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Christian Hundt and Linus Holtermann and Jonas Steeger and Johannes Bersch

Thünen Institute of Rural Studies, Ruhr-University Bochum, Department of Geography, Nordantech Solutions, Department of Data Science, Centre of European Economic Research

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Cluster externalities, firm capabilities, and the recessionary shock: How the macro-to-micro-transition shapes firm performance during stable times and times of crisis

By Christian Hundt[1], Linus Holtermann[2], Jonas Steeger[3], and Johannes Bersch[4]

[1] Thünen Institute of Rural Studies, Bundesallee 64, 38116 Braunschweig, Germany

[2] Geography Department, Ruhr University of Bochum, Universitätsstraße 150, 44801 Bochum, Germany

[3] Data Science Department, Nordantech Solutions, 200955 Hamburg, Germany

[4] Centre for European Economic Research (ZEW), L 7-1, 68161 Mannheim, Germany

Abstract

In this paper, we examine the macro-to-micro-transition of cluster externalities to firms and how it is affected by the macroeconomic instability caused by the recessionary shock of 2008/2009. Using data from 16,166 manufacturing and business services firms nested in 390 German regions, we employ within-firm regression techniques to estimate the impact of cross-level interactions between firm- and cluster-level determinants on phase-related differences in firm performance between a pre-crisis (2004-2007) and a crisis period (2009-2011).

The empirical results validate the existence of a macro-to-micro-transition that evolves best in the case of broad firm-level capabilities and variety-driven externalities. Furthermore, the results indicate that the transition strongly depends on the macroeconomic cycle. While the transition particularly benefits from a stable macroeconomic environment (2004-2007), its mechanisms are interrupted when being exposed to economic turmoil (2009-2011). Yet, the crisis-induced interruption of the transition is mainly restricted to the national recession in 2009. As soon as the macroeconomic pressure diminishes (2010-2011), we observe a reversion of the transmission mechanisms to the pre-crisis level.

Our study contributes to the existing literature by corroborating previous findings that the economic performance of firms depends on a working macro-to-micro transition of external resources, which presupposes sufficient cluster externalities and adequate firm-level combinative capabilities. In contrast to previous studies on this topic, the transition mechanism is not modeled as time-invariant. Instead, it is coupled to the prevailing macroeconomic regime.

Keywords: Macro-to-micro-transition, combinative capabilities, agglomeration economies, cluster-level externalities, unrelated variety, related variety, macroeconomic regimes, Great Recession, economic resilience

JEL: C33, R11, R58

1 Introduction

The spatial dimension has always been regarded as an important key to the explanation of economic growth, development and competitiveness, which holds true especially in the field of economic geography (Myrdal, 1957; Hirschman, 1958; Scott, 1988; Porter, 1998; Saxenian, 1996; Storper, 1995; Asheim, 1996; Maskell, 2001). Another surge has arisen just recently in response to the Great Recession of 2008/2009 that widely (re-)opened the scientific debate on economic resilience and put, among other things, a particular focus on the role of regions and their socio-economic endowments. While in the beginning, research on regional economic resilience was for the most part directed at setting up conceptual foundations (Pendall et al., 2010; Boschma and Martin, 2010; Hassink, 2010; Pike et al., 2010; Simmie and Martin, 2010; Martin and Sunley, 2015), recent research puts a stronger emphasis on empirical investigations. Studies of the latter group, in turn, frequently explore the impact of regional determinants that either promote or hamper economic resilience (for a comprehensive overview see Holtermann and Hundt, 2018). At the same time, however, the scope of these studies is typically restricted to the regional level alone and it does not account for the heterogeneity at firm-level, respectively. Such approaches are problematic insofar as they reduce resilience to a more or less monolithic phenomenon whilst subject themselves to the risk of ecological fallacies (Coleman, 1991).

In order to overcome this limitation, we are going to shift the research focus from 'regions that contain firms' to 'firms that are nested within regions' as we agree with Martin (2012) that firms – and not regions – are the actual agents of economic resilience. As a consequence, we examine regional determinants not according to their effects on regions per se but according to their impact on the economic performance of firms through a macro-to-micro transition of regional agglomeration economies. Of course, the basic idea of our approach is not entirely new. In fact, the impact of agglomeration economies on firm-level performance has already been subject to a number of studies in both business and regional economics. Nonetheless, the present state of research remains fractional since, among other things, the complex nexus of the region-firm-relationship has not been satisfactorily resolved yet. Business studies, on the one hand, normally focus on firm-related assets that help to internalize externalities while they fail at specifying both type and transmission of these externalities (Tsai, 2001; Girma, 2005; Kostopoulos et al., 2011). Regional studies, on the other hand, usually concentrate on the characteristics and influencing patterns of agglomeration economies at the aggregate level whereas neither firm-related capacities nor the link between regions and firms is sufficiently included (see de Groot et al., 2009 and Melo et al., 2009 for comprehensive overviews).

Only recently, however, regional economists (van Oort et al., 2012; Brunow and Blien, 2015; Smit et al., 2015) have started to fill this gap by interpreting regionally nested firms as being on the receiving end of agglomeration (dis-)economies. What is still missing, though, is a further linkage between the macro-to-micro transmission and dynamic changes in the economic environment. Whilst prior research scrutinizes the relationship at a given point in time, the temporal dimension and hence impact economic turbulences remain unknown. This is noteworthy, since turbulences, especially if they emerge as sudden shocks, are very likely to affect the patterns of how externalities are transmitted from regions to firms and thus take influence on the economic

performance of firms. Therefore, time-related changes are another important missing piece in the jigsaw of the firm-region-relationship.

In response to the aforementioned deficits, we develop our paper along three guiding insights. First, we explore the macro-to-micro transition from the perspective of the firm emphasizing its combinative capabilities as a precondition to internalize regional externalities in the form of tangible resources and knowledge spillovers. Second, we understand the transmission of knowledge spillovers from regions to firms as an interlinked process which is why we choose a cross-level regression approach in order to empirically validate the micro-macro-relation between firms and their respective regional environment including the knowledge spillovers between them. Third and most important, we integrate time-related changes in the firm's environment as we distinguish between two macroeconomic regimes, one representing a period of macroeconomic stability and the other a period of macroeconomic instability. In this way, we link the macro-to-micro transition of externalities with the notion of resilience asking how firm-level determinants and regional interactions shape firm performance during macroeconomic stability and instability.

The remainder of our paper is structured as follows. Section 2 explores the theoretical background, while section 3 elucidates the components and structure of the econometric model. Section 4 presents the data sources applied and introduces the dependent and explanatory variables. The empirical results are reported and discussed in Section 5. Section 6 concludes.

2 Theoretical background

In order to narrow the research gaps as identified above, we interlink the spatial and temporal dimension of economic actions while analyzing the according mechanisms from the micro perspective of the firm. We pursue this objective in two consecutive steps. First, we substantiate the spatial hierarchy between firms and regions and carve out its relevance for economic interactions (see section 2.1). Second, we demonstrate that regional externalities are likely to expose differing impacts on firm performance over time depending on whether the prevailing macroeconomic regime is characterized either by stability or instability (see section 2.2).

