WWII and after reunification. In our assessment, we assign every patent to a labor market region that is defined by NUTS3 codes (BBSR 2019), each representing a functionally integrated spatial unit based on commuting patterns. We exclude Berlin from our analysis because, both in the period before separation and after, various factors render it impossible to distinguish between East and West.[2]

Figure 4.1 presents patenting intensity in East and West Germany as the number of patents per 10,000 population before the separation in the period 1877–1945, in the years 1980–90, and post-unification from 1991 to 2014. Peculiarities of the East German patenting system under socialism hamper a direct comparison of patent data with the FRG. The main issue is that inventors in the socialist regime did not have to pay a registration fee, as was the case in West Germany, but rather received a financial reward for filing a patent. As a result, the number of patents filed by East

[2] Berlin was divided into four occupation zones, and only the Soviet-occupied part, East Berlin, belonged to the GDR. The other three occupation zones in Berlin (i.e., West Berlin) were given a special status and were closely linked to the FRG, both economically and politically. There are no reliable separate statistics for the economic situation in East and West Berlin since German unification in 1990, nor would such statistics be meaningful given the extensive integration of both parts. Berlin is therefore excluded in the empirical analyses. We also omit the Saarland region because it was not in the data from 1920–35, when the League of Nations managed the area.

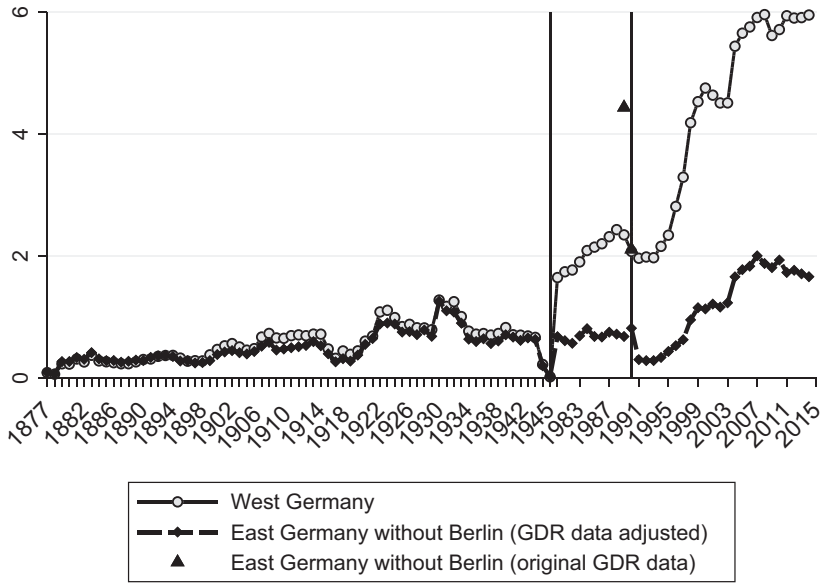

Fig. 4.1 Average number of patent applications per 10,000 population. Notes: The data for the pre-WWII period (1877–1945) and 1980–2014 for West Germany, as well as 1991–2014 for East Germany, are from PatentCity (Bergeaud and Verluise 2022). Vertical lines indicate the period of separation (1945–90). Data for East Germany between 1980 and 1990 is an adjusted measure based on Rassenfosse et al. (2019). Direct comparison between East and West Germany during the separation is not possible due to distinct systems of rewards and incentives. The non-adjusted number of East German patents in the year 1989 is taken from Hipp et al. (2023)

German inventors per 10,000 population was considerably larger than the number of patents filed by their West German counterparts.[3] In order to make the patents in East and West during the GDR period comparable, we calculate an adjusted number of GDR patents. Based on the assumption of a similar ratio between international and national-only patents in both

[3] While the share of national-only patents was rather high, the share of international GDR patents was much lower than in the West. Since we have no information about the residence of the inventors for GDR patents before 1989, we cannot omit international patents and patents of inventors with residence in East Berlin like in the other years.

parts of the country, we estimate the adjusted number of East German patents using the number of international patents.[4]

Figure 4.1 suggests that patenting intensity during the pre-separation years was very similar in the two parts of the country. Based on the adjusted number of East German patents, patenting activity in West Germany during the 1980s was much higher. However, the unadjusted number of patents per 10,000 population was considerably higher in the GDR.

