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Resilience and specialization – How German regions weathered the Great Recession

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Abstract: This paper takes an explorative approach for analyzing the economic development of German Spatial Planning Regions during and after the Great Recession covering the period from 2007 to 2017. Specifically, we are interested in the relation between the short- and the mid-term resilience of regions and in the role of the underlying economic structure in this regard. For this purpose, we categorize regions by their GDP per capita growth in the resistance and recovery phase and then characterize the resulting region types by their average structural characteristics and track their performance through the renewal and reorientation phase.

Our analysis reveals that, in general, larger shares of manufacturing, higher degrees of export orientation and specialization, and lower shares of public sector services are associated with weaker resilience and stronger recovery capacity. In addition, we observe a catch-up effect of regions with at least either an above-average resistance or recovery compared to regions with both weak resistance and slow recovery. However, we do not find a substantial reorientation effect because, in the case of Germany, the advantages of regional economic specialization still outweigh its potential disadvantages.

Keywords: regional economic resilience, Great Recession, German regions, resistance, recovery, renewal, reorientation, competitiveness, regional disparities

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1 Introduction

Modern economic history is also a history of shock-induced disturbances and recessions (Claessens et al. 2009, Kindleberger 2001, Plumpe 2012). In this paper, we focus on the economic turbulences caused by the Great Recession of 2008–09. Until the outbreak of the COVID-19 recession, the Great Recession had ranked as the by far biggest global economic downturn of the post-war period. From 2008 to 2009, the European Union and the Euro area suffered a real GDP decline of 4.3 respectively 4.5 percent, while the real GDP of Germany dropped by even 5.6 percent (World Bank 2020). In comparison to the other EU-15 countries, however, Germany not only stands out with its strong decrease in GDP but also with its equally strong recovery – restoring its pre-crisis GDP level only two years after its low (World Bank 2019). An important reason for the quick recovery is seen in the stabilizing countercyclical policy measures, whose implementation was favored, among other things, by Germany's relatively low debt ratio before the crisis (Cerra et al. 2013, Hubbart 2012, Hundt & Holtermann 2020, Rinne & Zimmermann 2012).

At the subnational level, however, the course of the crisis was by no means homogeneous. As we will show in detail later, the intensity of the GDP decline varied greatly between German regions, ranging from a maximum decline of 11 % to no decline at all. Likewise, the following recovery was strong and fast in some regions while being slow and lengthy in others. To describe and examine these heterogeneous patterns, this paper employs the concept of regional economic resilience. The concept allows capturing a region's direct response to the shock as well as medium-term changes in its economic performance and structure after the shock.

Despite the high relevance of the topic, so far only a few studies have empirically examined the resilience of German regions. Furthermore, a weakness of these studies is that they either only focus on short-term resilience (e. g., Jakubowski et al. 2013, Pudelko et al. 2018, Reiner 2010) or do not cover the total of German regions but only selected case studies (e. g., Plöger & Lang 2013, Schade et al. 2021, Wink et al. 2016). The results of resilience studies from other countries, on the other hand, can be transferred to Germany only to a limited extent, mainly

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due to differences regarding the institutional setting and the prevailing industry structures. Examples include Di Caro (2015), Martin et al. (2016), Giannakis & Bruggeman (2017), and Angulo et al. (2018) who respectively investigate the resilience of Italian, British, Greek, and Spanish regions. Our study addresses this research gap and thus scrutinizes both the short- and medium-term effects of the Great Recession on all German regions.

The industry structure is widely regarded as a key determinant of regional economic resilience (e. g., Martin & Sunley 2015). Our paper builds on this insight and applies it to a prominent feature of the German economy, namely its specialization in manufacturing industries. In line with our overall goal, we examine the role of this specific specialization not only for the resistance and recovery of regions but also for their post-shock economic development. At the same time, we inspect if the Great Recession has triggered significant changes in the regional and national industry structure. This can provide information as to whether German regions could improve their resilience after overcoming the 2009 shock.

The remainder of our paper is organized as follows. Section 2 introduces the key components of resilience theory and describes the linkages between resilience, regional development, and economic specialization. Section 3 establishes the analytical tools to measure resilience phases and characteristics of the industry structure. Section 4 examines the spatially uneven impact of the shock. Here, we assess the resistance and recovery of regions and, in a second step, examine the economic renewal and the extent of economic reorientation of regions after the shock. Section 5 eventually discusses the central findings of the paper and concludes with a critical reflection.

2 Resilience, regional development, and economic specialization

Belonging to the large group of approaches that seek to explain regional economic development, resilience is an attempt to understand the complex reaction of regional economies to external shocks. Martin and Sunley (2015) refer to the latter as "sudden, unexpected and 'out-of-the-ordinary'" – three criteria that accurately describe the demand shock that triggered the recession of 2008–09. The better the regional economy can withstand the impact of the shock, the higher its resilience.

In his state-of-the-art conceptual framework, Martin (2012) divides resilience into four different dimensions, which he refers to as resistance, recovery, renewal, and reorientation. Resistance and recovery together form short-term resilience. Resistance describes the capacity of a region to withstand external shocks and keep the negative impact of the shock as small as possible. Recovery, on the other hand, describes the region's capacity to restore its pre-crisis output level as quickly and completely as possible. If successful, the recovery phase is usually characterized by above-average growth rates, which are a result of the 'bounce-back' of the regional economy as soon as the direct impact of the shock diminishes (see also Friedman 1993).

After the recovery phase, the region can pursue its pre-crisis growth path again. However, the impact of the shock may cause structural changes, for example in the regional industry structure, which can lead to a transformation of the region's growth path – towards a higher or lower growth rate. This medium- to long-term influence of the shock is observed in two dimensions (Martin 2012): Firstly, by the renewal dimension, which covers the degree to which regions re-establish their old growth path or move to a new growth path, and, secondly, by the reorientation dimension, which departs from the growth path perspective towards a structural perspective: It covers to which extent regions adapt their economic structure as a result of the shock.

The concept of resilience is a building block for improving our understanding of regional economic development in general. As stated above, resilience deals with a short-term exceptional economic situation, but one that potentially influences long-term regional development. This link is also emphasized by Martin and Sunley (2015) who suggest that a region's performance during resistance and recovery is likely to directly influence both its post-crisis growth trajectory (renewal) and the extent of structural adjustments (reorientation). In particular, Martin and Sunley highlight the possibility that major shocks can either increase or decrease the magnitude of regional differences in GDP per capita over time and, in this way, alter the patterns of long-term economic development within and between regions.