2.1 Transition of externalities from regions to firms

We explicitly agree with the notion of a 'macro-to-micro transition' according to which 'the region generates economic opportunities and constraints for firms located in that region through agglomeration economies and agglomeration diseconomies' (van Oort et al., 2012: 9). We thereby accept the supposition that agglomeration effects do not impact the regional economy directly but only indirectly, i.e. through their moderating effect on firm performance (for similar arguments see Acs and Armington, 2004 and Martin et al., 2011). Hence, in linking the firm to the regional level we take two important aspects of economic reality into account. On the one hand, our approach recognizes that firms are not isolated from their geographically surrounding setting but nested within specific regional economic contexts. On the other hand, it discloses potential mechanisms of a macro-to-micro transition since regionally nested or 'embedded' (Grano-

vetter, 1973) firms can possibly enlarge their scope of economic actions by internalizing additional economic resources that are external to the firm but internal to the region. However, whether a firm actually succeeds in internalizing regional externalities, at least two preconditions must be met, namely the presence of agglomeration economies in the respective region and the firm's capability to make use of them.

The relevance of regional externalities primarily arises from the limitation of firm-related assets as they can provide complementary growth-relevant resources which help firms to expand their scope of economic actions. Which kind of growth-relevant resources are available in a particular case, depends on the specific type of agglomeration economies that are predominant in the respective region (Frenken et al., 2007). Referring to this, regional economic literature commonly distinguishes between localization economies that are based on sector-specific specialization, Jacobs' externalities that arise from cross-sectoral variety, and urbanization economies that originate from sector-independent density (Frenken et al., 2007; Boschma and Iammarino, 2009; van Oort, 2013). In this paper, we concentrate on externalities stemming from regional economic specialization and regional economic variety. In either case, of course, firms can only utilize (or be impaired by) specific externalities if they are both located in the respective region and included in the respective sector (for the operationalization of specialization- and variety-driven externalities see section 4.5). Hereinafter, the term 'cluster-specific' (externalities) is used to describe *sector-specific agglomeration forces of specialization and variety that differ between regions*.

A theoretical approach on how to model the transmission of regional externalities to firms is provided by van Oort (2013) with reference to McCann and Folta (2011). Van Oort (2013) suggests applying the knowledge-based view of the firm (Grant, 1996 and 2002) in order to capture the heterogeneity of firms' capabilities to access and utilize agglomeration economies. The basic idea is simple but convincing: 'Agglomerated firms can realize the potential benefits of location in an agglomeration only to the extent that they are capable of using and commercializing knowledge from co-located firms in combination with their own knowledge assets to create value' (van Oort 2013: 9). Such 'combinative capabilities' contain a) the firm's existing knowledge base, b) the number of its localized connections and c) its 'organizing principles' (Kogut and Zander, 1992). What is more, all three assets are assumed to increase the 'combinative capabilities' of the firm. As explained by van Oort (2013), a large existing knowledge base (a) is expected to improve the firm's ability to assess, access, and internalize externally available knowledge. Similarly, a high number of localized connections (b) is thought to facilitate the firm's active and purposeful collaboration with other firms to obtain, exchange, and mutually develop resources. Finally, 'organizing principles' (c), defined as the firm's ability to coordinate different parts of the organization and transfer knowledge among them, are assumed to increase the firm's efficiency in internal organization and thus make the resourceful application of regional externalities more likely.

As for this paper, we add another specification to this concept and assume a dual function of combinative capabilities that manifests itself in a two-fold-impact on firm performance. On the

one hand, while emphasizing their 'combinative' character, capabilities can have an *indirect* effect as far as they potentially broaden the firm's possibilities to make use of regionally bound externalities. These indirect effects are the main focus of our study. On the other hand, though, combinative capabilities can also *directly* augment the economic performance of the firm as the existing knowledge base, the number of its localized connections as well as the 'organizing principles' of the firm (Kogut and Zander, 1992) are likely to be growth-stimulating irrespective of the internalization of additional resources stemming from regional agglomeration economies. To conclude, we expect the impact of broad firm-level capabilities to be positive in either way: the broader the capabilities, the better ceteris paribus the economic performance of the firm.

2.2 Firm performance, cluster externalities, and different macroeconomic regimes

Not only are firms willing to access those agglomeration externalities from which they expect the most effective and efficient support. We further assume that firms, in case they are confronted with abrupt changes in their macroeconomic environment, are likely to alter their growth strategies and accordingly will seek for different, more suitable externalities. The extent to which firms will successfully adapt to shock-induced market fluctuations in turn depends on their 'dynamic capabilities' which Teece et al. (1997: 516) define as the facility to 'integrate, build, and reconfigure [its] internal and external resources'. Henceforth, 'dynamic capabilities' can be best understood as a dynamic version of combinative capabilities. Through adding a dynamic component to our study, we also take into account a widely accepted insight in regional research according to which agglomeration economies on localized economic growth generally differ across sectors, space, and time (Rosenthal and Strange, 2004; Van Oort, 2007; de Groot et al., 2009; Melo et al., 2009; Beaudry and Schiffauerova, 2009; Puga, 2010). We expect that firms seek to access other, more fitting externalities if sudden changes in their macroeconomic environment require so. Apart from this very basic assumption, phase-specific impacts of specialization- resp. variety-driven externalities on firm performances are hard to predict. Instead, different scenarios seem equally plausible.

To start with, we briefly discuss possible macro-to-micro transitions originating from localization economies as highlighted by Marshall (from a static perspective) and Marshall, Arrow and Romer (from a dynamic perspective) respectively (Marshall, 1920; Arrow, 1962; Romer, 1986). MAR externalities arise from industrial specialization of a defined geographic area and are, by our definition, available only to firms that *operate within this specialized sector* (see section 4.5 for a comprehensive operationalization). Provided this requirement is met, MAR externalities can help firms not only to participate in specialized factor markets, infrastructure or supplier networks, they also tend to promote incremental innovation and process innovation via regional knowledge spillovers, thanks to the tacit transmission of information across agents (Glaeser et al., 1992; Henderson et al., 1995). At least two distinct outcomes of the interaction between broad combinative capabilities and MAR externalities are conceivable. In the first scenario, firms with broad capabilities might derive the greatest benefit from MAR externalities in periods of macroeconomic stability. A simple explanation could be that firms make the best use of their positions within highly specialized and ramified clusters only if the cluster-related networks and business links are not disturbed by shock-induced turbulences. Besides, it takes a critical mass

before specialized resources are likely to generate an added value for the firms involved and a critical mass in turn takes a stable economic environment to evolve best (Porter, 1998; Maskell and Malberg, 1999). In the second scenario, firms with broad capabilities might particularly profit from MAR externalities in case the environment is specifically volatile. The idea is that, during and immediately following a sharp economic downturn, firms with already high capabilities command, compared to less capable firms, a higher number and more stable market relations in and outside of the cluster. In this way, they ensure themselves sufficient access to regional resources, while firms with lesser capabilities, on the contrary, might be cut off from supplier-costumer-relationships more easily. The question of whether the first or the second scenario will prevail cannot be answered on a mere theoretical base and requires detailed empirical examination.

In a next step, we take a short look at the interplay of broad firm capabilities and externalities stemming from variety. The latter are, by our definition, available only to firms that *belong to a sector that at the same time is characterized by a high degree of intra-sectoral variety at the subordinate (digit) level(s)* (see section 4.5 for a comprehensive operationalization). From a regional perspective, this measure corresponds with the notion of related variety as introduced by Frenken et al. (2007). From a firm perspective, however, the reasoning is very similar. The sole difference is that the relevant variety occurs within specific sectors (thus *intra-sectoral* variety), not within the entire region. In either case, variety-based externalities are rooted in a portfolio of industries that are interconnected through shared or complementary competences (Boschma and Iammarino, 2009). Firms can profit from such interconnections as they generally facilitate the firm's access to resources that are neither redundant nor too dissimilar to become integrated into their own portfolios. The more diversified the regional sector of the embedded firms, the easier their access to interconnected resources. The economic advantage of such firms is that they have more options to recombine their own knowledge base with knowledge inputs from other firms of the same intra-sectoral complex. Ideally, this constellation leads to spillover-driven knowledge fertilization and enables firms to obtain a competitive advantage by making quicker and better progress in the development of new products and/or technologies (Lazzeretti et al., 2011; Holm and Østergaard, 2013).