In 1991, the first year for which directly comparable data exist, we find only 0.31 patents per 10,000 population in East Germany, which is only 14.5% of the respective value for West Germany (2.14 patents per 10,000 population). Given that there was no significant East–West difference in patenting activity before the German separation, this difference indicates a rather pronounced negative impact of socialism on inventive activity.[5]

German reunification led to a radical reorganization of the East German innovation system. There was a sharp decline in East German patenting activity in the first years after reunification compared to the level in 1989/90. It is interesting that there was a negative trend in innovation activity in West Germany in 1989 and 1990, just before German reunification. Starting in the mid-1990s, however, patenting activity increased in both parts of the country, but because the increase of patenting intensity was considerably stronger in the West, the ongoing integration of the two innovation systems did not lead to convergence, especially in the second part of the 1990s. Starting in 2008, East German patenting intensity slightly declined, while increases continued in the West.

Overall, the strong increase in patenting activity in West Germany suggests that the West was able to benefit significantly more from the integration of the two innovation systems than the East. At the end of our observation period in 2014, the East–West gap of patenting intensity amounted to about 4.3 patents per 10,000 population. This is four times larger than the difference that was found at the end of the socialist period in 1991. This process of divergence is rather remarkable given the high level of public support such as financial subsidies for innovation activity in the East.

[4] Had the share of international patents in the GDR mimicked that seen in the FRG, the average number of patent applications per 10,000 population in the GDR would have been 0.60 in 1989, much lower than the respective value of 2.75 for the FRG. Simultaneously, the original (non-adjusted) number of patents registered at the GDR patent office was about 4 patents per 10,000 population (see Fig. 4.1).

[5] A multivariate difference-in-difference analysis that accounts for a number of regional determinants of innovation behavior confirms the magnitude of this effect; see Fritsch et al. (2023a).

4 Technological Shifts of Inventive Activity in Germany over Time

Comparing the technological composition of inventive activity in East and West Germany at the end of the socialist period in the year 1989,[6] we find a rather high level of similarity.[7] The correlation coefficient for the shares of patents in all IPC classes in the East and West in the year 1989 was about 0.6. Figure 4.2 illustrates this correspondence by showing the share of patents in the top 15 technological fields in East Germany and the respective share for West Germany.[8]

There are at least two reasons for this high level of similarity after more than 40 years of separation. First, in the pre-separation period, East and West Germany constituted an integrated innovation system with a common technological profile. Second, GDR political leadership pushed scientists and engineers to catch up with technological developments in Western countries, particularly in West Germany (Steiner 2010), resulting in research activities in corresponding technological fields.

The rather high similarity of technological profiles between East and West at the end of the socialist period can be attributed to a process of consolidation (*Flurbereinigung*), which was carried out largely at the expense of innovation activities in the East. In this consolidation process, West German research projects that were generally more advanced frequently outcompeted their East German counterparts (Grupp et al. 2002). This led to a growing East–West difference in patenting, particularly in

[6] Unfortunately, the available patent data for the time before WWII do not include information on the technological classification of an invention. For the technological profile of West Germany in 1989, we use RegPat data because the geocoded data by Rassenfosse et al. (2019) do not include information on the technology class of patents. For East Germany, we use data provided by Hipp et al. (2023) that encompasses the entire universe of granted patents in the GDR. We exclude foreign patents that were registered in the GDR because our focus is on the technological profile of East German inventors. For calculation of the technological profile in 2014, we use RegPat for both East and West Germany.

[7] The unit of analysis is IPC class ($N = 743$). Each IPC class is allocated to a specific technological field ($N = 35$) following Schmoch (2008).

[8] For both years, the technological fields are sorted according to the ranking for East Germany. There is hardly any technological field that is not in the top 15 in both East and West Germany.