It becomes clear that the four dimensions are not equally specific to the resilience approach. While resistance and recovery form the core of the concept, renewal and reorientation are more in the realm of general growth and development considerations. Nevertheless, the connection is relatively close, so it is not surprising that Di Caro and Fratesi (2018) presume that those factors that help explain economic growth in general are also among the

main determinants of regional economic resilience. These factors include, as Fratesi and Rodrìguez-Pose (2016) indicate, innovativeness, human capital, and agglomeration economies. Findings by Hundt and Holtermann (2020) and Holtermann et al. (2020), however, specify that the Di Caro-Fratesi statement applies to the recovery and renewal phase, but not necessarily to the resistance phase, where otherwise effective growth factors can either have no influence or even exhibit growth-reducing effects.

Yet, there is great agreement that the regional industrial structure is one of the most influential determinants of both regional economic resilience and regional economic growth in general (for respective overviews see Martin & Sunley 2015 and Buchholz & Barthelt 2021). One of the most relevant features in this regard is the extent of regional economic specialization. The growth-enhancing effects of specialization stem from localization advantages, or more precisely, from MAR externalities. MAR externalities, as established by Marshall (1890), Arrow (1962), and Romer (1986), originate from localization advantages that include labor market pooling, specialized suppliers, and technological knowledge spillovers. Their importance for clustering and regional economic development is also emphasized in more recent theories, for example in the concept of 'new industrial spaces' (Scott 1988), the closely related 'industrial districts' (Sforzi 1989), and the early models of the New Economic Geography (Krugman 1991).

However, empirical studies suggest that the expected externalities of specialization mainly translate into higher productivity (e. g., Cingano & Schivardi 2004, Henderson et al. 1995), while growth in terms of employment is rather encouraged by opposite patterns, i. e., diversity and Jacobs externalities (e. g., Combes et al. 2000, Glaeser et al. 1992, Jacobs 1969). However, not only the effects of specialization as such but also the temporal occurrence of these effects is complex. An example is provided by the cluster life cycle concept, where Menzel and Fornahl (2010) locate the beneficial effects of increasing (knowledge) specialization primarily in the growth and sustainment phase of clusters. In the potentially final stage of the life cycle, however, a high degree of specialization can have a negative impact as it carries the risk of lock-in, but even then, specialized clusters and regions can avert the resulting decline as long as they maintain or keep renewing their competitiveness (e. g., Porter 2008).

As regards resilience, specialization has further implications. Assuming that a regional economy is dominated by just one or only a few big sectors, a sector-specific shock can rapidly affect great parts of the economy and thus trigger a quick and region-wide downturn (Kemeny & Storper 2014, Martin & Sunley 2015). On the other hand, specialization not only increases the risk of vulnerability but can also accelerate recovery once the targeted sales markets recover and MAR externalities can take effect again (Pudelko et al. 2018).

If specialization is attributable to the manufacturing sector, the shock-induced fluctuations of specialized regions and clusters are likely to be enhanced (Pudelko et al. 2018). An important reason for this is the cyclical sensitivity of many manufacturing industries as investments and expenditures for long-term capital and durable consumer goods tend to be postponed during times of uncertainty until economic prospects improve again (e. g., Peterson & Strongin 1996). We emphasize this aspect because specialization in manufacturing industries is a prominent feature of the German economy. After all, the manufacturing sector in Germany accounts for a share of more than 24 percent in total employment, which represents the by far highest value among the EU-15 countries (Federal Statistical Office 2020a, Eurofound 2019). Of course, a high manufacturing share does not automatically equate to high specialization, but as we will demonstrate later in this paper, the high specialization of German regions can often be attributed to the strong presence of manufacturing industries.

As specialization in manufacturing tends to increase the necessity to sell the produced goods on international markets, it comes as no surprise that the German industry is also very export-oriented (Federal Ministry of Economics and Energy 2020). As regards resilience, being export-oriented might reinforce the effects of being specialized: The more the regional economic system depends on the demand of external consumers, the more affected it will be if these consumers suddenly drop out. In contrast, a versatile bunch of international trade relations can help replace the dropped out by new customers quickly and thereby contribute to a faster recovery. A similar effect can be expected if the drop in demand is only temporary, and the pre-crisis trade relations remain mostly intact.

It follows from the above that the industrial focus of regional specialization matters. While manufacturing and export-oriented industries are highly sensitive to external shocks, private service industries are less sensitive, followed by public sector services, which are barely influenced by external shocks at all (Martin 2012). The above-discussed resilience effects of specialization, therefore, apply primarily to specialization in the manufacturing sector (Pudelko et al. 2018). In contrast, specialization in public sector services can lead to reverse effects, that is to higher resistance, followed by a less dynamic recovery. This paper also takes a closer look at the diversity *within* the manufacturing sector to identify which specific manufacturing industries specialization refers to.

3 Measuring resilience capacities and regional industry structure

This paper takes an explorative approach towards analyzing the economic development of German Spatial Planning Regions[1] during and after the Great Recession covering the period from 2007 to 2017. Specifically, we are interested in the relation between the short- and medium-term resilience of regions and in the role of the underlying economic structure in this regard. For this purpose, we categorize regions by their GDP per capita performance during the resistance and recovery phase and then characterize the resulting region types by their average structural characteristics and track their performance through the renewal and reorientation phase.

3.1 Short-term resilience and region types

Within the period from 2007 to 2012, we calculate the duration of the resistance and recovery phase for each region individually, following the example of Pudelko et al. (2018) and Hundt & Holtermann (2020). Consequently, we assign an individual pre-crisis, low point, and post-crisis year to each region, with the low point marking the transition between the two successive phases. An alternative approach would be to use fixed intervals for each phase that are deduced from the cyclical development at the national level and apply them to all regions (see, e. g., Faggian et al. 2018). However, using national time points (2008 as the pre-crisis-year – 2009 as the low point – 2011 as the post-crisis year) would underestimate the impact of the shock in regions that already started to decline in 2008. Also, it would overestimate the recovery of regions that were able to recover in 2010.