Similar to the case of specialization, the interchange between broad combinative capabilities and externalities stemming from variety allows for two plausible, yet different scenarios. On the one hand, firms with broad capabilities might best utilize variety-driven externalities when the macroeconomic environment is stable. The underlying assumption is that the adoption of related technologies and, equally important, the incorporation of related production factors are challenging procedures that require a high level of planning security that is most likely guaranteed in periods of stability. On the other hand, though, variety-based externalities could turn out to be particularly beneficial in times of crisis. This scenario reflects the notion that a greater variety of accessible resources also promotes flexibility that, once firms are exposed to a sudden pressure to act, becomes a very essential tool in terms of defending and gaining market shares. Here too, theory alone cannot foretell whether the first or the second scenario will prevail. Instead, a thorough empirical examination is mandatory.

3 Econometric model

Our goal is to examine the interplay of combinative capabilities and cluster-specific externalities and its impact on firm performance. To investigate this matter, we employ cross-level interactions of firm features and regional externalities in addition to firm-level controls. We also include regional and sectoral indicators to reduce the omitted variable bias. Changes in the macroeconomic environment are modeled through two different regimes. The first regime ranges from 2004 to 2007 and represents a period of relative overall stability (pre-crisis). Sharply interrupted by the Great Recession of 2008-2009, however, it is followed by a period of instability that spans from 2009 to 2011 (crisis).[1] Our reference model reads as follows:

$$Performance_{ijr} = \alpha_j + \mu_r + \beta_1 X_{ijr,t} \times Z_{jr,t-s} + \beta_2 X_{ijr,t} + \beta_3 Z_{jr,t-s} + Controls_{ijr,t} + \varepsilon_{ijr} \qquad (1)$$

where i stands for firm, j for sector, r for region, and t for the period in which the explanatory variables of interest are measured. $Performance_{ijr}$ is the growth of the performance indicator measured as the change of the logarithmized indicator between the beginning and the end of the respective period.[2] $X_{ijr,t}$ denotes proxy variables for the combinative capacity of a firm and $Z_{jr,t-s}$ represents cluster-specific externalities. $Controls_{ijr,t}$ stands for additional control variables at firm-level. α_j is a sector fixed effect for sector j and μ_r is a region fixed effect for region r. To avoid endogeneity problems, we measure the explanatory variables at the beginning of our sample period, hence $t = 2003$. Following Henderson (2003) and Knoben et al. (2015), we assume that spatial externalities require time to be accessible for firms and use a one-year lag ($s = 1$) to measure cluster-level externalities.[3]

Next to the potential moderation of cluster-level effects through firm characteristics, we are mainly interested in the difference in firm performance between the crisis and pre-crisis period. For this purpose, we modify specification (1) and use the difference in performance between crisis and pre-crisis as dependent variable.[4] This leads us to the formula of model (2):

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[1] As proposed by Kroszner et al. (2007), we separate the pre-crisis period from the crisis period by one year, because the year prior to the crisis onset, in this specific instance 2008, cannot be clearly categorized as either stable or unstable.

[2] Note that the performance indicator at the beginning of a certain period is equivalent to the value of the indicator at the end of the previous year. For example, to gauge the performance during the pre-crisis period, we compute the difference of the logarithmized indicator at the end of 2007 and the end of 2003. In comparison to annual panel data models, the distribution of the dependent variable is less susceptible to outliers and zero-inflation due to the use of the geometric mean. If performance indicators, e.g. sales or employment, are measured through annual growth rates, the growth trajectories of firms are often dominated by outlier years with large increments as the majority of years show either none or only very small changes. In our set-up, we mitigate this problem through temporal aggregation. It is noteworthy, however, that this advantage comes at the expense of information loss. Following the critique of Barro (1997) on fixed effects panel model with annual data that purely rely on time series information and thus neglect conditional variables that are slowly moving, such as the regional externalities of interest, we consider it necessary to model the effects of the latter as described by Equation (1) and (2).

[3] We experiment with alternative time lags ($s = 0, s = 2, s = 3$). Due to the stationary nature of the cluster-level externalities, results are virtually the same. Moreover, we conduct robustness tests that employ pre-crisis data of firm-level and regional-level indicators to verify the reliability of our estimation results.

[4] This approach is very common in the context of firm-level micro data and can be found in several empirical studies, accordingly: Rajan and Zingales (1998), Claessens and Leaven (2003), Fisman and Love (2003), Cetorelli and Strahan (2006), Kroszner et al. (2007), and Claessens et al. (2012).

$$\Delta Performance = \alpha_j + \mu_r + \beta_1 X_{ijr,t} \times Z_{jr,t-s} + \beta_2 X_{ijr,t} + \beta_3 Z_{jr,t-s} + Controls_{ijr,t} + \varepsilon_{ijr} \quad (2)$$

where $\Delta Performance$ is our measure of the crisis-induced changes in firm-level performance ($\Delta Performance = Performance_{ijr,crisis} - Performance_{ijr,pre-crisi}$). Using within-firm differences in performance has the advantage of controlling for many firm characteristics, such as differences in profitability before the crisis and (unobserved) time-sluggish factors that explain differences in growth potentials between firms (Kroszner et al., 2007). Furthermore, the sector fixed effects control for the general severity of the crisis in each sector and the region fixed effects absorb all regional influences that are common to all firms within a region, such as urbanization economies. We apply heteroscedasticity-robust standard errors clustered simultaneously by sector and region, allowing for arbitrary correlation of firms within a sector or a region (Cameron et al., 2011).

4 Data sources, sampling strategy, and variables

4.1 Data collection

To test our models, we use data from the Mannheim Enterprise Panel (Mannheimer Unternehmenspanel – MUP) of the Centre for European Economic Research (ZEW). The MUP is based on the firm data pool of the Creditreform e.V., Germany's largest credit rating agency, and provides one of the most comprehensive databases of companies in Germany, second only to the official business register (which is not accessible to the public). At the end of 2013, the MUP contained information on 7.7 million firms. Comparisons of the active stock of firms in the MUP with the Business Register of the Federal Statistical Office indicate that the MUP gives by and large a representative picture of the corporate landscape in Germany (Bersch et al., 2014). The firm data are merged with additional information from the Creditreform e.V. on credit rating, ownership structure and firm´s bank account.

Detailed data on regional industry structure are required for our analysis as we intend to calculate indices of regional specialization and regional variety. Since no official statistics provides detailed information on the industry structure at the regional level (WZ 2008 digit class four or five), the indicators of regional agglomeration economies must be computed by means of an alternative approach. One common method proposes the appropriation of a representative sample of regionally located firms as such data can be used to calculate shares of specific sectors and to thereby create a detailed and reliable representation of the regional industry structure (Sedita et al., 2015). For this purpose, we again make use of the MUP because firm location, firm industry class, and the number of full-time employees are well documented in the data source. This provides us with the unique opportunity to generate indicators that capture the economic structure of regions at any level of the WZ 2008 industry classification. Following Sedita et al. (2015), we choose employment data to derive variables for the regional indicators.