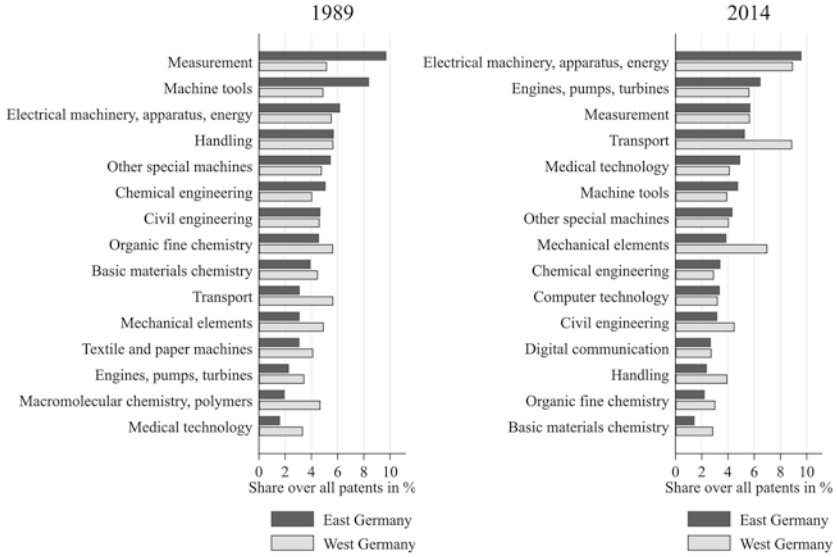

Fig. 4.2 Top 15 technological fields by the share over all patents (in %) in East and West Germany, 1989 and 2014

those technological fields where East and West Germany were both specialized in 1989, and hence implied a slight reduction of technological similarity. Since detailed analysis reveals that this consolidation process was largely completed in the first few years after the transition (Fritsch et al. 2023a), it can hardly contribute to explaining the increasing East–West gap in patenting that we see in the long term (Sect. 3).

From the mid-1990s onward, we see an increasing similarity of technological profiles of inventive activity in East and West Germany, such that the correlation coefficient for the shares of patents in all IPC classes increased even further, exceeding 0.7 in 2014. This increasing similarity of technological profiles was mainly due to the increase in patenting by East German inventors in technological fields that were quite common in West Germany but largely absent in the socialist system (for a more detailed analysis, see Fritsch et al. 2023a). The lack of East German experience in these technological fields may explain lower levels of patenting and the difficulties East Germany faced in catching up to West Germany. At the

same time, there were relatively few technologies where only East Germany specialized, making it hard to compensate for falling behind in technologies where West Germany had historically gained efficiency advantages.

5 Regional Shifts in Inventive Activity in Germany After WWII and German Reunification

German separation into a capitalist state and a socialist state after WWII, as well as the transformation process that began with reunification, led to extensive changes in the country's geographic innovation landscape. Figure 4.3 shows the number of patents per 10,000 population across German regions in the year 1938, just months before the outbreak of WWII. At that time, patenting activity in East and West Germany was generally at fairly similar levels, with highly innovative regions widely spread over the country. Eastern regions with relatively low levels of inventive activity were concentrated in the north of Berlin, while many low-patenting regions in the West were in its southeast (Bavaria). Regions with particularly high levels of patenting were Berlin, the southern part of East Germany, the region of Cologne, and larger areas in the southwest (Baden-Württemberg). At that time, the East German region of South Saxony around Dresden and Chemnitz was one of the most industrially advanced regions in Germany and even across Europe (Gutberlet 2014).

After WWII, the former German territories east of the rivers Neisse and Oder became part of Poland and the Soviet Union, and 14 million people were expelled and had to be integrated into the two newly emerging German states, the FRG and the GDR. At the same time, about 25% of the East German population emigrated from the GDR to the FRG until the closing of the border in 1961. These massive territorial changes and population movements implied a reorganization of regional economic structures. For example, about 9–13% of all East German firms—especially from the south of East Germany (particularly Saxony and Thuringia)—relocated to West Germany, particularly to Baden-Württemberg and Bavaria (e.g., Hefele 1998; Falck et al. 2013). This exodus included a number of well-known large firms, such as car manufacturers Audi and BMW as well as the Siemens company, and contributed to reshaping the local industrial structures in both parts of the country.[9]

Another factor was that the GDR government implemented several large-scale spatial policy projects that had a strong impact on the industrial

[9] For examples from the machine-tool manufacturing industry, see Falck et al. (2013).

