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Summary

Our paper seeks to provide empirical evidence for a spatial-temporal system of (short-term) regional resilience determinants. Based on groundwork from Martin (2012) and Martin and Sunley (2015), we employ a nested hierarchy of regional and national determinants to constitute the spatial dimension, while we model the temporal dimension through a resistance and a recovery phase. Utilising hierarchical panel data models for a sample of 22 European countries, we can confirm the presence of a spatial-temporal system as we find significant determinants at both spatial levels that are connected via cross-level interactions and reveal varying, if not opposing directions of influences across the sensitivity and recovery phase.

KEYWORDS: resilience, shocks, resistance and recovery, regional development, regional and national determinants, economic crisis, Europe

JEL: C33, R11, R58

1 Introduction

The 'Great Recession' of 2008/2009 has undoubtedly inspired the academic debate on regional economic resilience. Since the world economy was hit by the hardest economic crisis for decades, the number of scientific contributions to this topic has been increased considerably. The so far greatest progress has been made in the conceptional development of this field, whereby the publications authored or co-authored by Ron Martin (e.g., Simmie and Martin, 2010; Martin, 2012; Martin and Sunley, 2015; Martin et al., 2016) can be regarded as key contributions. Martin and colleagues introduce several basic principles to the theoretical debate that shape our current understanding of regional economic resilience. These principles include the systemic distinction between *engineering*, *ecological* and *adaptive* resilience (Simmie and Martin, 2010; Martin, 2012; Martin and Sunley, 2015), the decomposition of resilience into four phase-specific dimensions (*resistance*, *recovery*, *renewal*, *re-orientation*) (Martin, 2012), and the idea of a phase depending impact of *inherent/inherited* and *adaptable* resilience determinants (Martin and Sunley, 2015).

The focus of research on regional economic resilience is on two main questions (Simmie and Martin, 2010; Martin, 2012; Martin and Sunley, 2015; Martin et al., 2016): (1) How do regional economic systems react to external shocks in a short, middle and long-term perspective? (2) Why do regional economies differ in terms of their capacities to resist, to recover and to adapt? Question (1) puts emphasis on the temporal dimension of resilience. In this, the short-term perspective is captured by the engineering concept and can be best modelled by means of the resistance and recovery phase (Martin, 2012). The reference state of engineering resilience is a region-specific equilibrium growth path. From this viewpoint, resilience can be defined by the region's ability to bounce back from a shock-induced downturn and to return to its pre-shock growth path, respectively. The faster and the more comprehensive the return, the more resilient is the regional economy (Simmie and Martin, 2010).

The mid- and long-term perspective on resilience is represented by the concept of adaptive resilience (Carpenter et al., 2005; Hassink, 2010; Davoudi et al., 2012). This approach focuses on the capacities of regions to cope with changes in their macroeconomic, social and institutional settings. It is noteworthy that these changes do not have to be sudden phenomena. They can also arise from continuous, incremental processes. Following the adaptive approach, a region can be considered resilient if it adapts itself to altering economic challenges whilst remaining prosperous, creative and competitive. Not surprisingly, this concept does not offer a stable equilibrium state that the regional economy could return to. Instead, resilient regions are assumed to undergo constant changes while they adapt through time to various kinds of stress and challenges (Simmie and Martin, 2010). Martin and Sunley (2015), however, point to the risk of diluting the resilience concept if sudden shocks are not clearly separated from slow burns whose impact is already subject of many existing theories on structural transformation.

While question (1) addresses the temporal dimension, question (2) refers to the possible determinants of resilience. These determinants need to be structured according to useful criteria. From a geographical perspective, this involves localization and spatial hierarchies. Again, it is

Martin and Sunley (2015) who provide the hitherto most comprehensive list of potential resilience determinants. These factors are sorted by five main categories: *industrial and business structure*, *labour market conditions*, *agency and decision-making*, *financial arrangements* and *governance arrangements*. Although they are mainly divided up by content-related criteria, an underlying hierarchical structure becomes evident to some extent. In this regard, the category *agency and decision making* primarily addresses determinants that are tied to players at the micro level, while determinants with a predominantly local/regional reference are assigned to the categories *industrial and business structure* and *labour market conditions*. The two remaining categories, though, do not have a distinct spatial reference. Both *financial arrangements* and *governance arrangements* include determinates from the local as well as from the national or, in the case of the latter category, even the international level. The existence of a hierarchical system of resilience determinants, however, is not put into question.

Adding another feature to their conceptual framework, Martin and Sunley (2015) suggest that the impact of resilience-related economic attributes is – at least partly – phase-specific. For this reason, the authors distinguish between *inherent/inherited* factors on the one hand and *adaptable* factors on the other. While inherent/inherited factors are expected to be relevant in particular during the resistance phase, adaptable factors are assumed to primarily shape the recoverability of a region. It should be noted, however, that both groups are anything but strictly dissimilar. For the most part, they refer to common parameters including *sectoral structure*, *exports*, *productivity*, *technology*, *policy regime*, and *external relations*. From this, one can conclude that resistance and recovery are not necessarily affected by per se different factors, but by a set of widely similar determinants whose impact is likely to vary from phase to phase.

In a nutshell, Martin and colleagues have developed a strong conceptual basis according to which regional resilience can be considered a *multi-phase process* that is influenced by *hierarchically structured* and *phase-related* determinants. This in turn provides a clear agenda for empirical research. Hence, in a next step, we concisely assess whether and to what extent previous empirical investigations have addressed (a) the process character of regional resilience and (b) the hierarchical and phase-related structure of the underlying determinants. Our literature review covers the period from the 'Great Recession' onwards and we identify thirty studies that empirically examine at least one of the aforementioned dimensions. We define seven categories to compare these studies with respect to their methodological design. The most important categories, of course, include (a) the operationalization of regional economic resilience and (b) the scope of the underlying determinants. Further categories take in the shock(s) under investigation, the resilience indicators used, the temporal and geographical frame of the sample, and the main method(s) applied. A tabular overview is given in Appendix A.1.

Our literature review reveals that most empirical studies to date focus on the 'Great Recession' and its impact on European or North American regions (see Appendix A.1). This finding is not surprising as it reflects the topicality and the magnitude of the crisis as well as the fact that it predominately spread across Western industrialized countries. Of much more interest, however, is the empirical progress that has been made with respect to the key categories (a) and (b). The answer is relatively clear. As displayed in Appendix A.1, only seven out of thirty studies, hence less than a quarter, have concurrently investigated both the phases (a) and the phase-related determinants (b) of resilience. Such investigations include, to begin with, Martin (2012) and Martin et al. (2016) who examine the resistance and recoverability of UK regions covering three respectively four recessionary shocks within a time span from 1971 to 2014. As for the determinants, the authors focus on regional industries and make use of either descriptive measures (Martin, 2012) or shift share analysis (Martin et al., 2016) to assess the mutual relation between sector structures and resilience capacities over time.

Further country-specific studies that explicitly distinguish between resistance and recovery are conducted by Pudelko et al. (2018) and by Di Caro (2014). While Pudelko et al. (2018) concentrate on the Great Recession and its impact on Western German regions, Di Caro (2014) focusses on Italian regions and takes into account three major shocks from the early 1980s onwards. Both studies put special emphasis on the regional sector structure and make use of regression-based techniques to assess its resilience-related impact. The resilience of EU regions, in turn, is investigated by Davies (2011) and by Fratesi and Perucca (2018). Focusing on the Great Recession, both studies divide resilience into a resistance and recovery phase and apply linear regressions to analyze the phase-related patterns of potential determinants: policy measures in the case of Davies (2011), assets of territorial capital in the case of Fratesi and Perucca (2018). A seventh study that addresses the resistance-recovery nexus as well as the respective impact of determinants is carried out by Balland et al. (2015). Covering a time span from 1975 to 2002 and using various regression methods, the authors examine *technological* resilience through the example of US cities. Consequently, resilience is measured by patents, not on the base of GDP (Pudelko et al., 2018; Fratesi and Perucca, 2018) or via (un-)employment (Davies, 2011; Martin, 2012; Di Caro, 2014; Martin et al., 2016; Di Caro, 2018).

What all seven studies have in common, though, is that they are restricted to the regional level alone and thus do not capture the hierarchical structure of determinants. This limitation, however, is at least partly redressed by works from Crescenzi et al. (2016) and Giannakis and Bruggeman (2017). Crescenzi et al. (2016) take into account both regional and national determinants as they examine the resilience of EU regions during the Great Recession using one-level regression procedures. Giannakis and Bruggeman (2017) investigate the impact of the 2008/09-crisis on EU regions, too, but apply, alternatively, hierarchical structured regression techniques to explicitly model spatial hierarchies. Yet, they do not include national determinants and consequently do not explore interactions across different spatial levels. Besides, neither Crescenzi et al. (2016) nor Giannakis and Bruggeman (2017) account for the process character of resilience and distinguish between a resistance and a recovery phase, respectively.

The conceptual works of Martin and colleagues constitute regional resilience as a multidimensional notion. In the main, it includes (a) a temporal dimension that covers sequential (sub-)phases and (b) a spatial dimension that comprises hierarchically structured and, ideally, also phase-specific determinants (e.g., Simmie and Martin, 2010; Martin, 2012; Martin and Sunley, 2015; Martin et al., 2016). When compared to these two core dimensions, our literature review points out the need for further empirical research. As illustrated above, only seven out of thirty studies have so far modelled successive phases while accounting for the phase-specificity of the corresponding determinants at the same time. An even bigger gap, however, can be observed with regard to the spatial dimension as only two studies investigate regional and national determinants (Crescenzi et al., 2016) and model spatial hierarchies (Giannakis and Bruggeman, 2017), respectively. Eventually, no empirical study up to date has incorporated both the temporal and spatial dimension of resilience into one holistic estimation procedure (see Appendix A.1). This is where our empirical study starts.

The aim of this paper is to unify selected resilience determinants according to their temporal and spatial structure and to empirically investigate whether this distinction – as theoretically suggested by the seminal works of Martin and colleagues – creates added value in the form of so far uncovered mechanisms that drive regional economic resilience. With regard to the spatial dimension, we empirically test:

- to what extent regional resilience is shaped by different spatial levels,
- by which effects resilience determinants from different levels exert influence, and
- whether these determinants interact across different spatial levels.

With respect to the temporal dimension, we empirically examine:

- whether the impact of the determinants under investigation is either constant over time or shows phase-specific features.

In this empirical case study, the spatial dimension spreads over two levels and is constituted by a nested hierarchy of regional and national determinants. The temporal dimension basically adopts a short-term, thus engineering perspective and is modelled through a resistance and a recovery phase. The study is carried out for 249 NUTS-2 regions in 22 European countries and it covers a time span from 1990 to 2014.

The remainder of this paper is structured as follows: In section 2, we provide an in-depth introduction to our empirical case study. In a first step, we delineate the shock events and the resilience indicators under investigation (section 2.1). We then operationalize the phase-related patterns of resilience (section 2.2) as well as the hierarchical structure of resilience determinants (section 2.3). The structure of the corresponding statistical model is set out in section 3. In section 4, we present the patterns and mechanisms of resilience determinants in European regions as derived from our baseline models and verified by a comprehensive series of robustness checks. In the closing section 5, we critically discuss the central findings and their contribution to theory development, address limitations of our approach, and highlight important areas of future research.

2 Scope and structure of the case study

2.1 Resilience 'to what?' and resilience 'of what?'

Carpenter et al. (2001) put forward two fundamental questions that are relevant to define the empirical scope of our study. The first question relates to the origin, the nature and the size of the shock and thus reads 'resilience to what?'. The second question, 'resilience of what?', aims at the operationalization of resilience and hence refers to the choice of resilience indicators and the spatial delineation of the shock-affected economic system.

Regarding the 'to what?'-question, we adopt a macroeconomic concept that defines shocks as structural disturbances in the macroeconomic environment. These disturbances are sudden events that adversely affect the economic environment over a limited period of time. The shocks should fulfil the following characteristics (see among others: Blanchard and Watson, 1986; Ramey, 2016): (1) the shocks are 'exogenous forces' that are 'economically meaningful'; (2) the shocks are uncorrelated with each other; (3) the shocks are unanticipated.

Following the examples of Martin et al. (2016) and of Fingleton et al. (2012), we employ *national recessions* as shock events to the respective sub-national regions. We define a national recession as a year with negative output growth, whereby output is measured by inflation-adjusted GDP per capita. Those contractions of the output-cycle are (in general) unpredictable for economic agents and are 'meaningful' in the sense that they reflect disruptions in the macroeconomic system as a whole and not only exert economic pressure on isolated regions. By looking at national downturns, we can exclude region-specific crises that may arise from structural growth weaknesses, 'slow burns' or endogenous output drops on regional level. Even though it is unlikely for the growth performance of a single region to cause a national recession, it is arguable that our identification strategy might not be fully exogenous since national growth performance is the weighted average of regional growth rates. Hence, we introduce *banking crises* as a second shock indicator to validate the exogeneity of the recession indicator.[1] In our sample, most of the national recessions are direct consequences of banking crises (see Appendix A.2 for an overview of national recession dates and bank crises dates). As, in turn, the determination of banking crises dates is independent from the output growth of regions or countries, our identification procedure is likely to meet the assumption of exogeneity.