4.2 Identification and sampling strategy

To assess the performance of an establishment in times of economic turmoil is often problematic as it entails the risk of receiving biased indicators. For example, the performance of an estab-

lishment during a crisis-ridden business year might be additionally influenced by the performance of the firm to which the establishment belongs. In times of financial pressure or liquidity constraints it cannot be ruled out that firms cut back employment in some of their establishments not due to bad performance in these economic entities but because it is imposed by the overriding firm strategy. Other possibilities of exercising influence are internal profit transfers or even the shutdown of company divisions as a result of long-term strategic interests. For this reason, we employ firms instead of establishments as economic units of our analysis. We have to exclude, however, multi-regional firms from our sample as their data cannot be properly attached to the respective regions and thus would not allow us to draw precise conclusions on the effects of agglomeration forces.

With regard to the industrial focus, we restrict our analysis to manufacturing and business services while we exclude retail and customer-related services. The reason for this is that the latter predominantly follow the spatial distribution of the population and are therefore unlikely to exhibit specialization- resp. variety-driven patterns of geographical concentration that we intend to study. Furthermore, it is necessary to adjust the empirical set-up for extraordinary effects on firm growth. We therefore exclude all firms that are part of M&A transactions or takeovers, because these events can be supposed to be the main factor of growth in subsequent years. As the internalization of regional externalities requires embeddedness in the sectoral-regional system, we also constrain the sample to firms that were active on the market at least five years before the sample period starts. Moreover, we delete all firms with less than five full-time employees in 2003, because the combinative capabilities of such enterprises are considered too small to make effective use of cluster-related externalities. To remove small and young firms from the sample is in line with the well-established empirical finding that mature companies tend to benefit more strongly from specialized sectoral environments and the associated agglomeration forces (Keilbach, 2000; Audretsch and Thurik, 2000; Boschma and Frenken, 2011). To eventually ensure a valid comparison of firm performances between economically stable and instable times, we are compelled to restrict our sample to firms that are active over the span of both macroeconomic periods.

4.3 Dependent variables

We select two dependent variables to measure firm performance in both macroeconomic phases that we aim to compare: sales growth and growth of full-time equivalent employment (FTE). Both indicators are winsorized at the 1% level to reduce the impact of outliers. Sales growth can be regarded as a market-orientated resilience indicator because benefits that arise from financial reserves and assets of a firm are typically limited to stabilize sales in the short-run. Thus, the sales growth rate captures the direct short-term consequences of the 2008 demand shock and is of special interest at the management level. As a complementary measure, we follow Baptista and Swann (1998) resp. Chodorow-Reich (2014) and utilize employment rate as a proxy to gauge liquidity. It is related to the crisis insofar as while financial distress develops, layoffs are used as quick fixes to secure liquidity (Gittell et al., 2006). By using employment growth, we hence examine adaptive changes that managers may apply to ease financial constraints with the goal of improving the operating and net profit and ultimately the performance of the firm. Since

downsizing the labor pool depletes relational reserves which may limit a firm's future development potential (Gittell et al., 2006), we assume that layoffs are a measure of last resort to cope with crisis-driven constraints. Therefore, employment growth can be regarded as a resilience indicator that in particular attenuates the long-term consequences of the recessionary shock and should also concern regional policy makers.

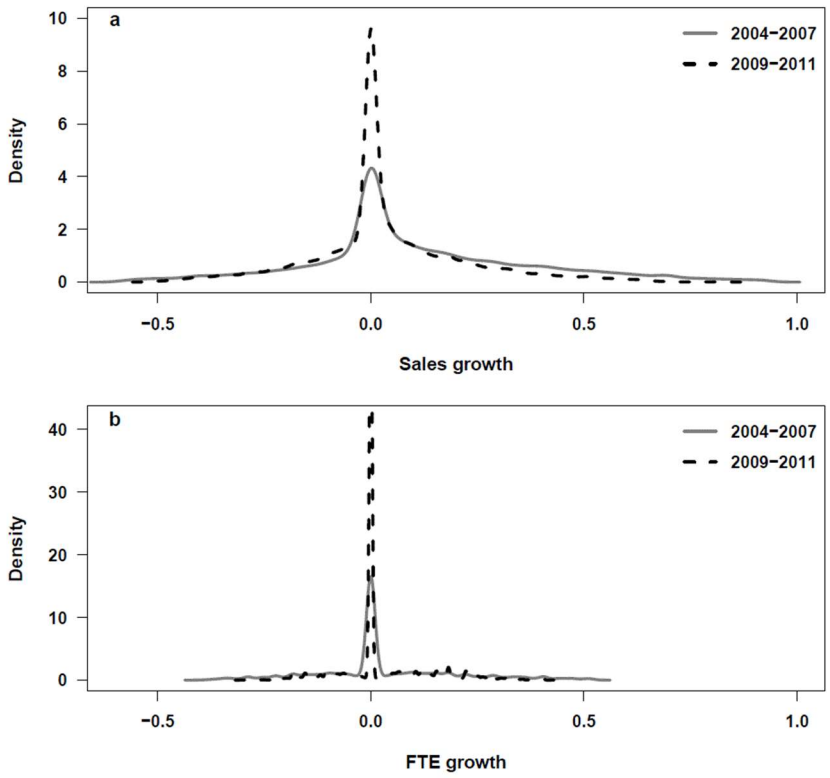

Figure 1: Density distributions of firm-level performance indicators.

Figure 1 plots the density distributions of the firm performance indicators.[5] As it can be seen, the patterns for sales growth and FTE growth considerably differ. As for sales growth, the left tails increase over time while the right tails decrease which indicates a rise in the share of relatively poorly performing firms during the crisis years (2009-2011). The distributions of FTE growth, on the contrary, are more stable, suggesting only minor crisis-induced changes. FTE growth is, especially in the crisis period, concentrated at zero, which implies, in general, a low variance in this indicator and that the majority of firms do not alter their workforce during the crisis. An important reason for this low fluctuation in FTE growth can be found in the government support of short-time working that enables firms to maintain their workforce regardless of the drop in demand and the resulting cut back on labor input (Möller and Ormerod, 2017; Pudelko et al., 2018). Since all firms in our sample can in principle benefit from this government intervention (European Foundation for the Improvement of Living and Working Conditions, 2010), we argue that, despite the underestimation of the true crisis-effect on FTE growth, the phase-related com-

[5] Appendix A.1 provides summary statistics for the firm performance measures before (2004-2007) and during the crisis (2009-2011 and alternate definitions).

parison of firm performances remains unbiased.[6] Overall, Figure 1 reveals a wide dispersion across firms in performance. While many firms' performances weakened during the turmoil, there were also firms that increased their performance in spite of the crisis. These variations would allow us to conduct meaningful empirical analyses.

4.4 Firm-level variables

As established by Kogut and Zander (1992), combinative capabilities consist of three complementary elements: (a) the 'existing knowledge base', (b) the 'number of localized connections', and (c) the 'organizing principles' of the firm. As for this study, we measure the 'existing knowledge base' by means of human capital while the 'organizing principles' are modeled through the size of the firm. Unfortunately, we have to drop the 'number of localized connections' because appropriate data is not available. As an alternative, we argue that firm size also captures some aspects originating from the firm´s cooperation networks, since it can be assumed that larger firms maintain a higher number of intra-regional co-operations than smaller firms. The firm's human capital is measured by relating the number of employees with an at least tertiary school qualification to the entire amount of employees. The natural logarithm of the number of full-time employees is used to gauge the size of the firm.