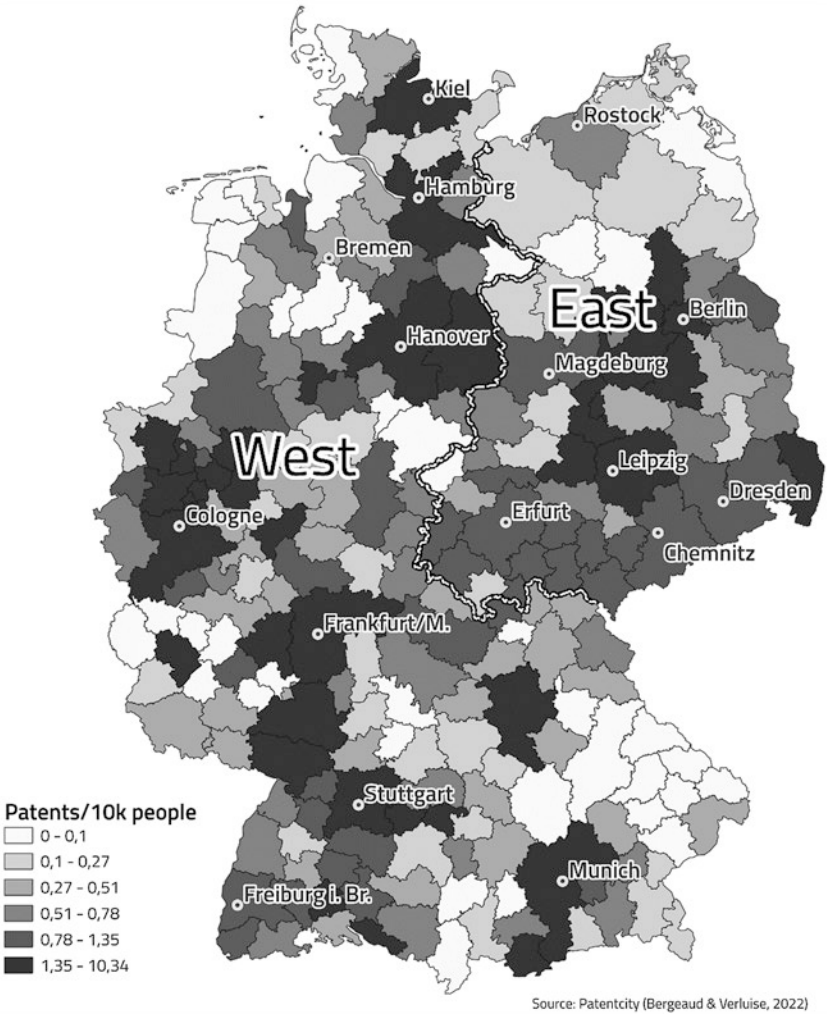

Fig. 4.3 Patents per 10,000 population, 1938. Notes: Solid borders outline the former GDR territories. Patents are assigned to regions according to the location of the applicant. Source: PatentCity (Bergeaud and Verluise 2022)

landscape of the East. One important building block of this policy in the GDR was to promote the industrialization of regions in the north that were heavily reliant on agriculture. Two famous examples are the creation

of a large steel complex in Eisenhüttenstadt and a petrochemical complex in Schwedt, two peripheral cities in the north lacking any industrial tradition. Berentsen (1981) vividly describes these cases and argues that the GDR intended to industrialize the northern regions in order to reduce regional disparities.

An exemplary case for this policy is the region of Mecklenburg, where in 1925 almost half of the population worked in agriculture, compared to only about 10% in South Saxony (Fritsch et al. 2023b). The share of the workforce employed in agriculture in Mecklenburg decreased to about 20% between the mid-1950s and 1990. At the same time, the share of manufacturing employment rose from 13% to about 23%. A good share of manufacturing employment was in the shipbuilding industry, which was developed from scratch because the previous centers of German shipbuilding on the coast of the Baltic Sea became part of Poland after WWII (for details, see Mohs et al. 1984; Mieck 2009).