Furthermore, our case study meets the assumption of uncorrelated shocks as both national recessions and banking crises occur at irregular intervals and are characterized by prolonged periods of economic growth between shock events. Possible exceptions are the national downturns in 2008/2009 and 2011/2012 during the aftermath of the global economic crisis. We adopt the reasoning of Reinhart and Rogoff (2014) and consider these successive recessions as a 'double dip' (for a detailed explanation, see section 2.2). In a next step, we test the assumption of the unpredictability of shocks. For this purpose, we compare one-year-ahead growth forecasts obtained from the IMF World Economic Outlook (WEO) database with historically observed national growth rates. More precisely, we regress the forecast error (the difference between actual

[1] Banking crises are defined by two types of events (Reinhart and Rogoff, 2011; Laeven and Valencia, 2013): (1) bank runs that lead to the closure, merging, or takeover by public sector of one or more financial institutions; (2) distress in the financial system that leads to closure, merging, or takeover of an important financial institution or group of institutions with simultaneous introduction of large-scale government assistance to the financial sector.

observed growth rate and midyear forecast in the previous year) on the recession or banking crisis dummy indicator.[2] Table 1 shows the estimation results.

Table 1: IMF Forecast Errors for Output Growth

Shock Types	National Recessions	Bank Crises
Next year forecast error	-0.0349 *** (0.0023)	-0.0364 *** (0.0043)

Notes: Regressions include country dummies. ***, **, * denote significance at the 1%, 5%, 10% level, respectively.

The regression results corroborate the assumption that national recessions, as well as banking crises, are unanticipated events. The negative and statistically significant coefficients indicate that the actual outturn of growth in recession or banking crisis years is well below the expected growth rate.

The question 'resilience of what?' addresses the choice of the resilience indicator. This choice depends on whether regional resilience should be evaluated either in absolute terms or in relative terms, while the latter means in relation to other regions (Sensier et al., 2016). In this study, we focus on absolute resilience. Hence, our resilience indicator is based on absolute annual output changes of each region when faced with the same type of shock-event. Specifically, we measure regional output in terms of real GDP per capita. GDP is the most common indicator to quantify (regional) economic capacities and data are consistently available on a comparable basis across the EU territory. We choose GDP over employment because the reaction of employment numbers towards exogenous shocks is often delayed as adjustment processes of labour markets – which arise, amongst other things, from labour market regulations – tend to be more time-consuming than the adjustment of output (Hall, 2010; Cazes et al., 2013). As we particularly focus on short-term 'engineering' resilience (see section 2.2 for more details), GDP per capita meets our requirements at the best possible rate. With regard to the geographical scale, we choose NUTS-2 regions as spatial units for the economic systems under investigation.

2.2 The process-related character of regional resilience

We define a shock-induced regional crisis as an interval that starts with contraction in regional GDP per capita and ends when GDP per capita returns to its pre-event level, or, alternatively, to its counterfactual trend-level. We specialize on recessionary shock episodes where regional growth decelerates to a negative rate because of a disturbance in the macroeconomic environment (see Figure 1a). This procedure enables us to exclude slowdowns of growth dynamics due to long-run growth volatility and growth decelerations that are postulated by regional growth theory, e.g. those that are generated by convergence to a steady state in neoclassical growth models (Hausmann et al., 2006). Fixing the starting date and the turning point for each region to the dates of the system-wide national recession, bears the risk of ignoring that the same shock

[2] The regression model includes country dummies to control for the forecast error that is 'typical' for each country. The recession (banking crisis) indicator is one in years of national recessions (banking crises) and zero otherwise.

might affect some areas earlier or later (Sensier et al., 2016). Thus, we treat each region as an economic system which responses individually to the national shock-event. In order to separate the immediate post-shock periods from longer periods of 'stable' growth prior to the next recession, we further split all regional growth trajectories into three mutually exclusive phases: resistance, recovery, and expansion (see Figure 1a). While resistance and recovery are at the core of our analysis, the expansion phase – defined as all years that are not classified either resistance or recovery – is only of secondary interest in this study.

The identification of the resistance phases is linked to all regional recessions that occur during times of national recessions (alternatively: banking crises) or within a window of one year around these national shock-events.[3] The resistance phase starts with the first year of decline in regional GDP per capita and ends when the regional low point is reached (from peak-to-trough). By definition, the average growth rate in this resilience component is negative, but there might be periods of temporally rebound within the phase.

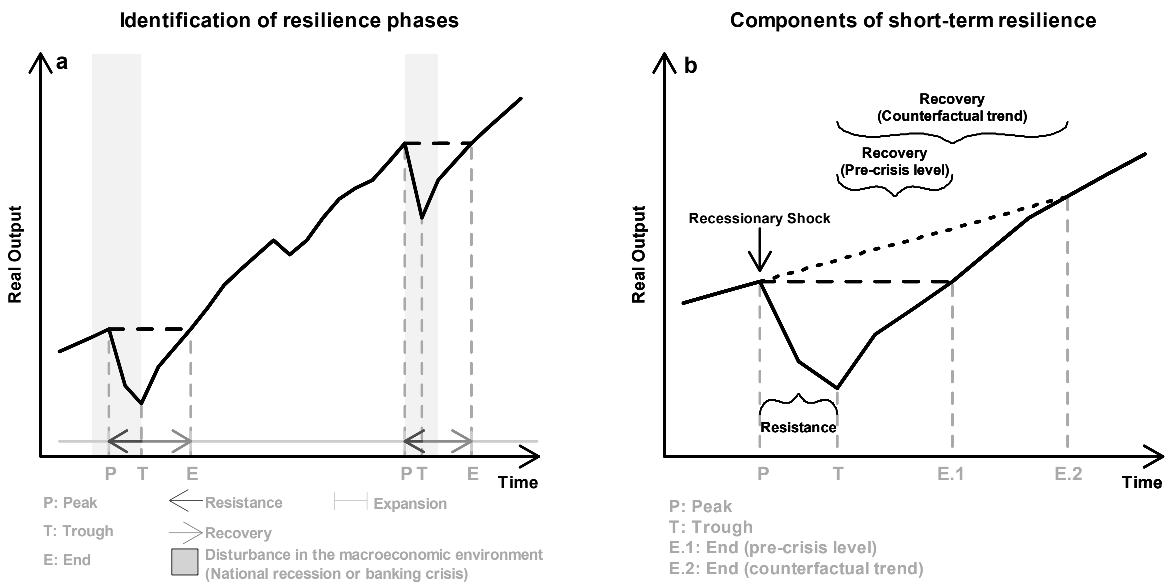

Figure 1: Phases of short-term resilience.

Recovery is defined as the period from the regional low point to the end of crises (trough-to-end), whereby the end date of crisis can be determined in two ways (see Figure 1b). Firstly, the recovery phase ends when the GDP value that immediately preceded the decline is attained again (dashed line). Secondly, the recovery phase ends when the GDP reaches the presumed level that would have been achieved in the absence of the shock (dotted line). Situations in which the GDP experienced a renewed downturn before reaching the threshold that specifies the end of crisis are regarded as 'double dips' (Reinhart and Rogoff, 2014). Under these circumstances, we consider the event as one crisis. Or, put in other words, a crisis cannot start if the region is already in crisis.

[3] We also experimented with alternative definitions of the crisis windows, expanding and contracting the length of the crisis by increasing the window size to two years or considering only the years of national recession as potential trigger of regional crisis. Our results are not sensitive to the alternative definitions.

Applying the pre-crisis level as reference state in our baseline model is consistent with the concept of 'engineered resilience' as the 'bounce back' to a pre-shock state is adequately captured in this approach. Moreover, the method has the advantage of being a transparent and readily available measure, which is why it exhibits a wide prevalence in economic studies and is regularly used by the International Monetary Fund (Hausmann et al., 2006; Mauro and Becker, 2006; Claessens et al., 2009; Fatás and Mihov, 2013; Reinhart and Rogoff, 2014; Sensier et al., 2016 among others). Nevertheless, there is an ongoing debate about the advantages and limitations of this method to determine the completion of a crisis. Some authors are concerned that the reference point of pre-event GDP produces a (too) conservative measure of the length of recovery and the costs of crisis because this method abstracts from trend-growth during the event (e.g. Mauro and Becker, 2006; Fatás and Mihov, 2013; Martin et al., 2016). For this reason, we additionally estimate a counterfactual scenario in which we first measure the average region-specific growth trend up to six years prior to the crisis and then project it into the post-shock period (as symbolized thru the dotted line in Figure 1b). In order to exclude hysteretic effects of shocks on long-run growth trajectories, we restrict the maximum length of the 'counterfactual' recovery (indicated by the distance from T to E.2) to be twice as long as the 'pre-crisis' recovery (from T to E.1).[4]

In tradition of the multi-phase business cycle as proposed by Burns and Mitchell (1946), we adopt a three-phased framework where expansions are followed by phases of resistance (regional recessions), which are followed by recoveries. The partitioning of the growth path into three discrete regimes can be found in many macroeconomic studies (Calvo et al., 2006; Hausmann et al., 2006; Fatás and Mihov, 2013; Cerra et al., 2013 among others). As stated by Fatás and Mihov (2013), the three-phase description of the business cycle is close to the spirit of Friedman´s 'plucking model' which bears high affinity to the notion of 'engineered resilience' (Martin, 2012). The 'plucking model' postulates that the output springs back to the long-run trend during recovery phases. Mean-reversion of output implies that the impact of recessionary shock is transitory and that growth rates during recoveries are on average higher than growth rates in all years of positive growth (Friedman, 1993; Kim and Nelson, 1999). Following these theoretical considerations, it is reasonable to suggest that the underlying growth dynamic is different between recovery years and expansion years. Hence, we consider it useful to isolate the recovery from the expansion phase because otherwise the true impact of recovery-related determinants might be concealed as potentially opposing effects between the phases might smooth each other out due to temporal aggregation. A similar problem arises if we analysed the determinants of overall (short-term) resilience whilst omitting the distinction between resistance and recovery. In our opinion, these procedures could lead to incorrect conclusions as important phase-specific attributes might be masked out. In fact, the question must be asked why opposing directions of crisis-related short-term economic development (downturn during resistance vs. upturn thru recovery) should not be accompanied by opposing directions of influences from the underlying economic determinants. Consequently, we assess the impact of short-term resilience determinants separately according to the resistance and to the recovery phase.

[4] Also, this cut-off avoids that the recovery phase remains incomplete in case the regional growth path does not catch up to the counterfactual trend.

2.3 The hierarchical structure of resilience determinants

Covering all plausible determinants of resilience and all possible spatial levels of influence in a single empirical analysis would be a major task. Even if the requisite data were available, the suitable evaluation strategy that considers the complex interplay of multifarious determinants is hard to find. Therefore, our case study focuses on selected determinants that do not suffer from data limitations and are available for all observation units on a comparable basis. As set out by Martin and Sunley (2015), resilience determinants can be categorized either as inherent or adaptable (see section 1). On the whole, adaptable determinants include government support measures or crisis-driven, hence abrupt adaptations of economic policies. As such, they often lack sufficient data sources, especially in terms of international comparability, which is why we confine the case study to inherent determinants of resilience. Martin and Sunley (2013) name five groups of inherent factors that are capable of shaping a region's resilience to major shocks. Four of them, specifically *structure*, *externalities*, *psychology*, and *fundamentals*, include determinants from the regional level, while *external conditioning factors* are related to the national level (see Figure 2).

The vast majority of inherent determinants are time sluggish. If at all, they gradually change over longer periods and, correspondingly, cannot be adjusted by policy makers in a short amount of time. Another common feature of inherent factors refers to their measurability since cross-regional or cross-country differences in, for example, psychology (e.g. sentiments and perceptions), fundamentals (e.g. business culture and arrangements of regional and national governance), or externalities (e.g. business practices) are usually not fully observable. This is problematic insofar as unobserved heterogeneity can lead to erroneous estimations which is why we intend to capture as much of it as possible in our empirical setting (see section 3). This is particularly important because the determinants are interlinked within groups as well as between groups (dashed lines in Figure 2). Hence, they are confounding factors that influence not only the resilience outcome, but also interfere with each other.