The list of firm-level controls includes a dummy variable indicating if the founder is active in firm´s strategic management, the number of patent applications per FTE (average of last three years), the age cycle (age and age squared), and the legal structure (lone founder, limited, listed).[7] Each of the aforementioned indicators is again measured by their values in the year 2003, so it is ensured that they are pre-determined with respect to the crisis. Another key role in explaining variance in performance can be assigned to the sectoral affiliation of the firm as firms in a given industry class can be substantially affected by, amongst other things, industry-specific capital and asset structures, export dependencies, and vulnerabilities. To effectively control for such effects, we include sector fixed effects at the two-digit level of the WZ 2008 industry classification.

4.5 Regional-level variables

In this study, we examine the interaction between firm characteristics and spatial externalities that originate from regional economic specialization and from regional economic variety (see section 2.2). Both forms of externalities are, by definition, available to all local firms within the same industry which gives them a region- and sector-specific character. For this reason, we term the regional agglomeration economies of interest as *cluster-specific* (sector within region). Technically, we assign each firm to its two-digit industry sector as well as to the NUTS-3 region (nomenclature in Germany: '*Kreise*' *and* '*Kreisfreie Städte*') in which the firm is located. The choice of a relatively detailed level of spatial aggregation is motivated by the strong distance decay that

[6] It is conceivable that some firms might be able to reap greater benefits from the short-time working program than other firms. A substantial portion of these heterogeneous effects, however, is cancelled out by sector fixed effects, size of the firm, and legal structure that are included as controls in our models.

[7] Summary statistics for the dependent variables and key explanatory variables are displayed in Appendix A.2 reports, while the correlation among variables is reported in Appendix A.3.

can be observed in knowledge diffusion and spillovers of spatial externalities (Audretsch and Keilbach, 2007; Baldwin et al., 2010). Furthermore, the application of smaller areal units allows us to depict a higher degree of regional variation in the economic structure.

As we also decompose variety into further sub-groups, we examine a total of four types of agglomeration economies. In addition to MAR externalities, these include externalities arising from within-cluster variety (V), from unrelated within-cluster variety (UV), and from related within-cluster variety (RV), respectively. Our first focus is on specialization-driven MAR externalities that arise from the geographical concentration of firms belonging to the same industry. Following Henderson (2003), we argue that the number of firms within a cluster is a suitable proxy for knowledge transmission. With this, we assume that each local firm, rather than each local employee, experiments with the choice of suppliers, input factors, costumers etc. which is why firms can be considered central agents in the exchange of knowledge and other relevant resources within the cluster. In consequence, we model MAR externalities through the 'size-effect' of the cluster that we in turn compute as the natural logarithm of the number of firms in the regional sector.

Second, we quantify externalities stemming from within-cluster variety (V) by which we capture regions-specific forms of intra-sectoral diversity. This measure is based on the variety specification of Fujita and Ogawa (1982), which bears resemblance with the entropy functions used in information theory. For our purpose it is necessary to calculate the variety for every two-digit class (sector) in each region, because firms are assigned to industries by means of two-digit levels.

$$V_{two-digit} = \sum_{i=1}^{I} p_i \, log_2 \left(\frac{1}{p_i}\right) \tag{3}$$

where p_i denotes the share of five-digit sectors i in each two-digit sector of interest. Note that in our case, the five-digit shares p_i are the number of employees in a five-digit sector i divided by the sum of employees in the respective two-digit sector and *not* in the respective region as in Frenken et al. (2007).[8]

Still, the aforementioned measure lacks detailed information about the specific nature of intra-sectoral diversity. This is why we, in a third step, decompose the overall within-cluster variety into unrelated (within-cluster) variety (UV) and related (within-cluster) variety (RV).[9] Unrelated variety, for one thing, reflects the extent to which a two-digit cluster is diversified in different types of activity at the subordinate three-digit level. Related variety, in comparison, displays a measure of related diversification within a given three-digit sector and thus captures a particularly high degree of technological proximity within an already interconnected two-digit sectoral

[8] Compared to Frenken et al. (2007), a change in the depth of digit-level is necessary because we are primarily interested in cluster-specific externalities. Since Equation (3) measures the within-cluster variety, it is identical to Equation (4) in Frenken et al. (2007). The sum of the varieties of the two-digit sectors, weighted by the two-digit shares within the region, results in the related variety at regional level.

[9] The overall variety of a cluster is the sum of its related variety and unrelated variety. The measure of overall variety shows high correlation with other variety/diversification indicators that are often used in literature, such as 1 - Hirschman-Herfindahl-Index ($\tau = 0.9751$).

complex (see section 2.2). The extent to which these two forms of variety contribute to the economic success of firms is another focus of our empirical analysis (section 5.3). Both variables are computed following Frenken et al. (2007), but with a change to the depth of used digit-level. Henceforth, for each two-digit class in the region, unrelated variety is computed as the sum of three-digit entropy, while related variety is measured as a weighted sum of entropy at the five-digit level (subcategory) within the respective three-digit class (categories):

$$UV_{two-digit} = \sum_{g=1}^{G} P_g \, log_2 \left(\frac{1}{P_g}\right) \quad (4)$$

$$RV_{two-digit} = \sum_{g=1}^{G} P_g \, H_g \quad (5)$$

with:

$$H_g = \sum_{i \in S_g} \frac{p_i}{P_g} \, log_2 \left(\frac{1}{p_i / P_g}\right) \quad (6)$$

$$P_g = \sum_{i \in S_g} p_i \quad (7)$$

where S_g is the three-digit sector which contains the corresponding five-digit sectors i, where $g = 1, \dots, G$. P_g denotes three-digit shares (categories) that can be derived by summing up all five-digit shares p_i (subcategories) of S_g.

In addition to the cluster-specific agglomeration variables, we use the average firm size in a cluster to control for the degree of competition: smaller average firm size indicates higher competitive pressure (Smit et al., 2015). Furthermore, the region fixed effects control for all factors that are common for all firms in one region, such as the level of urbanization or regional policy measures.

5 Empirical evidence for a regime-specific macro-to-micro transition

5.1 On the interplay of combinative capabilities and cluster externalities

In a first step, we estimate model (1) separately for both the pre-crisis (2004-2007) and the crisis period (2009-2011). Table 1 summarizes the results for sales growth in columns (1) and (2) and for FTE growth in columns (4) and (5), respectively.[10] With regard to the pre-crisis period we find that, on average, firms with higher combinative capabilities grow faster in sales on condition that they are located in clusters with a more diversified structure of economic activities (column (1)). In fact, overall variety (V) significantly interacts with both firm size and firm's existing knowledge base which points towards an existing transmission channel between cluster-level externalities and firm level capabilities. The finding is in line with our basic theoretical argument (see section 2.1): the broader the combinative capabilities arising from size and knowledge base, the easier the internalization of cluster-driven externalities and the more beneficial their related economic impact. Furthermore, our estimation results suggest that the transmission is likely to fail if the combinative capabilities are too small. As the insignificant coeffi-

[10] As the regression models reveal similar results for both variables to measure firm performance (albeit with smaller effect sizes in case of FTE growth), we limit our discussion to the variant using 'sales growth' that is less affected by governmental interventions (see section 4.3).

cients of the grand-mean centered cluster-level variables imply, firm-level capabilities have to be at a sufficient minimum to reap significant growth effects from the prevailing cluster externalities.[11] This growth-enhancing mechanism, however, only applies to variety-based externalities while it tends to be negative, though not statistically significant, in the case of MAR externalities. A possible explanation might be that in times of stable growth (2004-2007) the regional availability of specialized resources declines due to intense inter-firm competition. Assuming that large firms show a higher demand for production factors than smaller firms, at least in absolute numbers, the first-mentioned might experience the competition-driven shortage of regional resources earlier. The same might happen to firms with a broad knowledge base that particularly depend on high-quality, thus already relatively scarce location factors.