Other prominent examples of massive investments into new production plants include chemical manufacturing, lignite coal mining, and energy production in the Halle-Leipzig-Dessau triangle, and industrial agglomerations in South Saxony that built on the industrial heritage of the time before WWII.

Figures 4.4a and b display the regional structure of patenting intensity in the year 1989, just before the East German socialist regime collapsed. We show separate maps for East and West Germany because comparisons of patent numbers between the two parts are confounded by the much stronger incentives for filing a patent in the GDR system, which resulted in significantly higher numbers of patent applications there (see Sect. 3). Compared to the regional structure of the year 1938 (Fig. 4.3), some regions in the north of East Germany, particularly those on the coast of the Baltic Sea, had significantly increased their level of inventive activity, while the high level of patenting in the regions south of Berlin remained steady (Fig. 4.4a). In West Germany, there was a shift of patenting activity from the Ruhr area and further north to the south, particularly to the region of Munich, which was not a center of innovative activity before WWII (Fig. 4.4b).

In 2014, about two and a half decades after the collapse of the GDR regime, we see a clear East–West gap in patenting (Fig. 4.5). Innovation activity in East Germany is concentrated in a few highly innovative "pockets of excellence," namely Berlin, Dresden, and Jena. All other East German regions perform relatively poorly. Quite remarkably, all three