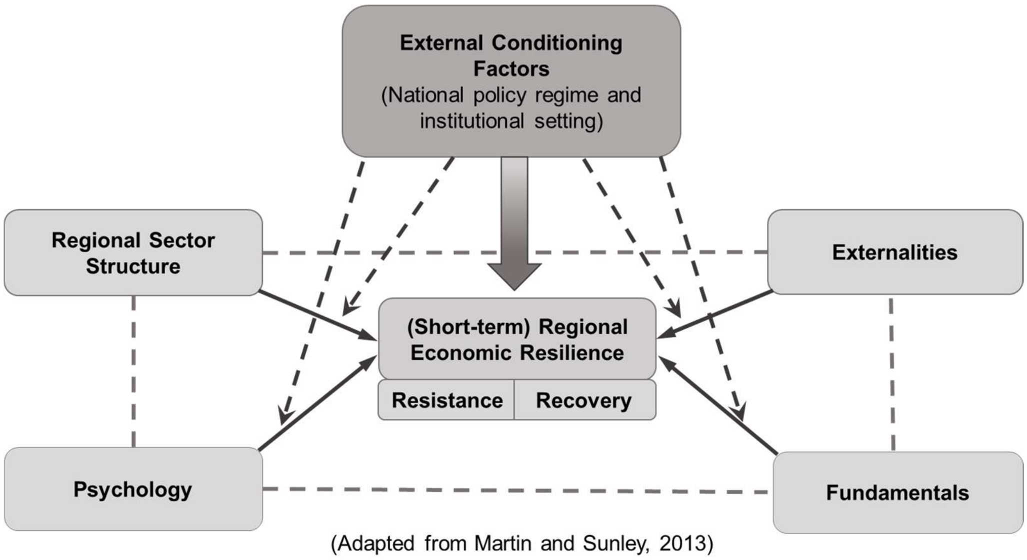

Figure 2: Inherent determinants of regional economic resilience.

Our hierarchical model contains determinants of two nested levels. The lower regional level comprises 249 NUTS-2 regions, while the upper national level includes 22 European countries. The units of observations are regions. The hierarchical relationship between regional determinants and external, viz. national condition factors manifests itself through direct and indirect impacts. The latter tell us to what extent regional determinants are moderated by factors from the upper national level (dashed arrows). Such cross-level moderations are of particular relevance in our empirical framework since this type of interaction constitutes a direct interplay between determinants from distinct levels within the hierarchical system. For example, factors from the regional and national level can be mutually reinforcing and therefore – in addition to the direct effects – enhance regional resilience by stabilizing or increasing growth rates during times of crisis. Furthermore, the regional determinants are shaped by the context level over time. Regarding this, the similarity of determinants is generally higher in regions within the same country compared to regions from different countries ('intraclass correlation'). Again, most of these factors that constitute similar resilience patterns of regions within a country are not fully observable – a fact that is addressed thru our empirical setting (see section 3).

Of the broad range of inherent determinants, we concentrate on selected factors from the regional sector structure and the national framework (as highlighted by the shaded background in Figure 2). There is consensus in the literature that the 'industrial portfolio' of a region (Conroy 1974), i.e. the local mix of economic activities takes a key role in shaping resilience capacities (e.g. Conroy, 1974; Dissart, 2003; Martin et al., 2016 among others). Since some sectors are more exposed to economic cycles than others, their responses to macroeconomic shocks vary due to their differentials in 'cyclical sensitivity'. For example, the cyclicality of manufacturing and production activities tends to be relatively high, wherever growth in the service sector is much more stable over time. Thus, regions that are specialized in manufacturing possess a more erratic response to recessionary shocks, other things being equal, than regions that disproportionate depend on services or the public sector (Martin et al., 2016). Also, 'cyclical sensitivity' implies a phase-specific impact of regional sector structure on short-term resilience which is why a distinction into a resistance and a recovery phase can be considered useful. To capture the economic structure of regions empirically, we include the respective shares of industry, financial and business services (FBS) and non-market sector in our models.[5]

The resilience-related effects that arise from the regional sector structure, however, may be further moderated by institutional factors at country level that are external to a single region. In this study, we model the institutional setting by means of the regulatory regime and the extent of macroeconomic stability. With regard to the regulatory density, we make use of two OECD-indices, namely labour market regulation (LMR) and product market regulation (PMR).[6] Again, we expect a phase-specific impact: while a high degree of regulation is, on the one hand, likely to facilitate imperfect competition and thus to stabilize output in the resistance phase, it could, on the other hand, impede the rise of more productive firms when the economy starts to recover. Furthermore, with respect to a potential cross-level moderation, a stricter regulatory regime is assumed to be more harmful in regions that exhibit an above-average share of 'cyclical sensitive' sectors. The reason behind this is that a strict regulation is likely to hamper the adjustment processes especially in those sectors that are greatly exposed to cyclical fluctuations and thus depend most on flexibility.

The macroeconomic stability is approximately measured by three variables: government deficit-to-GDP ratio, government debt-to-GDP ratio, and Eurozone membership. Fiscal deficit, the first variable, can be considered as a proxy for anticyclical policies in the sense of Keynes that are implemented to overcome shortfalls of demand and thereby stabilize the macroeconomic environment (Cerra et al., 2013). On the contrary, a high debt-to-GDP ratio is likely to limit the scope of action for active governmental interventions. The same holds for the uniform monetary policy in the Euro currency area that may reduce output growth in some countries during crises (Fingleton et al., 2015). It could be argued that fiscal deficit is more of an adaptive determinant than an inherent factor, but in our analysis, we determine the impact of fiscal deficit on growth as a function of public debt level, which can be regarded as an initial condition in each year. As all three variables are related to the scope of action for potential fiscal responses to an already eventuated crisis, we expect the above-mentioned effects to be relevant rather in the recovery than in the resistance phase.

3 The empirical model

The aim of our study is to provide empirical evidence for a spatially structured and phase-related system of short-term resilience determinants. We utilize a hierarchical linear model that allows taking complex spatial dependencies into account, in our case: regions nested within countries. Disregarding the embeddedness of lower level units can lead to biased estimates because spatial heterogeneity and 'intraclass correlation' are not appropriately captured (Mont-

[5] See Table A.3 for the summary statistics, data sources, and variable descriptions.
[6] Both indices are multiplied with -1, so that higher values indicate a less rigid labor market and a more competition-friendly environment, respectively.

marquette and Mahseredjian, 1989; Antweiler, 2001).[7] One important consequence is that the application of ordinary least squares (OLS) regression models would be error-prone. In our case, the OLS assumption of independent observations is violated. In fact, the error terms are positively correlated as regions in the same country are influenced by the same institutional setting. Hence, if the standard errors were computed under the assumption of an independent and identically distributed error term, they would tend to be downward biased and the risk of Type I errors would increase (Moulton, 1986; Moulton, 1990).

The following model serves as our baseline model throughout the analysis:

$$\boldsymbol{y_{ijt} = \mathbf{X}_{ijt-1}\beta_r + \mathbf{Z}_{jt-1}\lambda_r + \mathbf{X}_{ijt-1} \times \mathbf{Z}_{jt-1}\gamma_r + \theta_i t + \varepsilon_{ijt}} \quad \textbf{(1)}$$

where the dependent variable y_{ijt} denotes our indicator of resilience outcome proxied by growth of real GDP per capita of region i in country j at period t. X_{ijt-1} represents explanatory (exogenous) variables at the regional level including an intercept and economic structure variables. Z_{jt-1} relates to a set of variables at the national level containing country-specific indicators of the regulatory regime and macroeconomic stability. $\mathrm{X}_{ijt-1} \times \mathrm{Z}_{jt-1}$ denotes cross-level-interactions between region-specific indicators and national externalities. Note that all variables in X_{ijt-1} and Z_{jt-1} are lagged by one year to avoid reverse causality with output growth. This assumption implies that regions require time to internalize national externalities and that the economic structure exerts delayed impacts on growth. Since the inherent determinants possess only small year-to-year variations, this assumption is not likely to affect our estimation results.[8] $\theta_i t$ denote region-specific time trends, while β_r, λ_r and γ_r represent parameters of interest to be estimated. The subscript r indicates that the parameters are regime-specific and hence vary between the three business cycle phases outlined in section 2.2.[9] The hierarchical structure is introduced via the remainder term ε_{ijt} which follows an error component structure:

$$\boldsymbol{\varepsilon_{ijt} = \alpha_{j,r} + \mu_{ij,r} + \nu_{ijt,r}} \quad \textbf{(2)}$$

$$\boldsymbol{\alpha_{j,r} \sim N(0, \sigma^2_{\alpha_r})} \quad \textbf{(3)}$$

$$\boldsymbol{\mu_{ij,r} \sim N(0, \sigma^2_{\mu_r})} \quad \textbf{(4)}$$

$$\boldsymbol{\nu_{ijt,r} \sim N(0, \sigma^2_{\nu_r})} \quad \textbf{(5)}$$

[7] This approach is employed in many studies to confront the problem of (spatially) nested data, e.g. in: analyses of house price variations in districts (Baltagi et al., 2014; Fingleton et al., 2018); examination of the drivers of student's entrepreneurial climate perceptions (Bergmann et al., 2018); economic evaluation of regional health effects (Eibich and Ziebarth, 2014); estimation of spatial demand patterns (Case, 1991); educational studies where pupils are nested within schools or classrooms (Montmarquette and Mahseredjian, 1989).

[8] For example, the correlation coefficient between share of industry measured by data in 2004 (2009) and 2005 (2010) is 0.9942 (0.9850).

[9] Phase-related temporal variation in the model is captured by estimating a standard change point model, where the pre-defined resilience phases (see section 2.2) serve as structural breaks. More precisely, we created a dummy variable for each discrete regime r (taking a value of one for observations in years belonging to the regime (resilience phase) r and zero for observations in all other years) and interacted each regional and national level covariate with the regime-dummies.

where α_j denotes an unobservable country-specific time-invariant effect which is assumed to be normally distributed. μ_{ij} stands for the nested effect of region i within the jth country which is normally distributed, while ν_{ijt} symbolizes the remainder disturbance which follows a normal distribution. The assumption that the nested error components are independent of each other and among themselves is a standard assumption in the literature (Baltagi et al., 2014). We allow for phase-specific unobservable effects on the hierarchical levels to account for potential changes in unobserved heterogeneity. Failing to account for temporal variation in unobserved heterogeneity leads – in case it exists – to omitted variable biases and hence results in invalid inferences in panel data analysis (Park, 2012). This justifies, apart from the region-specific time trends, the interaction of all regression parameters (both observed and unobserved factors) with each of the three model phases. The hierarchical linear model is estimated according to the maximum likelihood procedure as described by Antweiler (2001).

The objective of the statistical model is to isolate the effects of the selected resilience determinant from effects that are related to (unobservable) confounding factors. In this regard, the panel data set-up offers two main advantages. First, we observe a longer time range and are able to assess the impacts of determinants from several shock-events of the same 'nature' (see section 2.1). This enables the model to absorb all cross-sectional differences in each resilience phase, preventing these average differences from influencing our estimates. Any time-constant region- or country-specific characteristics are accounted for via level-specific effects as expressed in formula (3) and (4). These parts of the error component are catch-all terms for any sources of spatial (unobserved) heterogeneity at regional and national level. This is particularly important as our study focuses on inherent determinants of resilience that are likely to be correlated with confounding time-sluggish factors deriving from, for example, the institutional setting (see section 2.3). Furthermore, gradual changes in regional growth rates that may be driven by slowly altering factors, such as demographic shifts, integration in the global economy, evolving institutions or slow adjustments in economic policies as well as long-run conditional convergence, are accounted for by region-specific time trends (Barro and Sala-i-Martin, 2004). Second, the panel model utilizes annual data and thereby captures temporal variations in the determinants of interest. In contrast to cross-section models that regress static pre-shock values of determinants on resilience indicators, our model recognizes that resilience determinants are exposed to potential shock-induced changes and adjustments (besides yearly fluctuations).

To provide evidence for a hierarchical system of resilience determinants we ascertain whether the national institutional setting proves to be relevant in addition to the regional level, and thus may be regarded as an autonomous dimension in explaining variations in resilience across regions. The Intraclass Correlation Coefficient (ICC) indicates the proportion of overall variance in regional growth that can be attributed to a specific hierarchical level in the model. By this measure of variance decomposition, we calculate the relative importance of each nested level. In addition, we have a primary interest in the detection of cross-level-interaction effects between the regional and national level in case that the impact of a regional determinant is further moderated by contextual factors at the national level. The coefficient of γ_r indicates whether a statistical significant relationship between determinants across levels arises in different phases of resilience. Finally, we empirically test the (null) hypothesis that the model parameters are equal across the resistance and recovery phase. Its purpose is to detect potentially heterogeneous phase-specific effects of resilience determinants. If the null hypothesis is rejected for a parameter, we can infer that the impact of the corresponding determinant on regional growth varies between the two components of short-term resilience.

The procedure of our empirical analysis consists of three consecutive steps. First, we employ an intercept-only model by means of which we calculate the ICC and assess the phase-specific importance of each level, respectively (see Table 2). Second, we add variables from both the regional and national level, before we test for cross-level interaction effects. We also test the sensitivity of estimation results by moving the endpoint of recovery from 'return to pre-crisis level' to 'return to counterfactual level' (see Figure 1b) and further replace national recessions by banking crises as exogenous shock events (see Table 3). It should be noted that our baseline model estimates the 'average' or 'pooled' impact of resilience determinants over the entire sample for shocks that exhibit a similar 'nature'. However, as requested by Martin et al. (2016), we bear in mind that the impact of resilience determinants might vary across different settings. For this reason, we re-run our baseline model for spatial and temporal subsamples (see Table 4).