In a second step, we employ the phase-related within-firm differences in performance as dependent variable (see model (2) in section 3). The estimated coefficients in column (3) thus represent the difference between the respective coefficients of the crisis and the pre-crisis model in column (2) and (1), respectively. As already indicated by the pre-crisis model, the phase-related comparison reveals opposite cross-level mechanisms for variety- and MAR-based externalities. As for variety-driven forces, the crisis vs. pre-crisis reduction in growth rate is greater for firms with broad combinative capabilities – modeled through size and knowledge base – that are at the same time located in diversified clusters. This can be explained by a crisis-induced interruption of the hitherto working macro-to-micro transmission channels: those firms that particularly benefit from cluster-specific externalities during stable times are no longer able to make use of them in times of economic turmoil (as documented by the small and insignificant cross-level effects in column (2)), which is why they experience a more pronounced reduction in growth rate than other firms. Apparently, the specific benefits of a high overall variety, such as the facilitated exchange of related knowledge, do not assist firms with developing short-term measures to response to crisis-driven challenges.

With respect to MAR externalities, we find an opposing relationship, namely, that firms with both broad combinative capabilities and a location in a specialized cluster are more capable of withstanding a shock-induced economic downturn. One explanation could be that these firms possess stronger market power and benefit from a higher number and more stable market relations within (and outside of) the cluster. Smaller firms, on the other hand, might be cut off from supplier-costumer-relationships more easily (Jüttner and Maklan, 2011). Also, skilled employees might prefer bigger companies because they are assumed to provide higher job security (Winter-Ebmer, 2007).

[11] Due to grand-mean centering, coefficients of cluster-level variables report the marginal effect of the determinant when firm size and knowledge base are both at their sample mean. The positive but insignificant coefficient of variety in column (1) indicates that growth effects stemming from a diversified cluster are not significant for firms with average knowledge base and size. However, growth effects become significant once combinative capabilities are slightly above the sample average. Detailed results are available upon request.

Table 1: Firm performance, combinative capacities, and cluster-specific externalities

	Sales growth			FTE growth		
	(1)	(2)	(3)	(4)	(5)	(6)
	Pre-crisis (2004-2007)	Crisis (2009-2011)	Crisis vs. pre-crisis	Pre-crisis (2004-2007)	Crisis (2009-2011)	Crisis vs. pre-crisis
Firm-level						
Size	0.0180 ***	0.0018	-0.0163 ***	-0.0081 ***	0.0006	0.0075 ***
	(0.0032)	(0.0022)	(0.0032)	(0.0023)	(0.0015)	(0.0020)
Knowledge base	0.0210 ***	0.0053	-0.0157 *	0.0074 *	0.0029	-0.0044
	(0.0079)	(0.0042)	(0.0082)	(0.0041)	(0.0021)	(0.0042)
Cluster-level						
Variety (V)	0.0043	-0.0022	-0.0066	-0.0034	-0.0012	0.0021
	(0.0048)	(0.0029)	(0.0064)	(0.0033)	(0.0016)	(0.0033)
MAR	0.0051	0.0038	-0.0013	0.0043	-0.0009	-0.0053 **
	(0.0046)	(0.0026)	(0.0061)	(0.0027)	(0.0016)	(0.0025)
Cross-Level Moderations						
Knowledge base * Variety (V)	0.0200 ***	0.0015	-0.0185 ***	0.0136 ***	0.0005	-0.0131 ***
	(0.0045)	(0.0033)	(0.0061)	(0.0037)	(0.0029)	(0.0039)
Size * Variety (V)	0.0078 **	-0.0014	-0.0092 ***	0.0014	-0.0019 *	-0.0034 **
	(0.0038)	(0.0023)	(0.0034)	(0.0020)	(0.0016)	(0.0015)
Knowledge base * MAR	-0.0052	0.0030	0.0082 *	-0.0027 *	0.0019	0.0046 **
	(0.0037)	(0.0023)	(0.0049)	(0.0016)	(0.0016)	(0.0023)
Size * MAR	-0.0040	0.0016	0.0055 **	-0.0017	0.0006	0.0023 *
	(0.0026)	(0.0014)	(0.0023)	(0.0013)	(0.0007)	(0.0012)
Observations	16,166	16,166	16,166	16,166	16,166	16,166
F-test (p-value)	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***
Adjusted R-Squared	0.0563	0.0154	0.0358	0.0273	0.0175	0.0157

Notes: Columns (1)-(3) show estimation results for firm performance measured by sales growth and columns (4)-(6) show results for analogous regressions with FTE growth. The dependent variable in columns (1) and (4) is the firm performance in the pre-crisis period. The dependent variable in regressions (2) and (5) is firm performance during crisis years. The dependent variable in columns (3) and (6) is the difference in firm performance between crisis period and pre-crisis period. Sector and region fixed effects and additional controls are included but not reported. All metric explanatory variables are grand mean centered such that the coefficients of non-interaction terms can be interpreted as the marginal effects evaluated when all variables are at the sample mean. Heteroskedasticity-consistent standard errors clustered by region and sector are reported in parentheses. Statistical significance level: 1 % ***, 5 % **, 10 % *.

In a third step, we assess whether the impact that firm- and cluster-level determinants exhibit on changes in firm performance between phases, i.e. in a crisis vs. pre-crisis comparison, is 'economically significant'. For this purpose, we calculate the difference in predicted crisis (vs. pre-crisis) effects on firm performance, when firm- and/or cluster-level variables are increased from the first quartile to the third quartile. We conduct three different scenarios: the simultaneous increase of all firm- and cluster-level determinants (a) and the increase of (selected) factors from either the firm- (b) or the cluster-level (c). Table 2 shows the results. In scenario (a) where cluster-specific externalities and combinative capabilities are increased simultaneously, the effect is economically relevant for sales growth: on average, a firm at the third quartile of combinative capabilities and located in a cluster at the third quartile of cluster-specific externalities experiences a 3.6 percentage points stronger decline of annual growth rate in sales between crisis and pre-crisis periods than a firm at the first quartile of combinative capabilities and located in a cluster at the first quartile of cluster-specific externalities. This is a large effect compared with an overall mean decline of 6.7 percentage points in sales growth between the two periods. In contrast, however, the analogous effect is negligible for FTE growth. Accordingly, we find only small and statistically insignificant effects sizes relating to FTE growth when increasing any of the factors of interest from the first to the third quartile. Again, this might be explained by the fact that the German labor market has proven to be highly resistant towards the recessionary shock of 2008/2009 (see section 4.3). Overall, the results corroborate our previous findings according to which the reduction in sales growth rate across the two periods is higher for firms

that are endowed with broad combinative capabilities whilst being nested in diversified or specialized clusters. This is another indication that the formerly working transmission of cluster-related resources to firms is sharply interrupted by the crisis. When looking at the effect sizes of specific determinants, we find that firm-specific factors (b) are more important for the cross-level interplay than cluster-specific externalities (c). In other words: A well-working macro-to-micro transmission predominantly depends on a sufficient amount of firm-level capabilities whilst requiring a stable macroeconomic environment.