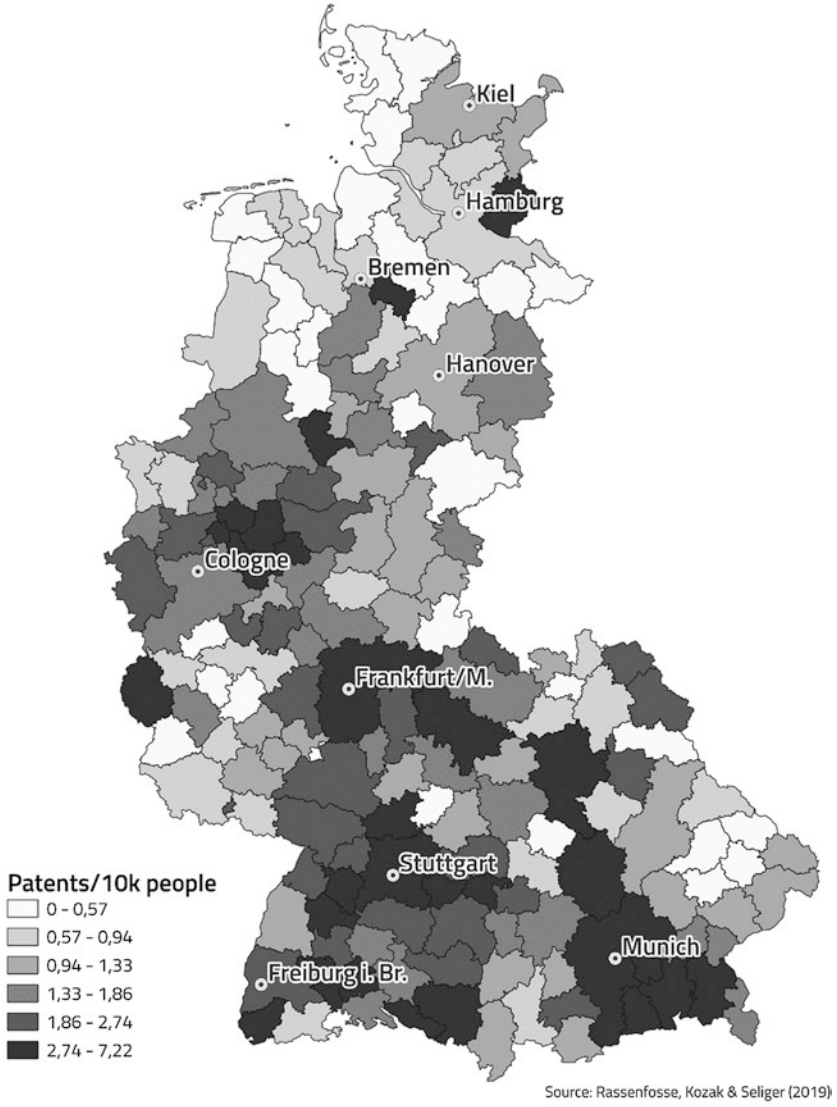

Fig. 4.4 (**a**) Patents per 10,000 population, 1989—West Germany. Notes: Patents are assigned to regions according to the residence of the inventor. Source: Rassenfosse et al. (2019). (**b**) Patents per 10,000 population, 1989—East Germany (GDR). Notes: Patents are assigned to regions according to the location of the applicant. Source: Hipp et al. (2023)

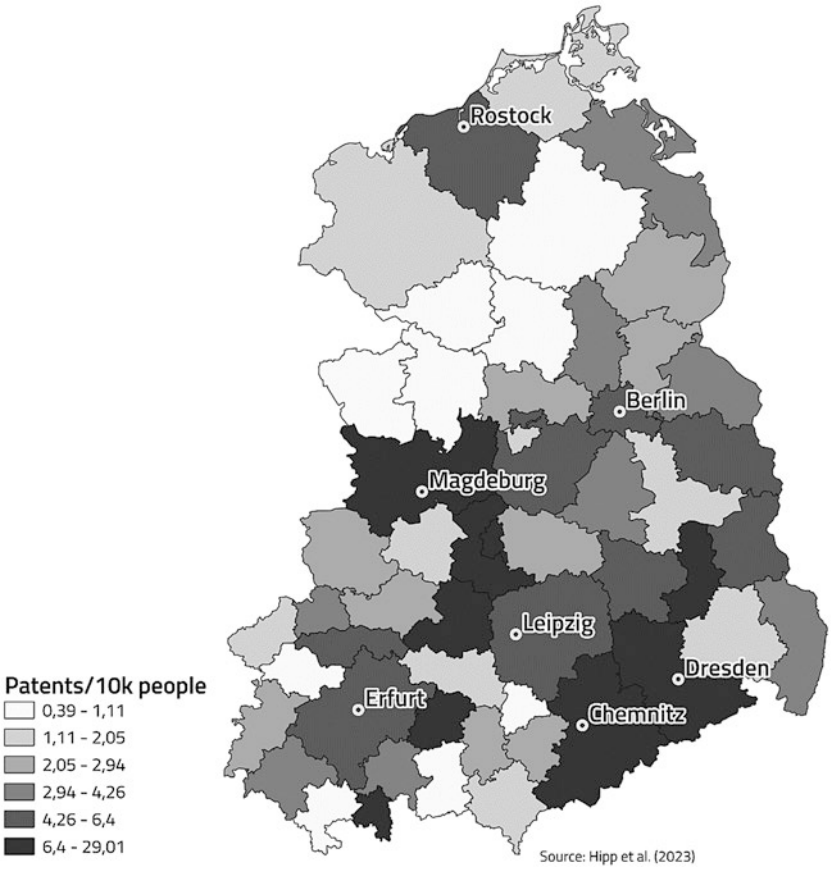

Fig. 4.4 (continued)

regional hot spots of innovation activity in East Germany were already innovation centers before WWII. It is also noteworthy that particularly Dresden and Jena represent "cathedrals in the desert," where innovation activity is not significantly connected to the surrounding area and creates geographic spillover effects (Fritsch and Graf 2011). Altogether, comparing the regional structures of patenting activity before WWII (1938), at the end of the socialist regime (1989), and in the year 2014 reveals pronounced traces of the socialist regime and of reunification.