4 The patterns of regional economic resilience in Europe

4.1 National differences in regional resilience

Table 2 shows the results of the intercept-only model, which are used to establish the share in variance of the two spatial levels under investigation. As stated through the ICC values in the penultimate line, 44.9% of the variance in regional GDP development during resistance phases of national recessions can be attributed to the national level, while the same level accounts for only 22.0% of growth variance in the subsequent recoveries. Similar results are received in the case of banking crises. Apparently, the relative importance of the overall institutional frame at national level tends to be higher in periods of output downturn, which fits in well with the observation that the within-country similarity of regions is comparatively higher in the resistance phase. At the same time, the influence of the national factors mitigates when the growth path switches to positive rates, indicating that regional determinants play a key role once the macroeconomic pressure diminishes. All in all, the test results strongly support the relevance of a national contextual level as well as the existence of (at least) two temporal growth regimes.[10]

[10] To underpin this assertion, we conduct likelihood-ratio tests to compare the goodness of fit of the current model with alternative model set-ups without macro level or distinct phases of resilience (see Table A.4 in the Appendix).

Table 2: Variance components of the hierarchical system

	(1) Shock: National Recessions		(2) Shock: Banking Crises	
	Resistance	Recovery	Resistance	Recovery
Intercept	-0.0327 ***	0.0352 ***	-0.0325 ***	0.0349 ***
	(0.0052)	(0.0033)	(0.0050)	(0.0039)
Variance component: country (σ_α)	0.0235	0.0130	0.0220	0.0162
Variance component: region (σ_μ)	0.0129	0.0044	0.0031	0.0056
Variance component: residual (σ_v)	0.0224	0.0241	0.0256	0.0249
ICC: country	0.4491	0.2200	0.4200	0.2885
Adjusted Overall R-Squared	0.4228		0.4341	

Notes: Variance components of hierarchical levels are expressed as square root of the variance to present the unexplained dispersion on each level in units of the dependent variable. ICC: country indicates the share of country-level variance in overall variance. The models are based on data from 249 NUTS-2 regions nested in 22 countries over 24 years (5,976 observations). ***, **, * denote significance at the 1%, 5%, 10% level, respectively.

In Figure 3, we plot the country effects separately for each growth phase to visualize the magnitude and patterns of the national differences. During the resistance phase, national deviations from the sample mean range from -4.62 percentage points (Lithuania) to 2.51 percentage points (Norway) in GDP growth in the case that national recessions are defined as shock-events (see Figure 3a). The average deviation between country effects is 2.35 percentage points which is equivalent to 0.87 standard deviations in phase-specific regional growth. The huge disparities in country effects indicate that regions in different countries react differently to recessionary shocks. Furthermore, Figure 3 provides evidence that there are clusters of negative and positive national effects. All countries in Eastern Europe exhibit below-average national effects, with statistically significant deviations from the sample average in the Baltic States and Poland, whereas regions in EU-15 states and Norway show, on average, a more resilient response towards national recessions. This relation is reversed in the phases of recovery. During recovery-growth, the mean deviation of country effects drops to an equivalent of 0.52 standard deviations (see Figure 3b). In this phase, only six country effects exhibit significant deviation from the sample mean in contrast to twelve significant deviants in the predecessor phase. Hence, the plotting of the country effects confirms a central finding of the intercept-only models, which is that the influence of the national level is comparatively high in the phase of resistance and considerably drops in the period of recovery (see Figure 3).

The right column of Figure 3 displays the phase-specific country effects in case banking crises serve as exogenous shock-events (see Figure 3c-d). The findings are very similar to those of the baseline model. We therefore argue that potential issues of endogeneity are rather weak or absent in our initial model set-up.

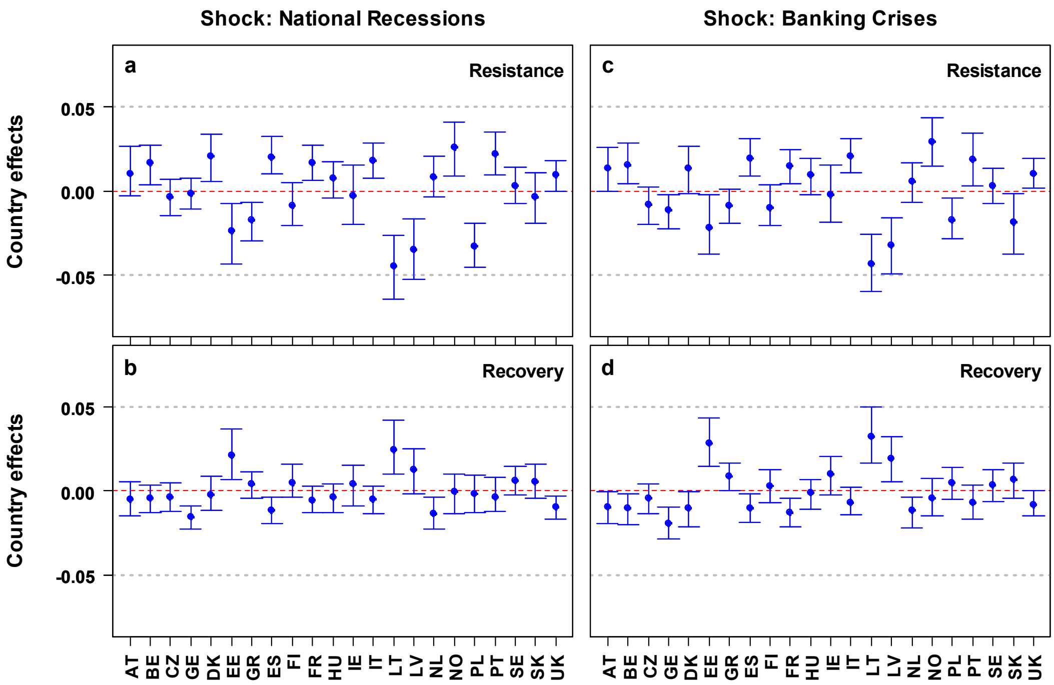

Figure 3: Phase-related country effects.

Notes: Figure displays country effects calculated on basis of intercept-only models (Table 2). Blue dots indicate point estimates of country effects centered by the sample mean growth rate in each phase and whiskers mark the corresponding 95% confidence intervals. Country effects represent national deviations from the sample mean growth rate in each phase. Red dashed lines indicate the sample mean growth rates (phase-specific intercept of the intercept-only model).

A distinctive feature of Figure 3 is that upward (downward) deviations of country effects from the sample mean in resistance years are accompanied by downward (upward) deviations in the recovery phase. To further investigate this conjecture, we plot country and region effects of these two sequential growth phases against each other. With regard to the country effects, whose plots are displayed in Figure 4a, the negative resistance-recovery nexus becomes immediately visible. The slope coefficient of the regression line indicates a statistically significant relationship at the 1% level. This result, however, should not be treated without caution given the relative small number of observations. The corresponding findings for the regional effects, as presented in Figure 4b, are less conclusive. Though the sign of the slope coefficient is also negative, the relation between resistance- and recovery-growth is rather weak and statistically not significant. Apparently, the impact of the overall institutional frame at country level – not necessarily of each national determinant, of course – on regional growth is contrary in the resistance and in the recovery phase. With respect to regional resilience, this finding is a two-edged sword: On the one hand, a given institutional setting helps to stabilize regional economies in periods of shock-induced downturns; on the other hand, the same setting impedes regional recovery during subsequent economic upswings. Inversely, a setting that expedites the recovery process obstructs the capacities to resist. Either way, the results highlight the autonomous role of the national level within the hierarchical system.

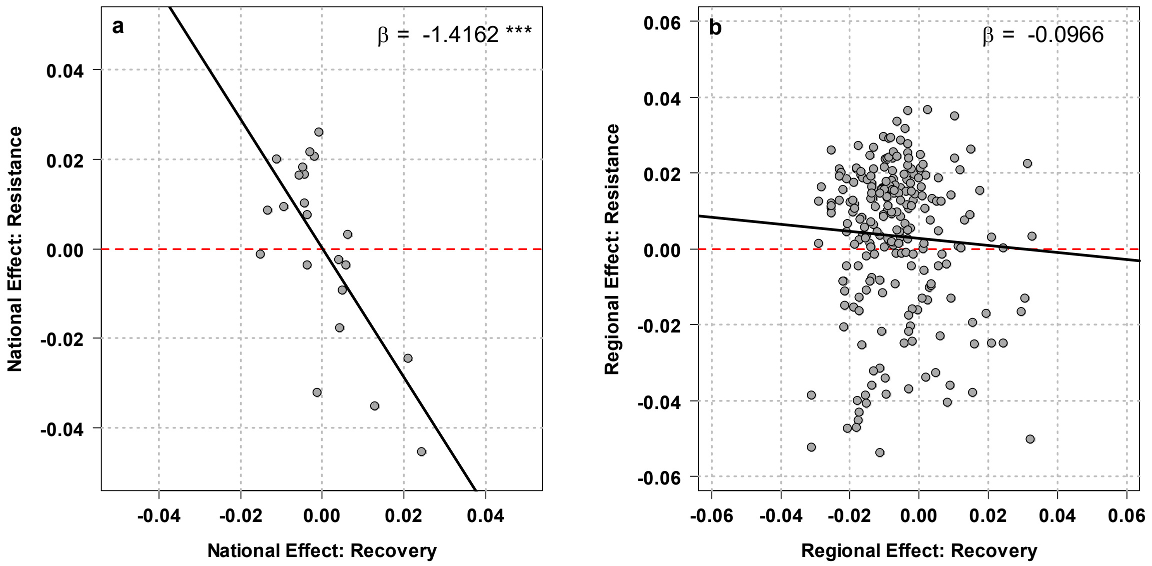

Figure 4: Relationship of national and regional effects in short-term resilience phases.

Notes: Scatterplots show the relationship between country effects in sequential resilience phases (a) and between regional effects in sequential resilience phases (b). Black line represents fitted regression line for each scatterplot. β denotes the slope of regression line, asterisks indicate statistical significance at the 1% (***), 5% (**), 10% (*) levels. National and regional effects are calculated on basis of estimation results from model (1) in Table 2.

4.2 How determinants vary between phases and interact across levels

As documented by the results of the variance decomposition, a substantial share of regional growth variance is to be found at the national level. Thus, the affiliation to different national contexts can contribute to explain variations in growth performance between regions, which applies not only, but particularly to the resistance phase (see section 4.1). In a next step, we investigate if determinants in our sample exert a statistically significant impact, whether they interact across levels and to what extent the patterns identified are phase-specific. Table 3 yields the estimation results of the hierarchical linear model. We run a number of regressions while adding variables of the regional and national level in a step-wise procedure. Model 3 is equivalent to the full model, including determinants of both hierarchical levels as well as cross-level interactions. In comparison to the intercept-only model, the adjusted overall R-squared increases only slightly across models, indicating that the added time-sluggish determinants hardly improve the fit of the model. In other words, the impacts of the inherent determinants on growth are, for the most part, already captured in the intercept-only model by means of the region and country effects as intended by our estimation strategy. Furthermore, the coefficients are consistent across models in Table 3, giving us confidence in the reliability of our estimation results.

Starting with the determinants at regional level, we observe that a higher presence of the non-market sector reduces, all other things being equal, the growth performance in both phases of short-term resilience.[11] This finding is partly counterintuitive: On the one hand, the recovery-retarding effect of a large public sector appears quite plausible given its lack of inherent market forces. On the other hand, the same reason has led us to expect that a high share of non-market activities would act as an ad-hoc stabilizer during recessionary downturns. A possible explanation for its rather destabilizing effect, however, could be the widening of fiscal austerity programs that cut-down spending on the public sector during the crisis (Martin et al., 2016). Then again, the results for FBS and industry shares correspond with our theoretical considerations (see section 2.3). Hence, regions that are specialized in manufacturing reveal a distinctively erratic response to recessionary shocks which we explain with the high cyclicality of manufacturing and production activities. On the contrary, regions that are characterized by a high share of FBS show a more stable development throughout the crises. The reason could be that many business-related services are based on rather long-term client relationships and thus are less affected by short-term turbulences in international markets.

Phase-specific impacts can also be detected with regard to the determinants at country level. With regard to the regulatory regime, the findings are partly in line with our theoretical reasoning (see section 2.3). That is, less regulated product and labour markets exert a supporting effect on recovery growth, while, contrary to our expectations, a higher degree of regulation does not mitigate the shock-induced impact in the resistance phase. Another determinant that shows effects of varying intensity across resilience phases is Eurozone membership. While it lacks a statistically significant impact on regional resistance, being a member of the Eurozone noticeably impedes a region's capability to recover. This finding is consistent with existing literature. A possible explanation is that regions in the European monetary union can – at least temporarily – suffer from an unfitting monetary policy as, for instance, the (national) instrument of currency devaluation is no longer available. A thorough discussion of this and further reasons can be found in Fingleton et al. (2015). A different macroeconomic indicator in our empirical set-up is fiscal policy. Relating thereto, we follow Cerra et al. (2013) and use fiscal deficit as variable to measure the overall fiscal stimulus. According to our results, regions nested in countries with expansionary fiscal incentives (expressed through larger values of fiscal deficit-to-GDP ratio) tend to benefit from an ad-hoc growth stabilizing effect of government intervention. Yet, the resistance-improving effect diminishes with increasing government debt-to-GDP ratio and eventually turns negative. The decreasing effect size and the finding that fiscal measures wear off with high indebtedness of a country is in line with other studies that examine the relationship for national GDP growth rates (Cerra et al., 2013; Hubbart, 2012).[12]

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[11] Please note: In case determinants are involved in cross-level interactions, the corresponding coefficients express the marginal effect when all interacted factors are at their sample mean (grand mean centering of explanatory variables).