In line with Martin (2012) and Pudelko et al. (2018), we define resistance as the 'degree of sensitivity' which is measured by the GDP per capita decline from a region's pre-crisis year to the respective regional low point (see index (1)). The calculation of recovery performance is similar but additionally takes the duration of this phase into account. Hence, we compute regional recovery as the average annual GDP per capita growth from the region's low point to the year of recovery when the region has successfully restored its pre-crisis output level (see index (2)). Since the end of the recovery phase is defined as the return to the pre-crisis output level and all (non-resistant) German regions recovered, a measurement of total regional recovery growth *without* the time component would simply reflect the regional contraction size in the resistance phase. Likewise, it would be too inaccurate to measure only the duration of the recovery phase, since we only have access to annual data.

$$(1)\quad Resistance\,Performance = \frac{GDP_l - GDP_p}{GDP_p}$$

with GDP = regional GDP per capita
p = regional pre-crisis year (last year with a positive growth rate before the downturn)
l = year of regional low, when min($GDP_{2008–2010}$)

$$(2)\quad Recovery\,Performance = \frac{1}{r-l} * \sum_{i=1}^{r-l}\left(\frac{GDP_{(l+i)} - GDP_{(l+i-1)}}{GDP_{(l+i-1)}}\right)$$

with GDP = regional GDP per capita
l = year of regional low, when min($GDP_{2008–2010}$)
r = year of regional recovery, when $GDP_r \geq GDP_p$

Based on the results of our calculations, we then group the regions into five different categories to get a better overview of the short-term regional resilience in Germany (also see Pudelko et al. 2018). The categories are based on the measured resistance and recovery performances, whereby regions with higher values than the average of all regions – excluding the resistant regions – are categorized as "high/strong" regions, while regions with lower values than the average are categorized as "low/weak" regions. This is done for the resistance and the recovery phase respectively so that we obtain the following five region types:

- low-resistance-strong-recovery regions
- high resistance-weak-recovery regions
- high-resistance-strong-recovery regions
- low-resistance-weak-recovery regions
- and, eventually, resistant regions – which show no shock-related decline in GDP per capita development at all.

However, the use of simple cut-off values comes with a problem: regions that are close to the mean have very similar GDP developments but can still be put in completely different categories. To solve this problem, we exclude regions that are within a half percentage point (based on the performance measures above) below or

1 Spatial planning regions consist of economic centers and more rural municipalities in their hinterlands. The center and its hinterland are economically linked by commuters who work in the center. A smaller-scale delineation that would treat rural locations as separate units of analysis would be less appropriate for our purposes, because potential spillover effects from the center to the surrounding area could not be automatically captured.

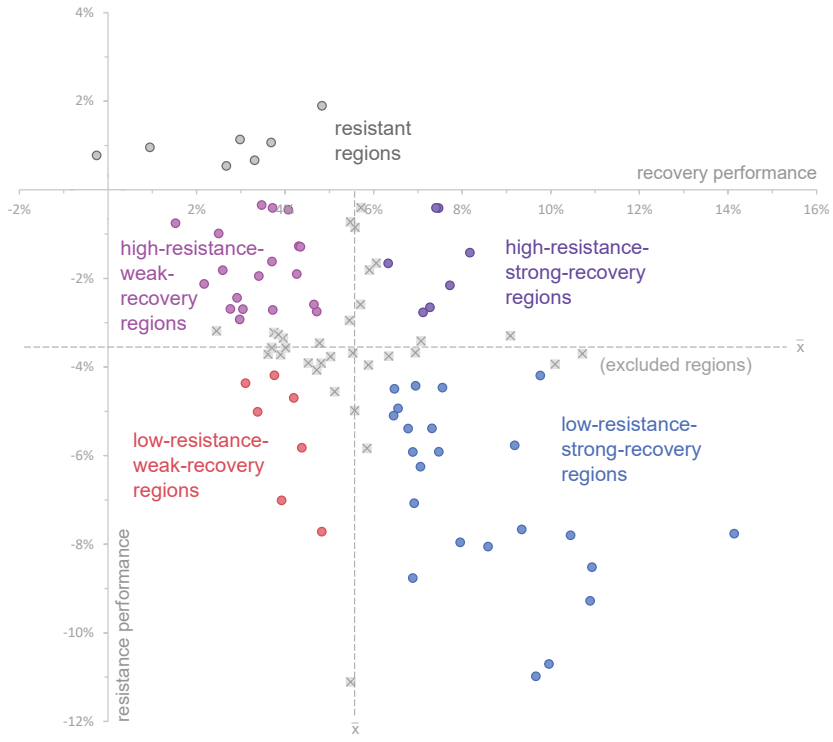

Figure 1: Resistance and recovery performance of German regions. **Data source:** INKAR 2020.

above the mean of resistance and recovery performance.[2] Regions that are average in one of the two phases are then removed from further analysis. Resistant regions are not excluded by this step, since they all have an above-average resistance performance, and a recovery phase is not defined for them. All in all, the above-described procedure reduces the number of regions to be studied from 96 to 63.

Figure 1 sorts the 96 regions according to their region type, that is, the regions are ordered by their resistance (y-axis) and recovery performance (x-axis) and are separated by the mean values of these performance measures. Regions that are within half a percentage point of the cut-off lines in Figure 1 are not included in the analysis. The dichotomous categorization helps identify the most fundamental differences in resilience performance between German regions quickly and reliably, which is why we accept the partial loss of information this entails.

3.2 Regional industry structure

To analyze the link between structural characteristics and resilience performance of German regions, we calculate the mean values of the regions' economic characteristics for each of the five resilience categories. Following our theoretical considerations from Section 2, we concentrate on variables that reflect Germany's relatively strong specialization in export-oriented manufacturing industries in the best possible way. Of course, this specific industrial imprint does not apply equally to all parts of Germany but shows regional variations instead.

Our variables include the extent of regional specialization and regional export orientation, as well as the shares of manufacturing and public service in the total regional labor force.[3] We use the Hirschman-Herfindahl-Index to measure regional specialization by the sectoral allocation of a region's workforce (see Index (3)). In addition, we use parts of the Krugman Specialization Index to gain better insight into the structural differences between the five region types (see Index (4)). The formula determines an index for the relative size of a given sector in region r in terms of employment, which provides information on the relative importance of sector s for region r *compared to all other Spatial Planning Regions*. A positive value of

2 Alternative calculations, such as a broader exclusion zone or an exclusion based on standard deviation, have confirmed the results.