Table 2: Economic size of crisis effects

	Sales growth	FTE growth
(a) Firm-level & Cluster-level	-0.0364 ***	0.0008
(b) *Firm-level*		
Size & Knowledge base	-0.0274 ***	0.0068
Size	-0.0195 ***	0.0090
Knowledge base	-0.0079 *	-0.0022
(c) *Cluster-level*		
Variety (V) & MAR	-0.0098	-0.0065
Variety (V)	-0.0076	0.0024
MAR	-0.0022	-0.0089

Notes: Prediction of crisis impact when values of determinants are increased from the first quartile to the third quartile (while holding the remaining determinants constant at the sample mean). Calculations are based on estimations reported in columns (3) and (6) of Table 1. Statistical significance level: 1 % ***, 5 % **, 10 % *.

To ensure the reliability of our estimation results, we conduct a series of robustness checks that use the difference in performance between crisis and pre-crisis as dependent variable (i.e. model (2), see Appendix A.4). The results are robust to various model specifications as we employ micro-level sales data instead of employment data to calculate the regional variables, measure the explanatory variables one year before crisis outbreak instead at the beginning of the sample, replace the region fixed effects and sector fixed effects by region × sector (cluster) fixed effects, and, eventually, add patents per employee as further firm-level control that potentially moderates the impact of cluster externalities. For the latter model specification, we do not find any statistically significant interaction effects of patents per employee while the coefficients of the other interaction terms remain stable. Moreover, we cannot detect statistically significant deviations in the impacts of tested determinants between manufacturing firms and business service firms (see Appendix A.5). Finally, we do not find any statistically significant non-linearities in our sample as we test for potential non-linear effects of firm-level determinants as proposed by Knoben et al. (2015) (see Appendix A.6).

5.2 Addressing potential sample selection and other biases

Our sample of firms is most likely suffering from a build-in survivorship bias, because firms that experienced the biggest decline in sales or FTE growth may have exited the sample due to bankruptcy, merger, or liquidation. Thus, we perform a Heckman selection model to control for a possible survivorship bias. In the selection equation, we include all explanatory variables from the outcome equation (which are identical to the explanatory variables in model (2)), as well as a credit rating index for each firm. The credit rating index is developed by Creditreform e.V. to

evaluate the creditworthiness of firms, whereby higher index values indicate less creditworthiness and the maximum score of 600 represents insolvency. In column (1) and (4) of Table 3, we report the results of the Heckman selection model for the difference in firm performance between the crisis and pre-crisis period. The selection equations confirm that firms with a higher score in the credit rating index were more likely not included in our sample. After controlling for this selection bias originating from the restriction to firms that are active over the entire sample period, the coefficients of the outcome equations are in line with results of our baseline models (see Table 1). If at all, the discrepancy between estimation results for sales growth and FTE growth is reduced due to the Heckman correction procedure.

Another bias in our sample may arise from the uneven distribution of firms across regions. A dominance effect of densely populated urban regions with an above-average number of firms might potentially govern the estimation outcome. Therefore, we run a weighted regression, using the same specification as in model (2), with the weights equal to the inverse of the square root of the number of firms for each region. This weighting scheme reduces the dominance of regions that possess a huge stock of firms in the estimation results. As it can be seen from column (2) and (5), the outcomes of the weighted regressions largely confirm our baseline results. Exceptions are the interaction terms of firm size and MAR externalities which enter positive, as in our baseline set-up, but lack statistical significance in the weighted regression models. Due to the down-weighting of urban regions that contain more often large firms and large clusters in our sample, the interdependency between firm size and cluster size becomes less distinct.

Finally, we test whether the growth performance of firms is additionally influenced by systematical cross-border spillovers from neighboring regions. We do so to address the modifiable area problem that may arise from the usage of administrative districts in our analysis (Openshaw and Taylor, 1979). Our baseline set-up is constructed in a way that spillovers originating from cluster-specific externalities are restricted to the home region, which might produce biased results. Therefore, we additionally include the average of cluster-specific externalities of neighboring regions in our model to assess the impact of larger distance knowledge-spillovers. Following spatial econometric tradition, we adopt the 'queen contiguity matrix' as spatial weights in the so-called spatial lag approach, assuming that regions with a common boundary are neighbors (Anselin 1988). The estimation results are reported in column (3) and (6). Most of the spatial lag coefficients show the same sign as their home region counterparts, but all are statistically insignificant. These findings are consistent with many empirical studies that conclude a strong distance decay and a limited effective range of knowledge diffusion and spillovers from spatial externalities (e.g. Audretsch and Keilbach, 2007; Baldwin et al., 2010). Hence, we argue that the application of administrative districts is appropriate for our empirical analysis.

Table 3: Heckman selection model, weighted regressions, and spatial lag of cluster externalities

Crisis vs. pre-crisis	Sales growth				FTE growth			
	(1)		(2)	(3)	(4)		(5)	(6)
	Heckman Selection		Weighted	Spatial lag	Heckman Selection		Weighted	Spatial lag
	Selection Equation	Outcome Equation			Selection Equation	Outcome Equation		
Firm-level								
Credit rating	-0.0052 ***				-0.0052 ***			
	(0.0004)				(0.0004)			
Size	-0.0385	-0.0163 ***	-0.0164 ***	-0.0161 ***	-0.0375	0.0074 ***	0.0073 ***	0.0076 ***
	(0.0252)	(0.0032)	(0.0036)	(0.0032)	(0.0248)	(0.0020)	(0.0021)	(0.0020)
Knowledge base	0.0619	-0.0155 *	-0.0135 *	-0.0158 *	0.0569	-0.0042	-0.0047	-0.0046
	(0.0524)	(0.0081)	(0.0082)	(0.0081)	(0.0516)	(0.0042)	(0.0047)	(0.0043)
Cluster-level								
Variety (V)	-0.0061	-0.0066	-0.0022	-0.0057	0.0459	0.0023	0.0017	0.0027
	(0.0443)	(0.0064)	(0.0080)	(0.0074)	(0.0424)	(0.0033)	(0.0034)	(0.0036)
MAR	-0.0232	-0.0013	0.0024	-0.0006	0.0186	-0.0051 **	-0.0049	-0.0064 **
	(0.0425)	(0.0061)	(0.0063)	(0.0068)	(0.0402)	(0.0024)	(0.0031)	(0.0026)
Spatial lag: Variety (V)				-0.0045				-0.0025
				(0.0084)				(0.0033)
Spatial lag: MAR				-0.0009				0.0024
				(0.0053)				(0.0021)
Cross-Level Moderations								
Knowledge base * Variety (V)	-0.0032	-0.0185 ***	-0.0199 ***	-0.0117 *	-0.0021	-0.0132 ***	-0.0134 ***	-0.0158 ***
	(0.0617)	(0.0061)	(0.0070)	(0.0068)	(0.0606)	(0.0039)	(0.0042)	(0.0050)
Size * Variety (V)	-0.0280	-0.0093 ***	-0.0065 *	-0.0094 **	0.0024	-0.0033 **	-0.0037 **	-0.0008
	(0.0285)	(0.0033)	(0.0035)	(0.0042)	(0.0282)	(0.0015)	(0.0017)	(0.0023)
Knowledge base * MAR	0.0353	0.0083 *	0.0136 **	0.0040	0.0144	0.0047 **	0.0053 **	0.0074 ***
	(0.0352)	(0.0049)	(0.0054)	(0.0052)	(0.0335)	(0.0022)	(0.0026)	(0.0026)
Size * MAR	0.0110	0.0056 **	0.0035	0.0041 *	0.0288	0.0023 **	0.0024	0.0027 *
	(0.0179)	(0.0023)	(0.0028)	(0.0022)	(0.0177)	(0.0012)	(0.0015)	(0.0014)
Spatial lag: Knowledge base * Variety (V)				-0.0107				0.0059
				(0.0075)				(0.0069)
Spatial lag: Size * Variety (V)				-0.0004				-0.0041
				(0.0035)				(0.0032)
Spatial lag: Knowledge base * MAR				0.0106				0.0050
				(0.0080)				(0.0037)
Spatial lag: Size * MAR				0.0032				0.0005
				(0.0037)				(0.0015)
Observations		16,166	16,166	16,166		16,166	16,166	16,166
F-test (p-value)		0.0000 ***	0.0000 ***	0.0000 ***		0.0000 ***	0.0000 ***	0.0000 ***
Adjusted R-Squared		0.0357	0.0484	0.0357		0.0156	0.0294	0.0157