[12] We like to remind the reader that all explanatory variables are lagged by one year. This standard approach mitigates the bias of reserve causation (e.g. Cerra et al., 2013; Christiano et al., 1999). For example, under Keynesian theories, an increase in fiscal deficit would boost growth. On the other hand, an increment in growth caused by policy actions would likely generate a fiscal surplus due to increased tax revenues. As pointed out by Cerra et al. (2013), potential endogeneity biases the coefficient towards zero. We thus can be confident that, in case we do find an effect, it is likely to be at the lower bound of the true policy impact.

Table 3: Baseline results and robustness checks

	Shock: National recessions									Recovery to counterfactual level			Shock: Banking crises		
	(1)			(2)			(3)			(4)			(5)		
	Resistance	Recovery	Difference	Resistance	Recovery	Difference	Resistance	Recovery	Difference	Resistance	Recovery	Difference	Resistance	Recovery	Difference
Intercept	-0.0327 ***	0.0352 ***	-0.0679 ***	-0.0242 ***	0.0407 ***	-0.0649 ***	-0.0242 ***	0.0392 ***	-0.0643 ***	-0.0253 ***	0.0378 ***	-0.0631 ***	-0.0239 ***	0.0360 ***	-0.0598 ***
	(0.0052)	(0.0033)	(0.0072)	(0.0054)	(0.0042)	(0.0075)	(0.0052)	(0.0044)	(0.0075)	(0.0060)	(0.0046)	(0.0071)	(0.0047)	(0.0051)	(0.0083)
Regional Sector Structure (Shares)															
Industry				-0.0382	0.0285	-0.0667 **	-0.0042	0.0665 **	-0.0707 *	-0.0049	0.0624 **	-0.0673 **	0.0111	0.0811 ***	-0.0700 **
				(0.0271)	(0.0260)	(0.0305)	(0.0296)	(0.0316)	(0.0314)	(0.0290)	(0.0300)	(0.0310)	(0.0275)	(0.0318)	(0.0322)
FBS				-0.0165	-0.0076	-0.0089	0.0029	-0.0251	0.0280	0.0078	-0.0285	-0.0207	0.0065	-0.0053	0.0118
				(0.0375)	(0.0366)	(0.0441)	(0.0402)	(0.0423)	(0.0476)	(0.0400)	(0.0393)	(0.0442)	(0.0390)	(0.0448)	(0.0503)
Non Market				-0.1105 ***	-0.0975 ***	-0.0130	-0.0935 **	-0.0965 **	0.0030	-0.0879 **	-0.0954 **	0.0075	-0.0639 *	-0.0910 **	0.0270
				(0.0370)	(0.0381)	(0.0430)	(0.0393)	(0.0423)	(0.0447)	(0.0386)	(0.0413)	(0.0427)	(0.0373)	(0.0431)	(0.0494)
National Determinants															
Product Market Regulation				0.0046	0.0139 ***	-0.0092 *	0.0037	0.0139 ***	-0.0102 *	0.0015	0.0096 **	-0.0081 *	0.0056	0.0041	0.0015
				(0.0050)	(0.0046)	(0.0055)	(0.0051)	(0.0046)	(0.0057)	(0.0049)	(0.0045)	(0.0054)	(0.0046)	(0.0045)	(0.0058)
Labour Market Regulation				-0.0025	0.0078 **	-0.0103 **	0.0011	0.0070 *	-0.0059 *	0.0016	0.0051	-0.0035	-0.0052	0.0052	-0.0103 *
				(0.0044)	(0.0036)	(0.0053)	(0.0047)	(0.0038)	(0.0058)	(0.0047)	(0.0039)	(0.0057)	(0.0043)	(0.0038)	(0.0060)
Euro				-0.0022	-0.0134 ***	-0.0122 **	-0.0024	-0.0132 **	0.0108 **	-0.0010	-0.0099 **	0.0089 **	-0.0081	-0.0028	-0.0053
				(0.0048)	(0.0046)	(0.0056)	(0.0047)	(0.0049)	(0.0057)	(0.0043)	(0.0044)	(0.0050)	(0.0055)	(0.0053)	(0.0069)
Government Debt				0.0329 ***	0.0208 **	0.0121	0.0358 ***	0.0190 **	0.0167	0.0352 ***	0.0179 **	0.0173 *	0.0300 ***	0.0226 **	0.0074
				(0.0071)	(0.0078)	(0.0094)	(0.0074)	(0.0079)	(0.0105)	(0.0073)	(0.0081)	(0.0101)	(0.0071)	(0.0082)	(0.0108)
Fiscal Deficit				0.0430	0.0604 *	-0.0174	0.0445	0.0535	-0.0090	0.0443	0.0542	-0.0099	-0.0026	0.0248	-0.0274
				(0.0320)	(0.0348)	(0.0449)	(0.0328)	(0.0347)	(0.0482)	(0.0327)	(0.0336)	(0.0459)	(0.0298)	(0.0347)	(0.0475)
Government Debt * Fiscal Deficit				-0.3131 ***	-0.0062	-0.3069 **	-0.2998 ***	0.0205	-0.3203 **	-0.2775 ***	0.0569	-0.3344 ***	-0.2153 ***	0.0569	-0.2722 *
				(0.0743)	(0.1284)	(0.1388)	(0.0769)	(0.1278)	(0.1512)	(0.0783)	(0.1167)	(0.1310)	(0.0760)	(0.1228)	(0.1407)
Cross-Level Moderations															
Industry * Product Market Regulation							0.0786 **	0.0020	0.0766 **	0.0714 **	-0.0012	0.0726 **	0.0572 *	-0.0087	0.0659 *
							(0.0333)	(0.0329)	(0.0346)	(0.0314)	(0.0295)	(0.0310)	(0.0302)	(0.0328)	(0.0395)
Industry * Labour Market Regulation							0.0710 **	0.0152	0.0558	0.0613 **	0.0067	0.0546	0.0104	-0.0028	0.0133
							(0.0319)	(0.0338)	(0.0258)	(0.0316)	(0.0318)	(0.0309)	(0.0327)	(0.0380)	(0.0432)
FBS * Product Market Regulation							-0.0218	0.0030	-0.0249	-0.0229	0.0025	-0.0254	0.0159	-0.0091	0.0249
							(0.0557)	(0.0468)	(0.0998)	(0.0517)	(0.0464)	(0.0508)	(0.0512)	(0.0477)	(0.0627)
FBS * Labour Market Regulation							0.0536	-0.0463	0.1000	0.0447	-0.0536	0.0983	-0.0031	-0.0633	0.0602
							(0.0441)	(0.0459)	(0.0975)	(0.0433)	(0.0424)	(0.0416)	(0.0512)	(0.0464)	(0.0542)
Non Market * Government Debt							-0.1714 ***	-0.0972	-0.0742	-0.1530 **	-0.1033	-0,0497	-0.1705 **	-0.1096	-0.0609
							(0.0673)	(0.0901)	(0.1018)	(0.0678)	(0.0794)	(0.0914)	(0.0674)	(0.0906)	(0.1076)
Variance component: country (σ_α)	0.0235	0.0130	0.0105	0.0224	0.0155	0.0069	0.0207	0.0160	0.0047	0.0207	0.0165	0.0042	0.0171	0.0168	0.0003
Variance component: region (σ_μ)	0.0129	0.0044	0.0085	0.0048	0.0048	0.0000	0.0051	0.0059	-0.0008	0.0051	0.0052	-0.0001	0.0039	0.0060	-0.0021
Variance component: residual (σ_ν)	0.0224	0.0249	0.0025	0.0248	0.0237	0.0011	0.0250	0.0234	0.0016	0.0250	0.0232	0.0018	0.0251	0.0244	0.0007
ICC: country	0.4491	0.2200	0.2291	0.4400	0.2900	0.1500	0.4046	0.3063	0.0983	0.4046	0.3241	0.0805	0.3113	0.3089	0.0024
Adjusted Overall R-Squared	0.4228			0.4422			0.4488			0.4805			0.4499		

Notes: Country effects, region effects, and region-specific time trends included but not reported. For the sake of brevity, results are only reported for the components of short-term resilience (resistance and recovery). All metric predictor variables are grand mean centered. Variance components of hierarchical levels are expressed as square root of the variance to present the unexplained dispersion on each level in units of the dependent variable. ICC: country indicates the share of country-level variance in overall variance. Columns (4) and (5) show robustness checks: (4) end of regional crisis is determined by recovery to counterfactual output level instead of return to pre-crisis level; (5) shocks to the macroeconomic environment are defined by banking crises instead of national recessions. All models are based on data from 249 NUTS-2 regions nested in 22 countries over 24 years (5,976 observations). ***, **, * denote significance at the 1%, 5%, 10% level, respectively.

However, phase-related patterns of influences are not restricted to either the regional or the national level. Similarly, we identify phase-sensitive cross-level interactions that point towards interdependencies between regional capacities and contextual factors on national level.[13] The phase-sensitivity manifests itself through the contrast between discernible significant cross-level interactions in the resistance phase and the obvious absence of such effects during recovery. This finding corresponds with the comparatively low share of country-level variance in overall variance when the regional economy starts to recover (see Table 2 in section 4.1). Apparently, the diminishing relevance of the national level during recovery does not stop at the corresponding moderation effects.

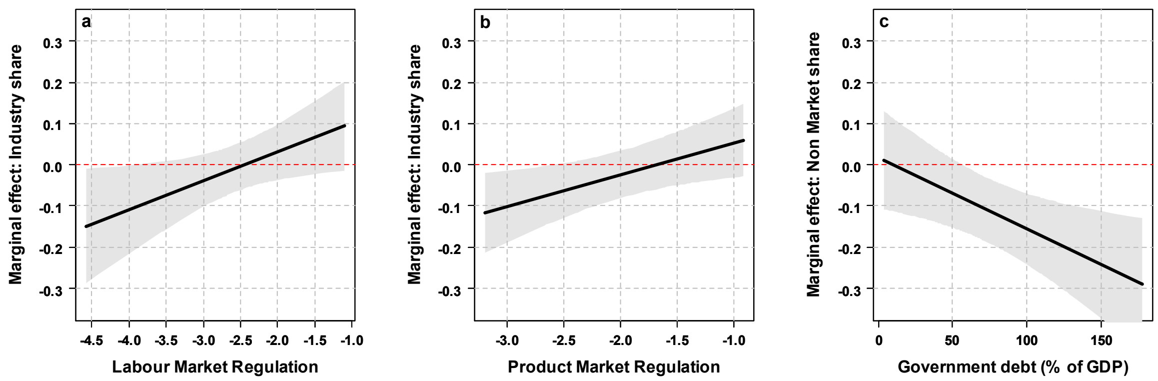

Figure 5: Cross-level interactions in resistance phase.

Notes: Black lines show point estimates for marginal effect of regional determinant on GDP per capita growth for different values of national moderator with 95% confidence intervals (grey). Point estimates are calculated on basis of estimation results from model (3) in Table 3 (resistance phase).

To exemplify the operating principle of cross-level interactions, we visualise the marginal growth effects of 'regional industry share' and 'regional non-market share' at different values of selected national moderators in Figure 5. Evidently, as to be seen in Figure 5a resp. 5b, the resistance-impeding effect of a high industry share becomes effective only in regions that are nested in countries were the regulation of labour resp. product markets is relatively low, whereby lower index values express a more rigid regulatory regime. In contrast, less strictly regulated macro environments do not enhance the resilience effect originating from the industry sector, at least not in statistical meaningful sense. In geographical terms, the resistance-reducing interplay between industry share and regulation can be traced back to the rigid labour market in Portugal and the relatively high barriers for competition in Portugal, Greece, Hungary, Poland, and in the Czech Republic. Besides, it should be noted that statistically relevant interactions involving the regulatory regime are restricted to the cyclically sensitive industry sector, while the financial and business services are not exposed to any national moderator at all.

[13] The residual standard deviation on national level σ_α decreases from 2.35 percentage points in the intercept-only model to 2.07 percentage points in model 3 (Table 3). On the other hand, the reduction of the national variance component is negligible in model 2, which contains national determinants but excludes cross-level interactions, compared to the intercept-only model. From these findings, we conclude that the inclusion of cross-level interactions is the main driver of the reduction of unexplained variance on national level in our case study sample.