3 At an earlier stage of the empirical setup, we also worked with the "related variety" concept (Frenken et al. 2007), but eventually abandoned it due to the paper's theoretical focus on "specialization." Moreover, the initial results on related variety suggested little additional insight.

this index indicates a relatively large sector, a negative value indicates a relatively small sector in comparison to all other regions. The index not only allows us to derive the relatively largest sectors in each region but also helps identify the industries to which manufacturing specialization in each region can be attributed. It should be kept in mind that the manufacturing industries are however not the absolute largest sectors by employment – which are in most regions the public sector services.

Regarding the export orientation of regions, we make use of a self-developed index that is computed as follows (see Index (5)): Firstly, we calculate the sectoral share of exports on all imports and production at the national level. These shares are multiplied by the regional employees in the respective sectors, which are then summed up at the regional level and lastly divided by the total number of all employees in the respective region. As the result, the indicator depicts the share of employees in a region that theoretically works in the production of export goods. This index allows us to depict the regional dependency on international markets, which is an important resilience indicator (see Section 2). Other existing indices either require regional sector-specific export data – which is not available to us – or do not use actual export data and are therefore not a direct measure of export-based dependency on international markets.

(3) Hirschman-Herfindahl-Index (HHI) for region r:

$$HHI_r = \sum_{s=1}^{88} i_{rs}^{\,2}$$

where i_{rs} denotes the employment share of sector s in region r:

$$i_{rs} = \frac{employees_{rs}}{employees_r}$$

(4) Relative sector size index (RSSI) of sector s in region r:

$$RSSI_{rs} = i_{rs} - \bar{i}_{-r,s}$$

where $\bar{i}_{-r,s}$ denotes the average share of sector s in all *other* 95 Spatial Planning Regions:

$$\bar{i}_{-r,s} = \frac{1}{95} \sum_{n \neq r} i_{ns}$$

(5) Export orientation (EO) of region r:

$$EO_r = \sum_{s=1}^{88} \left(employees_{rs} * \frac{exports_s}{production_s + imports_s} \right) / employees_r$$

where $employees_{rs}$ denote the number of employees in sector s in region r

All indices are calculated for 2007, 2013 and 2017 which allows the observation of potentially shock-induced changes in the economic structure of German regions. 2007 shows the structure prior to the Great Recession, while 2013 and 2017 respectively give insight in the situation shortly after the recovery and during the advanced stage of economic renewal and reorientation. All indicators are based on the employees paying mandatory social security contributions in Germany – subdivided into the different branches, following the two-digit level[4] of the European industry classification (NACE Rev. 2; see European Communities 2008).

4 The spatially uneven impact of the shock

4.1 The importance of economic structures for resistance and recovery

In this sub-section, we portray the five region types by chosen economic characteristics. In general, larger shares of manufacturing, higher degrees of export orientation and specialization, and lower shares of public sector services are associated with weaker resilience and stronger recovery capacity.

This is best demonstrated by the **low-resistance-strong-recovery regions** whose geographical focus is South-West Germany, particularly Baden-Wuerttemberg (Figure 2). Low-resistance-strong-recovery regions stand out in many ways: Among all region types, they have the by far highest share of manufacturing, the highest degree of specialization, the by far strongest export orientation, and the smallest share of public sector services (see values for 2007 in Figure 3). The combination of high specialization with a large manufacturing sector and a small public service sector indicates that the high degree of specialization of low-resistance-strong-recovery regions is quite substantial due to the strong presence of manufacturing industries (see Pudelko et al. 2018 for further empirical evidence). This interpretation is also supported by the relative specialization[5] of the low-resistance-strong-recovery regions in the automobile-, mechanical engineering-, and metalworking-industry, which all belong to the manufac-

4 Using lower-level data could be beneficial, but unfortunately, large portions of these data are not available for reasons of data protection.

5 All statements in Section 4 on relative sectoral specialization are derived from the RSSI (Section 3.2).

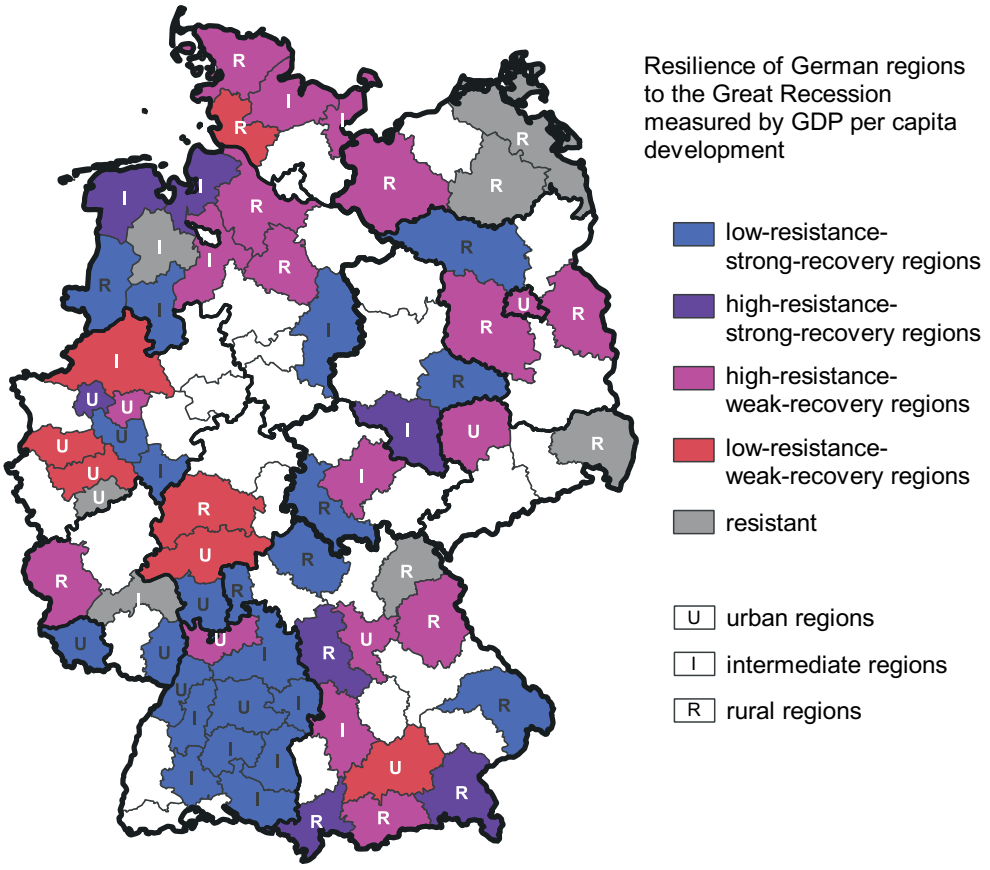

Figure 2: Geographical distribution of the five region types. **Data source:** BBSR 2017.

turing sector. The mechanical-engineering industry is also the third-largest industry in absolute terms here, which is noteworthy because all other four region types have retail, healthcare, and public administration among their top-3 and also no manufacturing industry among their top-5. Furthermore, of the ten relatively largest industries in the low-resistance-strong-recovery regions, nine are manufacturing industries, while the other region types have only up to three manufacturing industries among their ten relatively largest industries.