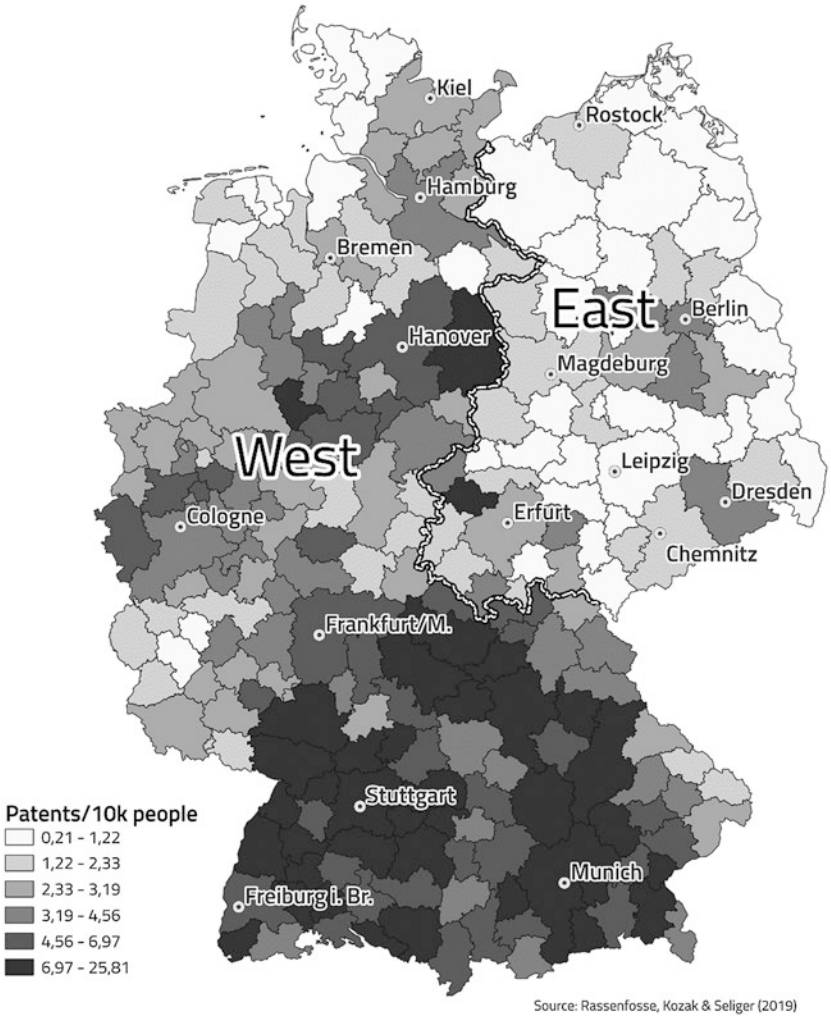

Fig. 4.5 Patents per 10,000 population, 2014. Notes: Solid borders outline the former GDR territories. Patents are assigned to regions according to the residence of the inventor. Source: Rassenfosse et al. (2019)

6 Conclusions

Investigating the development of patenting activity in Germany from the time before WWII until the year 2014, we find that the 40 years of separation into a capitalist West and a socialist East resulted in significant East–West disparities due to the socialist "treatment" of the East. The reunification of both German states in 1990 and the corresponding integration of the two innovation systems led to increasing levels of innovation activity in both parts of the country up until the mid-2000s. It is nevertheless remarkable that this increase was considerably stronger and more sustained in the West. This indicates that the West German innovation system benefited more from the unification than innovation activities in the East. As a result of these developments, there is increasing divergence in innovation activities in the post-reunification period, with the East falling increasingly behind.

There are several possible explanations for the relatively poor performance of the East German innovation system after reunification. First, during the separation and at the end of the socialist period, the technological profiles of the East and West German innovation systems were highly similar. A main source of this similarity is the common history of East and West Germany as an integrated innovation system in the pre-separation period. Another reason is that the GDR leadership pushed scientists and engineers to catch up with technological developments in Western countries, using West Germany in particular as a benchmark.[10] Because West German research was generally more advanced than that in East Germany, the similarity between their respective technological fields meant that, in most cases, West German R&D projects outcompeted their East German counterparts. Hence, the consolidation of research capacities after reunification was mostly at the expense of East German actors (Fritsch et al. 2023a).