Another example of a cross-level interaction is depicted in Figure 5c. Here, an increase in non-market share exhibits a statistically negative impact on output growth during the resistance period if regions are nested within countries that possess a debt-to-GDP ratio above 50 percent. In our sample, this threshold is crossed by all Western European, but by none of the Eastern European countries which can be explained by the shorter budget history of the latter. In addition, the negative growth effect of the non-market sector intensifies with higher government debts and even in the case of a relatively low debt-to-GDP ratio, we do not find any stabilizing effects from the non-market sector.

Eventually, we conduct a series of robustness checks that employ different operationalization methods and model specifications, respectively (see Table 3 and Appendix A.5). Model 4, to start with, shows the estimation results in the case that the counterfactual output level determines the end of the recovery period instead of the pre-crisis level (as depicted in Figure 1b). As displayed in Table 3, this procedure provides almost identical results as the baseline model. This may be interpreted as suggesting that short-term recovery and economic growth during stable times (here approximated by the longer recovery period) are driven by similar determinants, while it is the resistance period that is exposed to different, partly even opposing influences. Model 5, in turn, exploits banking crises as exogenous shock-events instead of national recessions (see section 2.1). Again, the estimation results are largely in line with our findings from the baseline model. The only discrepancy, however, refers to the indices of labour resp. product market regulation that – with the exception of the cross-level interaction between industry share and product market regulation – lose statistical significance when re-defining the shock event (see Table 3). As it would appear, banking crises, as long as they do not result in national recessions, are only weakly connected with the national regulatory regimes. Moreover, the results are robust to estimation procedures that allow the time trend to evolve non-linear, use year dummies to account for any abrupt shocks common to all regions, account for spatial autocorrelation in growth between regions via spatial lag model (see Appendix A.5).

4.3 Accounting for potential heterogeneity across samples

In a next step, we generate temporal (model 1) and spatial (model 2) subsamples to examine the generalisability of our baseline results (see Table 4 for an overview). With regard to the temporal dimension (model 1), we split the sample into two periods (1991-2004 and 2005-2014). The purpose is to isolate the 'Great Recession' that – unlike previous crises – hit the vast majority of European regions in 2008 and onwards. We find that estimation results for the inherent determinants in both subsamples deviate from the baseline results as shown in Table 3. It appears that a large number of coefficients differ between both temporal subgroups at a statistically significant level. For example, we find no relevant impact stemming from high share of FBS for the 1991-2004 period, while it, however, significantly enhances the shock-sensitivity of regions during years of the 'Great Recession'. Also, we observe that the supporting impact of expansionary fiscal incentives becomes effective only during the years 2005-2014 and that, in addition, the positive interplay between industry share and lowly regulated labour markets shifts from the resistance to the recovery phase when moving to the earlier sub-period (1991-2004). On the whole, the differing results reveal some specific characteristics of the 'Great recession' including its origins in the financial sector, the rapid spillover to the real economy, the unparalleled severity of the subsequent downturn, and, as a consequence, the prominent use of anticyclical policy measures.

With respect to the spatial dimension (model 2), we separate regions in the economically more developed EU-15 countries and Norway from regions in Eastern Europe. The division of the sample into space-specific subgroups reveals differences regarding the impacts of resilience determinants. For instance, the recovery-enhancing effect of a high industry share at regional level (model 3 in Table 3) can only be confirmed for the EU-15 group (plus Norway), while the supporting effect of low labour market regulation at national level only applies to the group of Eastern European regions. Likewise, the statistically significant cross-level interactions of the resistance phase turn out to be relevant during both phases in EU-15 regions, while, with the exception that a more competitive-friendly environment reinforces the strengthening effect of the industry sector during recovery, we do not find any significant moderations across levels within the Eastern European group. The sample-specific mechanisms suggest that effects of resilience determinants might vary depending on the level of economic development.

In accordance with the heterogenous impacts of (some) determinants between temporal subsamples, we also detect divergent effects of determinants between spatial subgroups that each represent different stages of economic development. It hence becomes clear that our baseline results can hardly be generalised and the operating direction of single resilience determinants is subject to context-sensitive conditions, respectively (see also section 5). Nevertheless, all subsamples confirm the baseline results insofar as they identify relevant determinants at both hierarchical levels, cross-level interplays of inherent determinants, and, last but not least, the existence of phase-related patterns.

Table 4: Heterogeneity across samples

	(1)						(2)					
	Europe-wide crisis in 2008/2009 vs remaining shocks						EU-15 and Norway vs Eastern Europe					
	Resistance			Recovery			Resistance			Recovery		
	1991-2004	2005-2014	Difference	1991-2004	2005-2014	Difference	Non-East	East	Difference	Non-East	East	Difference
Intercept	-0.0210 ***	-0.0209	-0.0001	0.0396 ***	0.0542 ***	-0.0146	-0.0238 **	-0.0158	-0.0080	0.0400 ***	0.0040	0.0360
	(0.0080)	(0.0220)	(0.0204)	(0.0064)	(0.0177)	(0.0160)	(0.0092)	(0.0372)	(0.0413)	(0.0072)	(0.0292)	(0.0296)
Regional Sector Structure (Shares)												
Industry	0.0890 **	-0.0725	0.1615 ***	0.0513	0.1571 **	-0.1058	-0.0176	0.2069	-0.2245	0.0745 **	0.2075	-0.1330
	(0.0411)	(0.0432)	(0.0548)	(0.0403)	(0.0712)	(0.0787)	(0.0301)	(0.1279)	(0.1327)	(0.0325)	(0.1278)	(0.1338)
FBS	0.0770	-0.1205 **	0.1975 ***	-0.0471	-0.0461	0.0010	-0.0668 *	0.0194	-0.0862	-0.0481	-0.0412	-0.0069
	(0.0498)	(0.0583)	(0.0746)	(0.0492)	(0.0631)	(0.0775)	(0.0399)	(0.1840)	(0.1951)	(0.0435)	(0.1544)	(0.1659)
Non Market	-0.0215	-0.3028 ***	0.2812 ***	-0.1360 ***	-0.3153 ***	0.1793 **	-0.1723 ***	0.3000	-0.4723 *	-0.1421 ***	-0.1238	-0.0183
	(0.0545)	(0.0579)	(0.0733)	(0.0494)	(0.0683)	(0.0793)	(0.0406)	(0.2441)	(0.2461)	(0.0453)	(0.2118)	(0.2188)
National Determinants												
Product Market Regulation	0.0111	0.0548 ***	-0.0437 **	0.0180 **	-0.0195	0.0374 *	-0.0131 *	0.0255	-0.0385 *	0.0160 **	0.0161	-0.0001
	(0.0125)	(0.0133)	(0.0194)	(0.0076)	(0.0219)	(0.0210)	(0.0064)	(0.0224)	(0.0222)	(0.0066)	(0.0131)	(0.0143)
Labour Market Regulation	0.0050	0.0038	0.0012	0.0044	-0.0159 *	0.0203 **	-0.0074	0.1493 **	0.1568 **	0.0021	-0.0066	0.0088
	(0.0073)	(0.0093)	(0.0111)	(0.0056)	(0.0094)	(0.0087)	(0.0052)	(0.0775)	(0.0714)	(0.0054)	(0.0283)	(0.0285)
Euro	0.0157 *	-0.0518 **	0.0676 **	-0.0179 ***	-0.0348 **	0.0168	0.0207 ***	-0.0116	0.0323	-0.0125 **	-0.0595 **	0.0470 *
	(0.0086)	(0.0237)	(0.0238)	(0.0066)	(0.0153)	(0.0158)	(0.0052)	(0.0371)	(0.0366)	(0.0060)	(0.0242)	(0.0255)
Government Debt	0.0514 ***	0.0358 ***	0.0156	0.0059	0.0309 **	-0.0250	0.0448 ***	0.1610	-0.1162	0.0455 ***	-0.1218 ***	-0.1672 ***
	(0.0178)	(0.0102)	(0.0216)	(0.0160)	(0.0133)	(0.0198)	(0.0075)	(0.1234)	(0.1123)	(0.0096)	(0.0454)	(0.0454)
Fiscal Deficit	-0.0495	0.1738 ***	-0.2233 ***	-0.0020	0.1048 **	-0.1068	0.1553 ***	0.4131	-0.2578	0.1176 ***	0.0965	0.0211
	(0.0655)	(0.0484)	(0.0795)	(0.0720)	(0.0486)	(0.0859)	(0.0309)	(0.5703)	(0.5368)	(0.0419)	(0.1893)	(0.1922)
Government Debt * Fiscal Deficit	0.0630	-0.9404 ***	1.0034 ***	0.1156	0.0564	0.0593	-0.5566 ***	1.7383 *	-2.2949 **	-0.3662 **	1.1518 **	-1.5180 ***
	(0.1990)	(0.1009)	(0.2223)	(0.2234)	(0.2213)	(0.3178)	(0.0758)	(1.0633)	(1.0208)	(0.1712)	(0.4453)	(0.4736)
Cross-Level Moderations												
Industry * Product Market Regulation	0.1156 ***	0.0991 *	0.0156	0.0204	-0.0760	0.0964	0.0619 **	0.1320	-0.0701	0.0245	0.1826 **	-0.1581 *
	(0.0456)	(0.0599)	(0.0686)	(0.0444)	(0.1204)	(0.1197)	(0.0337)	(0.0895)	(0.0987)	(0.0344)	(0.0870)	(0.0920)
Industry * Labour Market Regulation	0.0422	0.0788 **	-0.0367	0.0609 *	0.0629	-0.0020	0.0492 *	0.0037	0.0455	0.0587 **	-0.1014	0.1601
	(0.0318)	(0.0368)	(0.0443)	(0.0319)	(0.0383)	(0.0452)	(0.0251)	(0.1344)	(0.1389)	(0.0283)	(0.1182)	(0.1243)
FBS * Product Market Regulation	-0.0261	0.4953 ***	-0.5214 ***	0.2096	0.0158	0.1938	0.0016	-0.4125	0.4141	0.0744	0.0301	0.0443
	(0.0830)	(0.1238)	(0.1225)	(0.2118)	(0.0378)	(0.2160)	(0.0555)	(0.3252)	(0.3215)	(0.0478)	(0.3334)	(0.34553)
FBS * Labour Market Regulation	0.0760	0.0860	-0.0100	-0.0376	0.0292	-0.0668	0.0021	-0.2245	0.2266	0.0045	-0.2123	0.2156
	(0.0576)	(0.0621)	(0.0588)	(0.0713)	(0.0294)	(0.0635)	(0.0429)	(0.3828)	(0.3782)	(0.0444)	(0.3518)	(0.3334)
Non Market * Government Debt	-0.0380	-0.0229	-0.0151	-0.0041	0.0079	-0.0120	-0.1383 **	-0.3283	0.1900	-0.1668 *	0.8009	-0.9677 *
	(0.1214)	(0.0840)	(0.1446)	(0.1203)	(0.1518)	(0.1797)	(0.0646)	(0.6231)	(0.5973)	(0.0929)	(0.5753)	(0.5766)
Variance component: country (σ_α)	0.0145	0.0243	-0.0098	0.0161	0.0172	-0.0011	0.0241	0.0191	0.0050	0.0129	0.0270	-0.0141
Variance component: region (σ_μ)	0.0049	0.0062	-0.0013	0.0060	0.0083	-0.0023	0.0069	0.0050	0.0019	0.0082	0.0080	0.0002
Variance component: residual (σ_ν)	0.0233	0.0254	-0.0021	0.0221	0.0249	-0.0028	0.0249	0.0257	-0.0008	0.0244	0.0261	-0.0017
ICC: country	0.3709	0.4635	-0.0926	0.3308	0.3004	0.0304	0.4652	0.3473	-0.1179	0.2007	0.4945	-0.2938
Adjusted Overall R-Squared	0.4995						0.4872					

Notes: Estimation results of baseline specification for subsamples of data: (1) sample is divided in two sub-periods, years from 1991 to 2004 and years after 2004 to separate the severe Europe-wide recession starting in 2008/2009 from the remaining shock-events; (2) subsamples for regions that belong to EU-15 countries (including Norway) and regions in Eastern Europe. ***, **, * denote significance at the 1%, 5%, 10% level, respectively.

5 Concluding remarks

5.1 Discussion

The aim of this paper was to provide empirical evidence for a spatial-temporal system of resilience determinants that so far has only been a theoretical idea (see section 1). This idea, however, is certainly justified. Grounded in the conceptual framework as developed by Ron Martin and colleagues (Simmie and Martin, 2010; Martin, 2012; Martin and Sunley, 2015; Martin et al., 2016), our empirical set-up integrates two hierarchically structured spatial levels (regions nested in countries) and two subsequent components of short-term regional economic resilience (resistance and recovery). The necessity to distinguish between different levels and phases is well documented by means of our empirical results. With respect to the spatial hierarchy, we find statistically significant determinants of resilience at the regional as well as at national level in both phases of short-term resilience. The simultaneous presence of cross-level interaction effects further indicates that the national context does not affect the resilience of all nested regions equally. Instead, the size and direction of growth effects from contextual factors depend on regional characteristics, as exemplified here by sectoral composition. From a regional perspective, this means that differences in resilience are not solely caused by unrelated determinants from different levels. In fact, the impacts of regional determinants are distinctively moderated by elements of their surrounding institutional setting. These findings imply that resilience determinants are hierarchically structured and that the regional patterns of resilience are additionally shaped by the interlinkages of country-specific institutional factors and regional determinants.