Most of these industries, including the significant automobile-, mechanical-engineering- and metalworking-industry, are strongly export-oriented, which explains their high exposure to the global recession of 2008–09 and, therefore, their above-average decline during the resistance phase (e. g., Eltges et al. 2009). Another factor increasing the vulnerability of low-resistance-strong-recovery regions was the dynamic pre-crisis growth of their export sectors that benefited from the generally booming global economy and the increase in demand for German capital and consumer goods (Lucke 2012). As a result, production factors tended to accumulate in the fast-growing but also highly exposed export sectors, hence increasing the vulnerability of the affected locations (see also Figure 4).

On the other hand, though, the specialization in export-oriented manufacturing industries proved helpful for the dynamic recovery of these regions. Although the immediate bounce back from their low point was primarily owed to their competitive strength, the low-resistance-strong-recovery regions also benefited from the anti-cyclical policy measures taken by the national government (Möller & Ormerod 2017, Pudelko et al 2018, Rinne & Zimmermann 2012). These measures had an implicit spatial dimension and accordingly affected regions to varying extents. As pointed out by Pudelko et al. (2018), the extension of short time-working, to name one prominent measure, was used particularly often in highly industrialized regions with a distinct export-orientation, such as low-resistance-strong-recovery regions, where it helped firms retain their workforce and have it ready when the (international) sales markets started to recover.

With the help of the graphical illustration in Figure 3, the structural differences between low-resistance-strong-recovery regions and the other region types can be quickly

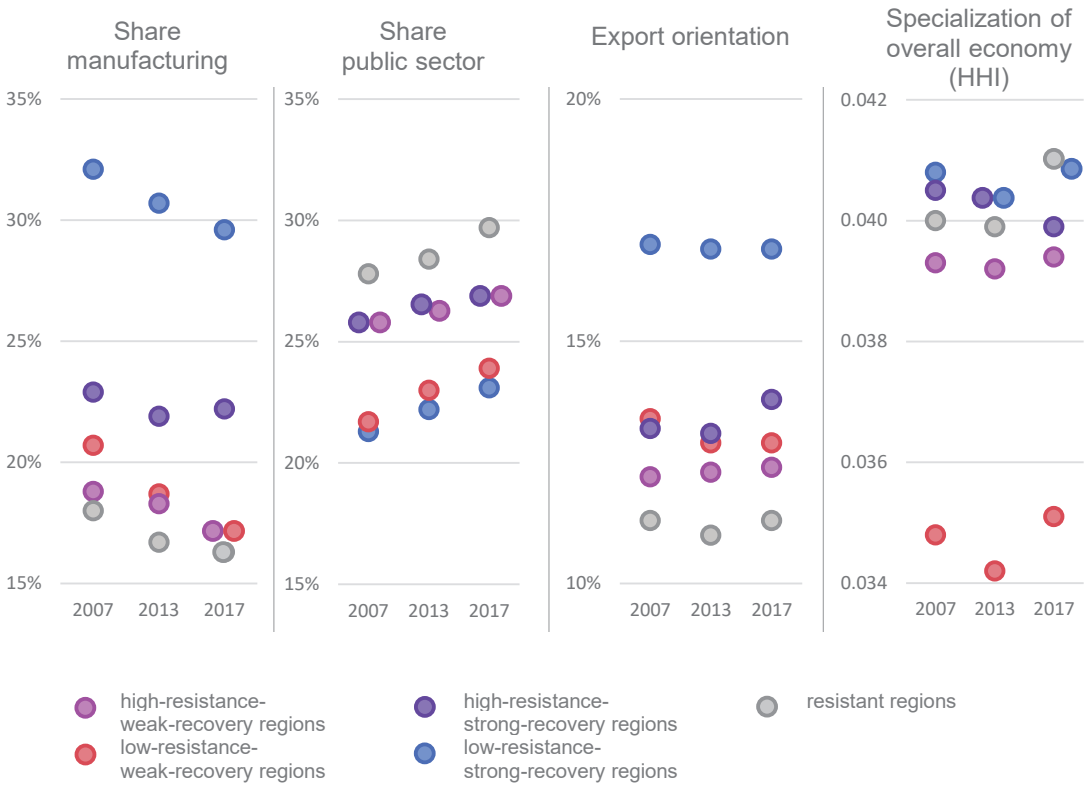

Figure 3: Development of chosen regional economic characteristics over time. **Data sources:** Statistics of Federal Employment Agency 2018, 2019a, 2019b; Federal Statistical Office 2012, 2017, 2019.

identified. The greatest differences are with the **resistant** and the **high-resistance-weak-recovery regions**, which are the opposite of low-resistance-strong-recovery regions in many aspects. That is, they are characterized by the smallest shares of the manufacturing sector, the lowest degrees of export-orientation, and the highest shares of public sector services (see values for 2007 in Figure 3). They also show moderate overall specializations, but this is likely to occur especially in the public service sector such as in education, public administration, and social work, in which both region types not only show an absolute but also a relative specialization. Specialization in these sectors can be expected to have a stabilizing rather than a destabilizing effect. It is therefore hardly surprising that both resistant and high-resistance-weak-recovery regions – which are often rural and located in north-eastern Germany (Figure 2) – were able to keep the impact of the shock minimal. Another resistance-enhancing factor of the high-resistance-weak-recovery regions is their only moderate pre-crisis growth dynamics (Figure 4). Similar to the assumed mechanisms in low-resistance-strong-recovery regions, the smaller pre-crisis growth of high-resistance-weak-recovery regions may have led to a *lesser* factor accumulation in the growth leading sectors and therefore to a lesser vulnerability to shocks within these sectors. Their lower degree of export-oriented specialization can also help explain their below-average recovery. In fact, many fiscal or market-based growth stimuli after the shock were at least implicitly directed at the national export sector (see above), which is why lesser export-oriented regions benefited from these stimuli to a lesser extent.