Second, the pronounced migration of East German scientists and engineers to West Germany that took place during the consolidation process in the first few years after reunification may have reinforced specialization

[10] A prime example of this is the case of the Carl Zeiss company, a world-leading producer of optical instruments since the nineteenth century. After WWII, this company split into an East German and West German firm. After 40 years of separation into a socialist and a market-oriented environment, Kogut and Zander (2000) show that the technological profiles of both firms remained very similar.

and scaling advantages of innovation activities in West Germany and severely weakened innovation activity in the East (Dorner et al. 2016).

Third, the turbulence caused by the radical restructuring of the GDR innovation system destroyed many established links among actors and hampered the establishment of the trustful relationships necessary for the effective division of innovative labor. Considerable time was also required for the rebuilding of the public administration, the radical reform of the system of higher education, and the reorganization of extra-university public research. It also took quite some time for the institutions of education and research in both parts of the country to become sufficiently integrated. This resulted in a prolonged period during which innovation activity in East Germany suffered from a lower level of "systemness," that is, a lower level of relational embeddedness and mutual interplay of its political, economic, technological, and cultural systems.

Finally, after 1990, a large part of East German patenting shifted toward technological fields where West Germany had considerably more extensive experience. This specialization may have implied a continuous and growing efficiency advantage contributing to the widening East–West gap in the level of patenting.

Although the empirical evidence clearly suggests that the consolidation of innovation activities, as well as the net migration of R&D personnel from East to West, was largely completed within the first few years after reunification, it is hard to overstate the significance of these two developments in explaining the growing distance between innovation activities in East and West Germany. Moreover, it may require a considerable period of time for the East German innovation system to recover from the radical shock transformation and show the same level of systemness as its long-established West German counterpart (Ruhrmann et al. 2022). It is rather remarkable that the massive financial support for innovation activities in East Germany over the last decades has not been able to prevent innovation in East Germany from falling further behind.

Another reason for the lag in East German innovation activity—one frequently cited in the political debate—is that the economy in this part of the country mainly consists of small and medium-sized companies, with only a few large companies as an exception. This argument has some justification, given that large companies often perform important functions in innovation systems as gatekeepers and brokers (Agrawal and Cockburn 2003; Graf 2011). However, it can also be argued that the small-firm structure of the East German economy is a symptom of low economic

performance, ultimately due to the insufficient success of innovation efforts. The dominance of small-scale firms as an explanation for the lag in East German patenting also fails to account for the tendency of smaller firms to file a greater number of patents per unit of R&D input (Cohen and Klepper 1996).

In considering the importance of an effective innovation system for regional development, our analyses yield some important implications for policymakers. First, our findings shed light on the problems related to a disruptive and radical shock transformation of a socialist innovation system into a market-based system. The German example demonstrates that sudden exposure to global competition, combined with a radical reconstruction of institutional structures, may result in long-term low innovation performance. Even massive policy support with high subsidies for innovation activities could not prevent the widening East–West gap regarding innovation activities.[11]

A further important policy implication of our analysis—one that holds independent of the actual transformation strategy applied—concerns the technological profile. The example of East Germany makes it very clear that a country and region need to develop specific technological competencies to avoid being outcompeted. This is particularly relevant in the context of increasing globalization and interaction among different types of innovation systems. Hence, policy should aim to develop specific knowledge and capabilities to remain competitive and successfully participate in the international division of labor.

There are several limitations to our analyses which provide avenues for further research. Despite finding that technological similarity between East and West Germany explains the development of East–West differences in patenting after 1990, there is room for investigating the underlying mechanisms of this process in greater detail. A further limitation follows from the well-known weaknesses of patents as indicators of innovation activity (Griliches 1990; Nagaoka et al. 2010). Hence, we do not know if our results hold for innovation processes unrelated to patenting, such as the adoption and implementation of new technology. Another open question concerns the effects of the knowledge transfer from the

[11] This failure casts doubt on hopes for a quick recovery from radical transformation processes. Other former socialist transformation countries implemented strategies that led to much more gradual changes. We are, however, not aware of great improvements in innovation performance in any of these cases (Meske 2004; Radosevic 1998, 2022).

West to the East and the rather generous financial support of East German innovation activities since unification. What was the impact of the public promotion policies, and why were such measures insufficient for preventing an East–West divergence?

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