Examining the temporal dimension, we observe a diminishing relevance of the national level as well as the absence of statistically meaningful cross-level interactions during recovery (see section 4.1 resp. 4.2). The observation of varying, if not opposing directions of influences across the sensitivity and recovery phase, however, is not restricted to the cross-level interactions. It rather appears to be a general feature of our models covering both regional and national determinants (see section 4.2 and 4.3). Hence, our results tend to contradict with the finding of Di Caro and Fratesi (2018) according to which those factors that help to explain economic growth in normal resp. stable times are also useful to understand resilience patterns. If at all, this assumption might apply to the recovery but not to the resistance phase. Instead, ignoring the temporal two-component structure entails the risk of imprecise, if not false conclusions on the driving mechanisms stabilizing and/or destabilizing regional economies in times of crises. Such false conclusions may arise from the oppression of phase-specific patterns if, for example, opposing impacts of determinants in the resistance and recovery phase cancel each other out or if certain determinants should be relevant only for one specific phase, but not, on the other hand, for overall resilience.

Furthermore, findings from comparison of subsamples indicate heterogeneous patterns of influence across different time-periods and spatial subgroups, even for shocks that possess a similar 'nature' (see section 4.3). Overall, there is no straightforward evidence that changes in the impacts of determinants follow a regular pattern. The obvious absence of a general mechanism, however, is in line with the concerns expressed by Martin et al. (2016) who argue that averaging across cycles, or shock-events in our case, might produce misleading results since resilience capacities could not be viewed as being independent from the respective temporal and spatial context. Instead, it is plausible that the impact of a specific determinant depends, among other things, on the type of the shock, on the shock-specific transmission channels, on the duration and spatial expansion of the economic disturbance, and on spillover-effects that are triggered or altered by the shock. While it is notoriously difficult to disentangle the effect channels of resilience determinants, we conjecture, based upon our empirical results, that a hierarchically structured framework offers benefits to assess and understand the role of resilience determinants in the context of 'engineered resilience'. Our assessment is supported by the fact that significant effects stemming from regional and national determinants as well as from corresponding cross-level interactions are an essential part in all of our model specifications.

5.2 Limitations and outlook

Any model has its limitations, and we recognize a few caveats in our own approach. The first refers to the number of resilience determinants as our study is restricted to a small selection of inherent determinants and does not include any adaptive determinants. As a consequence, the generalizability of our results is somewhat limited. In particular, we cannot rule out that time-varying adaptive factors affect the interrelationship between inherent determinants and resilience outcome. Future empirical studies are thus encouraged to incorporate a larger number of inherent as well as adaptive determinants. The categories as suggested by Martin and Sunley (2013) may serve as guidelines in this regard (see Figure 2). Enlarging the number of determinants would not only allow taking into account potential interactions between inherent and adaptive factors, but also to examine the existence of hierarchically structured resilience determinants on a broader and more complex empirical base.

Second, the construction of hierarchical levels needs not to be constrained to two levels. For example, federal states can form the meso level in the case of a federalist political system within a country. Furthermore, it is conceivable that determinants at the upper level are interlinked with other institutional environments and that regional determinants might also depend to some extent on national factors that have their origin outside of the own institutional environment. Another level that is worth being integrated into a multi-level system is the micro level as it contains no less than the actual agents of economic resilience, for instance firms and entrepreneurs. All these extensions of our two-level model as portrayed in this case study are useful points of reference for future research.

Notwithstanding its only minor importance in our empirical set-up (see Appendix A.5), we consider the role of spatial spillovers as another keystone of future resilience research. Regardless of the spatial scale of analysis, the disregard of spillover-effects bears the risk of underestimating the effect-size of determinants. If the resilience capability, e.g. proxied by higher output growth, of a region depends on resilience capabilities in neighbouring regions, then the effect of a determinant is not constrained to the own region but indirectly affects resilience in neighbouring regions as well. Numerous examples for such interdependencies are plausible in the context of economic resilience. For example, negative demand shocks in specific regions might also lower the output of their trade partners that are not directly affected by the shock but suffer from deteriorating export opportunities; or disturbances in the financial system might initially affect the financial centres and then spill-out gradually to interlinked regions and with a further delay to more remote areas. Hence, further research on this topic is likely to improve our understanding of processes that shape the distributional patterns of shock-induced damage and resilience over space and time.

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Appendices

A.1: Literature overview

Study	Recessionary shock(s)	Operationalization of resilience (a)	Time range	Indicator	Sample	Determinants (b)			Quantitative method(s)
						Spatial level	Specific focus	Phase-specific	
Pudelko/Hundt/Holtermann (2018): Review of Regional Research	Great Recession of 2007-09 (GR)	Resistance = average growth rate (2009-low point) Recovery = average growth rate (low point-2012)	2007-2012	GDP	Germany - LMR (labor market regions)	Regional	Industry structure	Resistance, recocery	OLS, SL
Angulo/Mur/Trivez (2018): The Annals of Regional Science	GR	Engineering/ecological = post-shock growth drops Adaption = sectoral shift	2002-2015	Employment	Spain - NUTS-2	Regional	Industry structure	Type-specific: engineering, ecological, adaptive	Dynamic FE, SAR, shift share
Bristow/Healy (2018): The Annals of Regional Science	GR	Four groups (2008-11): resistant/recovered/ not recovered (upturn)/ not recoverd (no upturn)	2001-2011	Employment	EU - NUTS-2	Regional	Innovation capacities	No	Descriptive measures
Di Caro (2018): The Annals of Regional Science	Late 1970s-early 1980s, 1992-95, GR	Engineering/ecological = responses of regional labor market to changes in the national unemployment rate	1977-2014	Employment	Italy - macro regions	No determinants	None	No	LSTAR
Faggian/Gemmiti/Jaquet/ Santini (2018): The Annals of Regional Science	1995, GR	Four groups (2007-10): high/low resistance/recovery (compared to national average)	2007-2011	Employment	Italy - LLS (local labor systems)	Regional	Industry structure	No	Multinomial logit
Fratesi/Perucca (2018): The Annals of Regional Science	GR	Resistance = e.g., maximum reduction of GDP (ref=2008) Recovery = e.g., difference btw. low point and value in 2012	2007-2012	GDP	EU - NUTS-3	Regional	Territorial capital	Resistance, recocery	OLS
Kitsos/Bishop (2018): The Annals of Regional Science	GR	Difference btw. 2004-07 average and 2008-14 low point	2004-2014	Employment	UK - LAD (local authority districts)	Regional	Wide range, no specific focus	No	OLS
Mazzola/Lo Cascio/Epifanio/Di Giacomo (2018): The Annals of Regional Science	GR	Average of the annual percentage change from 2008-14	2000-2014	GDP, exports and employment	Italy - NUTS-3	Regional	Territorial capital	No	SAR, SEM

Study	Recessionary shock(s)	Operationalization of resilience (a)	Time range	Indicator	Sample	Determinants (b)			Quantitative method(s)
						Spatial level	Specific focus	Phase-specific	
Giannakis/Bruggeman (2017): European Planning Studies	GR	Non-resistant = 0, resistant = 1 (both compared to national average)	2002-2013	Employment	EU - NUTS-2	Regional	Wide range, no specific focus	No	Multilevel logistic regression
Ray/MacLachlan/ Lamarche/Srinath (2017): Environment and Planning A	1991/92, GR	Percentage decline from peak to trough	1987-2012	Employment	Canada - provinces	Regional	Industry structure	No	Shift share
Courvisanos/Jain/Mardaneh (2016): Regional Studies	throughout the 2000s, GR	Indirectly via cluster categories	2001-2011	Employment	Australia - LGA (local government area)	Regional	Income, type of region, industry structure	No	Cluster analysis
Dubé/PolèSe (2016): Regional Studies	GR	Resistant = no negative change over 1995-2009 rebound = no negative change over 2007-2012	1995-2012	Population, (un-)employment	Canada - economic and metropolitan areas	No determinants	None	No	Descriptive measures
Eraydin (2016): Regional Studies	1978–81, 1988–89, 1994, 2001, GR	Four groups: prospering/ shock-resistant/ non-resilient/ resilient-transforming	1978-2011	GDP	Turkey - NUTS-2	Regional	Vulnerarbility, resources adaptive capacity, policies	No	SUR, discriminant analysis, ANOVA
Martin/Sunley/Gardiner/Tyler (2016): Regional Studies	1974-1976, 1979-1983, 1990-1993, GR	Contraction (resistance) and expansion (recovery) compared to national average re-orientation: sectoral shift	1971-2013	Employment	UK - NUTS-1	Regional	Industry structure	Resistance, recocery, re-orientation	Shift share
Sensier/Artis (2016): Regional Studies	Mid 1970s, 1980s, early 1990s, GR	Percentage employment loss during recession(s)	1971-2011	Employment	Wales - unitary authorities	Firms	Industry affiliation	No	Descriptive measures, logistic regression
Crescenzi/Luca/Milio (2016): Cambridge Journal of Regions, Economy and Society	GR	Average annual growth rate since shock	2004-2010	GVA, Employment	EU - NUTS-2	Regional, national	Wide range, no specific focus	No	OLS
Fratesi/Rodriguez-Pose (2016): Cambridge Journal of Regions, Economy and Society	GR	Growth in period 2008-2012	1995-2012	Employment	EU - NUTS-2	Regional	Openness, economic performance in pre-crisis period	No	Descriptive measures, OLS (incl. spatial tests)

Study	Recessionary shock(s)	Operationalization of resilience (a)	Time range	Indicator	Sample	Determinants (b)			Quantitative method(s)
						Spatial level	Specific focus	Phase-specific	
Sedita/De Noni/Pilotti (2016): European Planning Studies	GR	Growth in period 2008-2013	2004-2013	(Un-)employment	Italy - LLS (local labor systems)	Regional	Industry structure	No	OLS
Sensier/Bristow/Healy (2016): Spatial Economic Analysis	Early 1990s, GR	Resistant/recovered/ not recovered (upturn)/ not recoverd (no upturn)	1992-2011	Employment, GDP	EU - NUTS-0, NUTS-3	No determinants	None	No	Descriptive measures
Balland/Rigby/Boschma (2015): Cambridge Journal of Regions, Economy and Society	City-specific	Resistance = vulnerability and crisis-intensity Recovery = crisis duration	1975-2002	Patents	USA - cities	Local	Wide range, no specific focus	Resistance, rececery	Logistic regression, OLS, Cox
Capello/Caragliu/Fratesi (2015): Journal of Economic Geography	GR	Downturn 07-09/ recovery 09-11/ downturn 11-12/ recovery 11-15 = annual average growth rates	1990-2030 (foresight)	GDP	EU - NUTS-2	Regional, national	Wide range, no specific focus	No	Scenario-based, quantitative foresight (MASST3 model)
Di Caro (2017): Papers in Regional Science	GR	Engineering/ecological = responses of regional labor market to changes in the national unemployment rate	1992-2012	Employment	Italy - NUTS-2	Regional	Wide range, no specific focus	Type-specific: engineering, ecological	LSTAR
Fingleton/Garretsen/Martin (2015): Journal of Economic Geography	GR	Comparison of counterfactual and actual recovery paths	1981-2011	Employment	EU - NUTS-2	Regional	Output, capital	No	Spatial panel
Cellini/Torrisi (2014): Regional Studies	Various recessions from 1890 to 2008	Post-shock growth rates	1890-2009	GDP	Italy - NUTS-2	No determinants	None	No	SURE, RCM
Di Caro (2014): Cambridge Journal of Regions, Economy and Society	Early 1980s, early 1990s, GR	Percentage recessionary decline (resistance) and post-recession growth (recovery) rel. to national performance	1977-2013	Employment	Italy - NUTS-2	Regional	Industry structure	Resistance, rececery	SUR, VECM
Fingleton/Garretsen/Martin (2012): Journal of Regional Science	1973-1975, 1980-1981, 1990-1991, GR	Post-shock growth rates	1971-2010	Employment	UK - NUTS-1	No determinants	None	No	SUR, VECM

Study	Recessionary shock(s)	Operationalization of resilience (a)	Time range	Indicator	Sample	Determinants (b)			Quantitative method(s)
						Spatial level	Specific focus	Phase-specific	
Martin (2012): Journal of Economic Geography	1979-1983, 1990-1993, GR	Contraction (resistance) and expansion (recovery) compared to national average re-orientation: sectoral shift	1972-2010	Employment	UK - NUTS-1	Regional	Industry structure	Resistance, recocery, re-orientation	Descriptive measures
Davies (2011): Cambridge Journal of Regions, Economy and Society	GR	Resistance = percentage point changes in unemployment rates (2008-2009) Recovery = ditto (2009-2010)	2005-2010	Unemployment	EU - NUTS-2	Regional	Policies	Resistance, recocery	Univariate OLS
Groot/Mohlmann/Garretsen/ de Groot (2011): Cambridge Journal of Regions, Economy and Society	GR (mainly at the national level)	Percentage change 2008-09	1980-2003, 2008-09	GDP	EU - NUTS-2	Regional	Industry structure	No	OLS
Dijkstra/Garcilazo/McCann (2015): Journal of Economic Geography	National shock: GR	Annual percentage change	1996-2011	GDP, Employment, Unemployment,	European regions: OECD TL3 regions and NUTS-3 regions	Regional	Region Types	No	Descriptives