The two remaining types include the high-resistance-strong-recovery regions and the low-resistance-weak-recovery regions. The typically rural and intermediate **high-resistance-strong-recovery regions** are mainly located in Bavaria and the Northwest of Lower Saxony (Figure 2). Despite visible differences, the high-resistance-strong-recovery regions are still those with the greatest similarity to low-resistance-strong-recovery regions in terms of industry structure: They possess the second-highest shares in both manufacturing and specialization and they are third in export orientation (see values for 2007 in Figure 3). They also show a relative specialization into two manufacturing industries – the chemical and food industry –, even though these industries are not among their five absolute largest industries. While these features are likely to explain their above-average recovery, the above-average resistance of high-resistance-strong-recovery regions might be attributable to the relatively strong co-presence of public sector services that rather

serve domestic demand and are consequently less affected by international sales declines, hence their assumed stabilizing effect.

Low-resistance-weak-recovery regions, however, show similar degrees of manufacturing and export orientation as high-resistance-strong-recovery regions, raising the question of why the former weathered the shock worse. An obvious reason for their lower resistance is the relatively strong presence of the financial sector. Not only do low-resistance-weak-recovery regions show a strong relative specialization in the finance and insurance industry, but the finance industry is also the sixth-largest industry in absolute terms. The strong negative impact of the Great Recession on these regions can therefore be attributed to the fact that the recession had its origins in a global financial crisis that hit locations of the financial and insurance sector disproportionately hard (Keeley & Love 2010). This will certainly explain the development of the 'Rhein-Main'-region (which contains the financial center Frankfurt), but might also apply to the regions of Munich, Cologne, Düsseldorf, and Muenster where the finance and insurance sector also accounts for a large share of the regional economy (Statistics of the Federal Employment Agency 2019). This effect was reinforced, as Keeley & Love (2010) further explain, by the fact that the Great Recession was preceded by an often-disproportionate growth in the financial sector, which is likely to have increased the vulnerability of the aforementioned regions. Furthermore, it is plausible to assume that the finance and insurance sector has also influenced the slow recovery of low-resistance-weak-recovery regions as the weak growth of this sector has lasted longer than that of the national economy (German Council of Economic Experts 2010).

Another possible explanation for why low-resistance-weak-recovery regions performed worse than high-resistance-strong-recovery regions, despite similar export orientation, is provided by Duranton & Puga (2000, 2001). The authors argue that firms at a later stage of the life cycle prefer to locate in smaller, more specialized cities, while younger firms favor locations in economically diversified agglomerations to help them develop their ideal production process. Smaller cities, in turn, are often to be found in the mostly rural and intermediate high-resistance-strong-recovery regions, which is why export firms in these regions should on average be more mature and have more stable market relations with suppliers and customers than the younger firms in the more diverse and populous low-resistance-weak-recovery regions. The quicker recovery of high-resistance-strong-recovery regions could thus be due to a higher degree of maturity at the firm level.

4.2 Short-term resilience and its impact on renewal and reorientation

Figure 4a tells us that all five region types could broadly restore their average pre-crisis growth paths after overcoming the shock. Nevertheless, low-resistance-weak-recovery regions are the only region type that does not achieve a significantly higher GDP per capita level in 2011 compared to the pre-crisis level of 2008. This may be counterintuitive, as low-resistance-weak-recovery regions represent the region type with the highest average income. An important reason for this seeming contradiction is once again the strong presence of the finance and insurance sector, which on the one hand contributes to high regional incomes, but on the other hand, weakens resilience to financial crises. The consequence of this can be seen in Figure 4b which shows a remarkable catch-up effect of the four other region types compared to the low-resistance-weak-recovery regions. Apparently, the global crisis affected the positioning of the regions to each other, with middle- and low-income regions being more resistant or recovering better and thus catching up to high-income regions. It is noticeable that this catch-up effect was limited to the short-term resilience period, favoring region types with at least one 'above-average' phase, either during the resistance or the recovery period, while the combination of low resistance and slow recovery proved particularly detrimental. Once the pressure of the shock diminished, the catch-up process came almost instantly to a halt, and convergence between the richer low-resistance-weak-recovery regions and the poorer other region types slowed down significantly.

Consequently, while the crisis-induced shift in the GDP curves is surprisingly sustainable and has reduced interregional inequality in Germany to a certain extent, there is almost no significant change in regional disparities outside of the resistance-recovery period, at least if the regions under investigation are categorized based on their short-term resilience capacities. This changes somewhat if we use conventional categories, such as East-West or Urban-Intermediate-Rural distinctions, instead of resilience categories. In these cases, as shown in Figures 5a and 5b, we can observe a slight but steady convergence between the richer and poorer region types, although we cannot make any statement at this point as to whether and to what extent this is due to the effects of capital accumulation (Solow 1956), to external effects associated with the generation of new knowledge (Romer 1986, 1990), with investments in human capital (Lucas 1988) or in infrastructure (Barro 1990). However, the significant catch-up effect seen in Figure 4b as a direct result of the crisis cannot be