A.2: Bank crisis and national recession dates

	National Recessions	Bank Crises
Austria (AT)	2009	2008-2012
Belgium (BE)	1993	
	2009	2008-2012
	2012	2008-2012
Czech (CZ)	1991-1992	
	1997-1998	1996-1998
	2009	2008-2012
	2012-2013	2008-2012
Denmark (DK)		1990-1992
	1993	
	2008-2009	2008-2011
	2012-2013	2008-2011
Estonia (EE)	1991-1994	1991-1993
	1999	
	2008-2009	2008-2011
Spain (ES)	1993	
	2009	2008-2012
	2011-2013	2008-2012
Finland (FI)	1991-1993	1991-1994
	2009	2008-2012
	2012-2014	2008-2012
France (FR)	1993	1993-1994
	2009	2008-2012
Germany (GE)	1993	
	2003	
	2009	2008-2012
Greece (GR)	1990	
	1993	1991-1995
	2008-2013	2008-2010

	National Recessions	Bank Crises
Hungary (HU)		1991-1994
	2009	2008-2012
	2012	2008-2012
Ireland (IE)	2008-2010	2007-2013
	2012	2007-2013
Italy (IT)	1993	1990-1995
	2008-2009	2008-2013
	2012-2014	2008-2013
Lithuania (LT)	1991-1994	
	1999	
	2009	2008-2011
Latvia (LV)	1991-1995	1995-1996
	2008-2010	2008-2011
Netherlands (NL)	2002	
	2009	2008-2012
	2012-2013	2008-2012
Norway (NO)		1990-1992
	2009	
Poland (PL)	1991	1991-1994
Portugal (PT)	1993	
	2003	
	2009	2008-2012
	2011-2013	2008-2012
Sweden (SE)	1991-1993	1991-1994
	2008-2009	2008-2011
	2012	
Slovakia (SK)	1999	1998-2000
	2009	2008-2011
United Kingdom (UK)	1991	1991
		1995
	2008-2009	2007-2011

A.3: Data description and summary statistics

Regional Level

Growth of real GDP per capita [Growth]
Data source: Cambridge Econometrics (CE)

Min.	1. Qu.	Median	Mean	3. Qu.	Max.
-0.1610	-0.0030	0.0149	0.0136	0.0326	0.2603

Share of Industrial Sector [Industry]
Description: Share of total GVA (%): Industry
Data source: Cambridge Econometrics (CE)

Min.	1. Qu.	Median	Mean	3. Qu.	Max.
0.0508	0.2348	0.2906	0.2900	0.3393	0.6475

Share of Financial and Business Services [FBS]
Description: Share of total GVA (%): Financial and Business Services
Data source: Cambridge Econometrics (CE)

Min.	1. Qu.	Median	Mean	3. Qu.	Max.
0.0516	0.1662	0.2183	0.2150	0.2505	0.5684

Share of Non Market Sector [Non Market]
Description: Share of total GVA (%): Non Market
Data source: Cambridge Econometrics (CE)

Min.	1. Qu.	Median	Mean	3. Qu.	Max.
0.1133	0.1926	0.2259	0.2284	0.2609	0.4449

National Level

Product Market Regulation [PMR]
Description: OECD Indicators of Product Market Regulation (index scale: 0-6) multiplied with -1: higher values indicate more competition-friendly regulatory environment
Data source: OECD

Min.	1. Qu.	Median	Mean	3. Qu.	Max.
-3.1900	-2.2300	-1.6400	-1.7670	-1.3400	-0.9200

Labour Market Regulation [LMR]
Description: OECD Indicators of Employment Protection (index scale: 0-6) multiplied with -1: equally weighted sub-indices Regular contracts including collective dismissals (EPRC) and Temporary contracts (EPT): higher values indicate less rigid labour market regulation
Data source: OECD

Min.	1. Qu.	Median	Mean	3. Qu.	Max.
-4.8300	-2.7600	-2.3800	-2.3620	-2.1700	-1.1000

Government Debt [GD]
Description: Total gross government debt-to-GDP ratio (%)
Data source: OECD

Min.	1. Qu.	Median	Mean	3. Qu.	Max.
0.0366	0.4263	0.5886	0.6382	0.7992	1.7790

Fiscal Deficit [FD]
Description: General government deficit as percentage of GDP (%): negative values indicate financial surpluses
Data source: OECD

Min.	1. Qu.	Median	Mean	3. Qu.	Max.
-0.1846	0.0170	0.0323	0.0347	0.0525	0.3213

Euro [Euro]
Description: Dummy indicating that Euro is used as currency
Data source: OECD

A.4: Likelihood-Ratio Tests: alternative model specifications

	Model with national level and resilience phases (Reference Model)
Reference Model without resilience phases	2827.7 [0.0000]
Reference Model without national level	191.2 [0.0000]
Reference Model without national level and resilience phases	2856.7 [0.0000]

Notes: Likelihood-Ratio tests comparing the intercept-only model (model (1) in Table 2) with alternative model specifications. Table shows test statistics and p-values in square brackets.

A.5: Additional robustness checks

	(1) Baseline		(2) Baseline: Time trends sq.		(3) Baseline: year dummies		(4) Baseline: spatial lag	
	Resistance	Recovery	Resistance	Recovery	Resistance	Recovery	Resistance	Recovery
Intercept	-0.0242 ***	0.0392 ***	-0.0184 ***	0.0457 ***	-0.0468 ***	0.0063	-0.0209 ***	0.0267 ***
	(0.0052)	(0.0044)	(0.0048)	(0.0050)	(0.0089)	(0.0049)	(0.0035)	(0.0035)
Regional Sector Structure (Shares)								
Industry	-0.0042	0.0665 **	0.0038	0.0785 **	-0.0394	0.0383	-0.0050	0.0533 *
	(0.0296)	(0.0316)	(0.0278)	(0.0296)	(0.0265)	(0.0309)	(0.0241)	(0.0275)
FBS	0.0029	-0.0251	0.0282	-0.0028	-0.0146	-0.0417	0.0179	-0.0255
	(0.0402)	(0.0423)	(0.0374)	(0.0391)	(0.0371)	(0.0395)	(0.0327)	(0.0360)
Non Market	-0.0935 **	-0.0965 **	-0.0615	-0.0679 *	-0.0657 **	-0.0729 **	-0.0585 **	-0.0804 **
	(0.0393)	(0.0423)	(0.0375)	(0.0405)	(0.0334)	(0.0331)	(0.0297)	(0.0348)
National Determinants								
Product Market Regulation	0.0037	0.0139 ***	0.0143 **	0.0246 ***	0.0021	0.0142 ***	0.0040	0.0119 ***
	(0.0051)	(0.0046)	(0.0049)	(0.0046)	(0.0048)	(0.0049)	(0.0037)	(0.0039)
Labour Market Regulation	0.0011	0.0070 *	0.0030	0.0086 **	-0.0034	0.0034	-0.0007	0.0045
	(0.0047)	(0.0038)	(0.0043)	(0.0040)	(0.0040)	(0.0036)	(0.0033)	(0.0033)
Euro	-0.0024	-0.0132 **	-0.0006	-0.0125 ***	0.0040	-0.0165 ***	-0.0014	-0.0123 ***
	(0.0047)	(0.0049)	(0.0044)	(0.046)	(0.0047)	(0.0050)	(0.0037)	(0.0044)
Government Debt	0.0358 ***	0.0190 **	0.0489 ***	0.0368 ***	0.0260 ***	0.0290 ***	0.0165 ***	0.0123 *
	(0.0074)	(0.0079)	(0.0077)	(0.0092)	(0.0067)	(0.0077)	(0.0057)	(0.0068)
Fiscal Deficit	0.0445	0.0535	0.0243	0.0387	-0.1335 ***	0.0233	-0.0334	0.0458
	(0.0328)	(0.0347)	(0.0330)	(0.359)	(0.0312)	(0.0356)	(0.0263)	(0.0326)
Government Debt * Fiscal Deficit	-0.2998 ***	0.0205	-0.3000 ***	-0.0675	-0.4467 ***	-0.1405	-0.1603 **	0.0196
	(0.0769)	(0.1278)	(0.0797)	(0.1300)	(0.0652)	(0.1194)	(0.0655)	(0.1162)
Cross-Level Moderations								
Industry * Product Market Regulation	0.0786 **	0.0020	0.0956 ***	0.0293	0.0433 *	-0.0268	0.0610 **	0.0159
	(0.0333)	(0.0329)	(0.0318)	(0.0338)	(0.0247)	(0.0327)	(0.0281)	(0.0307)
Industry * Labour Market Regulation	0.0710 **	0.0152	0.0676 **	0.0199	0.0584 **	0.0057	0.0697 **	0.0194
	(0.0319)	(0.0338)	(0.0302)	(0.0307)	(0.0275)	(0.0317)	(0.0282)	(0.0316)
FBS * Product Market Regulation	-0.0218	0.0030	-0.0018	-0.0431	-0.0323	0.0024	-0.0158	0.0256
	(0.0557)	(0.0468)	(0.0510)	(0.0465)	(0.0454)	(0.0446)	(0.0414)	(0.0409)
FBS * Labour Market Regulation	0.0536	-0.0463	0.0531	-0.0419	0.0279	-0.0446	0.0418	-0.0396
	(0.0441)	(0.0459)	(0.0415)	(0.0418)	(0.0366)	(0.0433)	(0.0360)	(0.0399)
Non Market * Government Debt	-0.1714 ***	-0.0972	-0.2098 ***	-0.1195	-0.1774 ***	-0.1545 *	-0.1225 **	-0.1230
	(0.0673)	(0.0901)	(0.0753)	(0.0877)	(0.0601)	(0.0855)	(0.0580)	(0.0806)
ρ (spatial lag)							0.4147 ***	
							(0.0055)	
Variance component: country (σ_α)	0.0207	0.0160	0.0185	0.0164	0.0194	0.0155	0.0137	0.0117
Variance component: region (σ_μ)	0.0051	0.0059	0.0031	0.0042	0.0055	0.0066	0.0052	0.0077
Variance component: residual (σ_v)	0.0250	0.0234	0.0248	0.0234	0.0206	0.0228	0.0205	0.0224
ICC: country	0.4046	0.3063	0.3550	0.3224	0.4548	0.2997	0.2953	0.1962
Adjusted Overall R-Squared	0.4488		0.4709		0.5151		0.4642	

Notes: Robustness checks of baseline results: (1) baseline model: specification (3) in Table 3; (2) as in column 1 but with squared time trends; (3) as in column 1 but with additional year dummies; (4) as in column 1 but with spatial lag in growth. ***, **, * denote significance at the 1%, 5%, 10% level, respectively.

The inclusion of year dummies (model 3) entails potential drawbacks as they absorb parts of the shock effect, especially in years when (all) regions are affected by external shock-events simultaneously. In case of the latter, the filtering of the yearly sample-wide economic situation eliminates much of the variance in regional growth that we aim to explain by means of resilience determinants. Nonetheless, the year dummies also control for common year-specific adaptive resilience measures that are missing in the model and are potentially correlated with both the resilience indicator and one or more of the included determinants. Thus, we decided to employ the model specification as a simple robustness check to test whether year-specific adaptive determinants influence the estimation results. As it can be taken from model 3, this concern is baseless as the robustness check provides almost the same results as the baseline model.

Model 4 accounts for potential spatial correlation between regions in our sample by introducing a spatial lag in output growth. The coefficient of the spatial lag ρ measures the strength of spatial dependence analogous to the autocorrelation coefficient of a temporal lag in time series analysis. Following spatial econometrics tradition, we adopt the so-called Queen Contiguity matrix as spatial weights, assuming that regions with a common boundary are neighbours (Anselin 1988; LeSage and Pace 2009). Allowing for spatial autocorrelation in the dependent variable, however, leads to inconsistent regression parameters and standard errors in OLS estimations due to simultaneous neighbour to neighbour relations (Manski 1993).

Therefore, we apply Maximum Likelihood (ML) techniques to overcome the endogeneity-related inaccuracies (LeSage and Pace, 2009; Elhorst, 2009). The spatial extensions of the regression model do not change the main findings of our baseline model (see model 4). One notable exception is the ICC, which indicates a lower relative importance of the national level in the spatial lag model. Growth spillovers are stronger between nearby regions and regions within the same country (see section 2.3), thus some of the between-group growth variance in the baseline model can in fact be explained by (stronger within-group) spillover-effects at the regional level rather than by institutional factors at the national level. Although a detailed analysis of spatial dependence is beyond the scope of the paper, we like to emphasize that spillover-effects are themselves an important determinant of regional economic resilience.