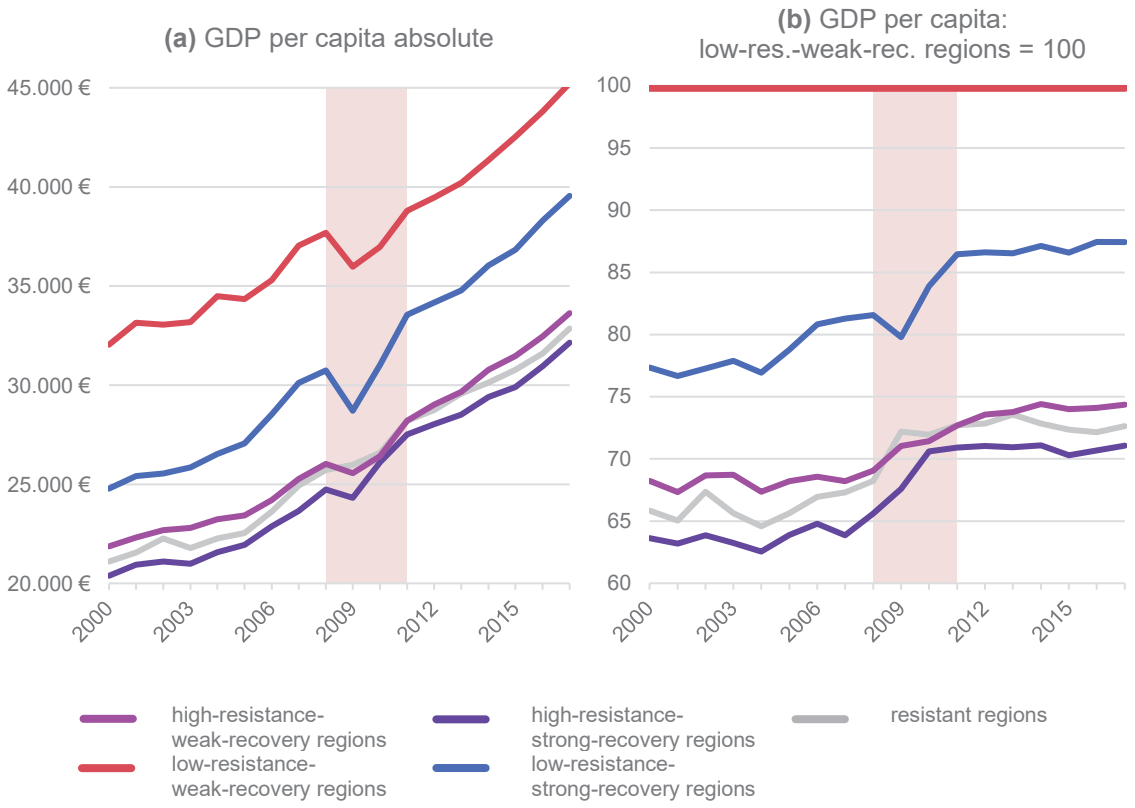

Figure 4: GDP per capita growth in the five region types from 2000 to 2017. **Data source:** INKAR 2020.

spotted in Figures 5a and 5b. If anything, a slight catch-up effect of intermediate regions can be observed, but this is likely to be related to the numerous intermediate regions in both the low-resistance-strong-recovery and the high-resistance-strong-recovery categories. A clear crisis-induced reduction in interregional inequality can therefore only be identified if the regions are grouped according to their short-term resilience capacities, which could also be the reason why Dijkstra et al. (2015) find no similar effect for European regions.

In the next step, we look at potential links between the recessionary shock and the extent of the subsequent economic reorientation, expressed by medium-term changes in the economic structure of regions. The results show that changes in the economic structure of German regions during and after the shock have remained modest. As for regional economic specialization and regional export orientation, we observe only small adjustments of usually less than one index or percentage point between 2007 and 2017 (right half of Figure 3).

Over the same period, the share of employees in the manufacturing sector fell by an average of around two percentage points (while the public sector share rose by roughly the same amount) (left half of Figure 3). The decline in manufacturing is thus somewhat more pronounced than the slight reduction in export orientation and specialization. However, its decrease can still be considered relatively small in comparison to the preceding decades when the manufacturing's share in the German and, before 1990, Western German workforce had shrunk by five (1997–2006) or even more than six (1987–1996) percentage points (Federal Statistical Office 2020a). Even the industrial structure of the highly exposed low-resistance-strong-recovery regions has proved broadly stable after the shock. Although their manufacturing share fell a little more sharply, the three leading sectors of low-resistance-strong-recovery regions in 2017 are still the same as in 2007, and their ranking (in terms of employment) has also remained the same: 1) automotive engineering, 2) mechanical engineering, 3) manufacture of metal products (Statistics of the Federal Employment Agency 2018).

The high degree of structural stability also raises the question of the nature of the shock and the changes it has forced. It was Béné et al. (2012) who first pointed out that "resilience emerges as the result [...] of these three capacities: absorptive, adaptive and transformative capacities, each of them leading to different outcomes: persistence, incremental adjustment, or transformational responses". Furthermore, the authors suggest that the type of response is causally linked to the intensity of change whereby

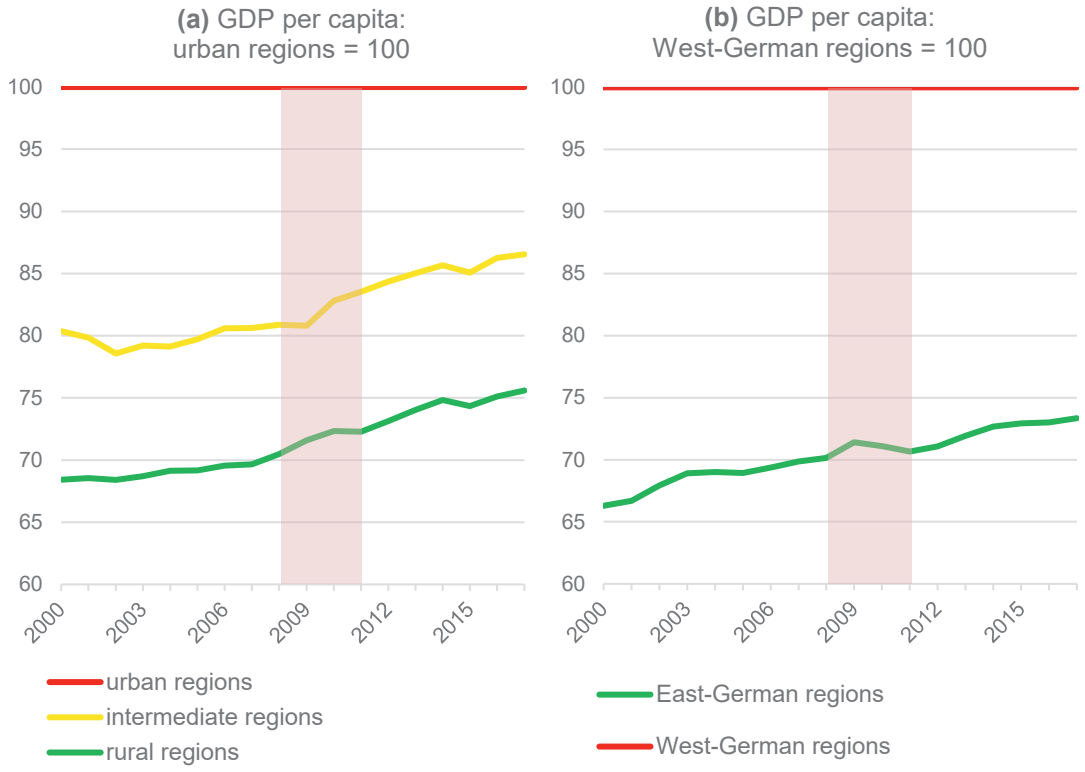

Figure 5: GDP per capita growth in the different region types from 2000 to 2017. **Data source:** INKAR 2020.

higher intensities of change are assumed to require more comprehensive resilience capacities. However, there is a noteworthy difference between the intensity of the shock and the intensity of change triggered by the shock. For the German economy, we can state that the recessionary shock – regardless of its magnitude – has not triggered a comprehensive or even transformational change. Instead, the intensity of required change can be classified as 'mild' or possibly as 'medium' if we further assume incremental adjustments at the firm level for which we could not control in this paper. The fact that the severe shock resulted in only slight changes is also due to the nature of the shock. The Great Recession of 2008–2009 was primarily a demand shock that led to a temporary decline in exports and investments but left the competitive supply structures of the German economy unscathed (Bofinger et al. 2020). Therefore, after the financial sector had been stabilized and the temporary gap in demand had been bridged with the help of anti-cyclical measures, the still competitive German producers were able to meet the (international) demand as soon as it picked up again. Evidence of this is provided by the German export figures that certify the continuing success on the international sales markets (Federal Statistical Office 2020b). In fact, throughout the 2010s, Germany continued to be the world's third-largest exporter of goods, surpassed only by the USA (2nd) and China (1st) (see, for instance, Comtrade 2021). This observation can be interpreted as a sign of high and constant competitiveness, especially in the manufacturing sector.

5 Discussion and outlook

In this paper, we have examined the short- and medium-term resilience of German Spatial Planning Regions to the external shock of the Great Recession. Based on their short-term GDP per capita development, we have divided the regions into five categories and, in a second step, have disclosed linkages between their economic performance and their industry structure. Our analysis reinforces the resistance-decreasing and recovery-enhancing effects of manufacturing-based, export-oriented specialization. Further, we were able to show that low-resistance-weak recovery regions showed a relatively low overall resilience performance, most likely due to their relative specialization in the financial industry. This also led to a catch-up effect of the other region types compared to the low-resistance-weak-recovery regions. Although this catch-up effect is limited to the resistance-recovery period, it nevertheless has a lasting effect. It thus appears that differences in short-term resilience can lead to medium-term changes

in disparity levels, favoring region types with at least one 'above-average' phase either during the resistance or the recovery period.

Concerns that Germany's high specialization in export-oriented manufacturing would weaken its resilience have proved unfounded. At least during the 2010s, the potential problems of Germany's great dependence on its industrial sector were hardly noticeable. After all, Germany was able to quickly restore its pre-crisis growth trend while exceeding the average growth performance of the other EU-15 countries not only during the recovery but also in the renewal phase (World Bank 2019). Given this development, the advantages of Germany's strong specialization in manufacturing industries still seem to outweigh its potential disadvantages. This is also evidenced by the above-average growth of low-resistance-strong-recovery regions during the pre-crisis and the recovery period as well as by their stable growth since 2012 which demonstrates that national economic growth in recent years was driven quite substantially by specialized, export-oriented regions (Figure 4). Kemeny & Storper (2014) come to a comparable conclusion for U.S. counties, as they find a beneficial effect of specialization on regional productivity and wage dynamics between 1998 and 2010.

Our results are also consistent with Delgado and Porter (2021), who find that industries in strong clusters were particularly resilient during the Great Recession. This fits well with the situation in Germany where specialization takes place within numerous competitive clusters with different industry focuses, with the side effect that the manufacturing sector is more diverse than it may appear at first glance (Federal Ministry of Economics and Energy 2021). Furthermore, the OECD (2019) certifies Germany has a relatively low level of product market regulation which indicates a competitive business environment. Hundt & Holtermann (2020) show that such an environment is not only an important driver of competitiveness in general but also helps strengthen the resilience of manufacturing industries, which are a typical asset of many low-resistance-strong-recovery regions. Against this background, the drop in 2008–09 can be interpreted as merely a cyclical downturn of an otherwise competitive economy, where efficient companies could defend or regain their market shares after the fiscal support had successfully served its purpose of temporary stabilization. As a result, the re-orientation of industry structures due to the shock remained modest. For policymakers, these considerations suggest the combination of two complementary strategies: a short-term strategy aimed at the ad-hoc stabilization following the shock event, and a medium- to a long-term strategy aimed at the strengthening of competitive capabilities to promote sustainable growth.

In summary, there is much to suggest that resilience in Germany has emerged as the result of strong absorptive capacities that helped preserve the basic economic structures not only throughout resistance and recovery but also through the renewal phase. Since Germany's strong presence in the world markets is due to a high degree of competitiveness, the benefits of specialization and internationalization have proven greater than the associated risks of high exposure to external shocks. The fact that Germany's export sector benefited from favorable international developments during the 2010s – examples include the high demand for capital goods in emerging economies, most notably in China (Lucke 2011, Fratzscher 2014), and the constantly growing money supply that stimulated worldwide demand (Horn et al. 2009, Brunnermeier et al. 2018) – does not fundamentally change this. However, this assessment remains valid only if the leading clusters succeed in maintaining their (international) competitiveness. The economic development of the Ruhr area has proven that this is anything but a matter of course and it remains to be seen whether the automotive sector – the key industry not only of many low-resistance-strong-recovery regions but of the German economy as a whole (Project Group Joint Diagnosis 2019) – will be able to defend its global market share as new environmentally friendly drive technologies become more widespread.

The descriptive character of our paper makes it subject to certain limitations and leaves room for further improvements. It should therefore be borne in mind that the different resilience capacities of German regions are likely the result of *many* factors. Ultimately, regional economies are shaped by numerous heterogeneous firms and workers, as well as by a multitude of factors and processes, with the regional industrial structure representing only one possible, yet important resilience determinant (Martin 2012). To overcome this somewhat narrow focus, future work could aim to examine the causal relationship between national and regional determinants on the one hand and the resilience capacities of German regions on the other, using longer time series with continuous dependent variables. A promising method to achieve this is multi-level panel analyses (see Hundt & Holtermann 2020 for an empirical example and Beenstock & Felsenstein 2020 for addressing potential problems arising from absent regional data). However, the aforementioned shortcomings should not hide the fact that our results show a relatively clear relationship between this paper's main indicators (specialization, manufacturing, export-orientation) and the development of German regions during and after the Great Recession. Therefore, we consider this paper as a reliable framework for future research in this area.

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