Notes: Dependent variable is the difference in firm performance between crisis period and pre-crisis period. Columns (1) and (4) show estimation results of Heckman selection model, columns (2) and (5) show results of weighted regressions, columns (3) and (6) show results of model specification that includes the cluster-specific externalities of neighboring regions as additional variable (spatial lag: Queen). Sector and region fixed effects and additional controls are included but not reported. All metric explanatory variables are grand mean centered such that the coefficients of non-interaction terms can be interpreted as the marginal effects evaluated when all variables are at the sample mean. Heteroskedasticity-consistent standard errors clustered by region and sector are reported in parentheses. Statistical significance level: 1 % ***, 5 % **, 10 % *.

5.3 Decomposition of variety: the impact of related variety and unrelated variety

We now take a closer look at the role of cluster-level variety by decomposing the overall variety (V) into related variety (RV) and unrelated variety (UV) (see section 2.2 resp. 4.5). It is noteworthy that the overall within-cluster variety (V) already contains relatedness between firm activities, since all firms that belong to a cluster are part of the same two-digit industry sector. Table 4 shows the estimation results. They are, overall, consistent with our baseline results (see Table 1).[12] With respect to the role of variety, the results suggest that unrelated variety within a cluster is the main driver of the growth enhancing effect stemming from the interplay of within-cluster variety and broad combinative capabilities during the pre-crisis period. In contrast, we find no statistically significant growth effects of related variety at cluster-level during stable macroeco-

[12] Regarding the similar, yet less distinct results for FTE growth, we again focus on the models using 'sales growth' as dependent variable.

nomic times (see column (1)). It is notable, however, that the interaction term between related variety and firm-level knowledge has a negative sign and thus points into an opposite direction than any other variety-measure. These results are consistent with the findings of Boschma (2005), Nooteboom et al. (2007), Mameli et al. (2012), and Crespo et al. (2014) that a higher accumulation of related activities in a sector might result in too much cognitive proximity, which leads to lock-in effects, redundant knowledge creation, and scarce contribution to the enhancement of existing knowledge.

Table 4: Decomposition of cluster-level variety

	Sales growth			FTE growth		
	(1)	(2)	(3)	(4)	(5)	(6)
	Pre-crisis (2004-2007)	Crisis (2009-2011)	Crisis vs. pre-crisis	Pre-crisis (2004-2007)	Crisis (2009-2011)	Crisis vs. pre-crisis
Firm-level						
Size	0.0179 ***	0.0018	-0.0161 ***	-0.0081 ***	0.0006	0.0075 ***
	(0.0032)	(0.0022)	(0.0031)	(0.0023)	(0.0015)	(0.0020)
Knowledge base	0.0222 ***	0.0061 *	-0.0161 **	0.0081 **	0.0031	-0.0050
	(0.0070)	(0.0035)	(0.0081)	(0.0033)	(0.0021)	(0.0036)
Cluster-level						
Related Variety (RV)	-0.0020	-0.0076	-0.0056	-0.0071 *	-0.0029	0.0042
	(0.0064)	(0.0051)	(0.0088)	(0.0041)	(0.0026)	(0.0045)
Unrelated Variety (UV)	0.0091	0.0019	-0.0072	0.0005	0.0000	0.0005
	(0.0069)	(0.0036)	(0.0092)	(0.0039)	(0.0016)	(0.0042)
MAR	0.0060	0.0045	-0.0016	0.0049 *	0.0008	-0.0057 **
	(0.0045)	(0.0027)	(0.0061)	(0.0029)	(0.0017)	(0.0026)
Cross-Level Moderations						
Knowledge base * Related Variety (RV)	-0.0083	-0.0153 ***	-0.0070	-0.0033	-0.0032	0.0001
	(0.0083)	(0.0058)	(0.0102)	(0.0054)	(0.0043)	(0.0076)
Size * Related Variety (RV)	0.0037	0.0017	-0.0019	0.0009	-0.0026	-0.0035
	(0.0053)	(0.0052)	(0.0065)	(0.0031)	(0.0028)	(0.0033)
Knowledge base * Unrelated Variety (UV)	0.0332 ***	0.0096 **	-0.0236 ***	0.0216 ***	0.0023	-0.0193 ***
	(0.0053)	(0.0039)	(0.0062)	(0.0044)	(0.0027)	(0.0042)
Size * Unrelated Variety (UV)	0.0091 **	-0.0032	-0.0123 ***	0.0013	-0.0017	-0.0030
	(0.0041)	(0.0025)	(0.0038)	(0.0026)	(0.0014)	(0.0022)
Knowledge base * MAR	-0.0024	0.0047 **	0.0071	-0.0009	0.0023	0.0033
	(0.0043)	(0.0024)	(0.0053)	(0.0023)	(0.0017)	(0.0028)
Size * MAR	-0.0036	0.0013	0.0049 **	-0.0017	0.0006	0.0023 *
	(0.0027)	(0.0015)	(0.0024)	(0.0013)	(0.0008)	(0.0012)
Observations	16,166	16,166	16,166	16,166	16,166	16,166
F-test (p-value)	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***
Adjusted R-Squared	0.0571	0.0160	0.0358	0.0279	0.0175	0.0159

Notes: Columns (1)-(3) show estimation results for firm performance measured by sales growth and columns (4)-(6) show results for analogous regressions with FTE growth as performance indicator. The dependent variable in columns (1) and (4) is the firm performance in the pre-crisis period. The dependent variable in regressions (2) and (5) is firm performance during crisis years. The dependent variable in columns (3) and (6) is the difference in firm performance between crisis period and pre-crisis period. Sector and region fixed effects and additional controls are included but not reported. All metric explanatory variables are grand mean centered such that the coefficients of non-interaction terms can be interpreted as the marginal effects evaluated when all variables are at the sample mean. Heteroskedasticity-consistent standard errors clustered by region and sector are reported in parentheses. Statistical significance level: 1 % ***, 5 % **, 10 % *.

While the growth-decreasing interaction of related variety and knowledge base only begins to take shape during the pre-crisis period, it doubles in terms of effect size whilst becoming statistically significant in times of economic turmoil. One explanation might be that firms with a high amount of internal knowledge that are at the same time located in highly related clusters suffer from a tight integration in an interconnected network of sector-specific spillovers which leads to a higher exposure and vulnerability to shock transmission. In contrast, the interplay of firm's knowledge base and unrelated variety maintains its positive impact on firm performance during crisis years, albeit the effect size is much lower than during pre-crisis years. Seemingly, a greater variety of accessible resources, if not too related, promotes flexibility that helps firms to cope

with unexpected challenges. Overall, our findings imply that unrelated variety (UV) is the pivotal component of variety in the context of firm resilience as it largely determines the mode of action of overall variety (V) as displayed in Table 1. However, we like to reiterate that in this paper unrelated variety is measured from a firm perspective and in fact corresponds with the notion of related variety at the regional level as introduced by Frenken et al. (2007).

5.4 Alternative crisis definition

We further examine whether the results are affected by alternative crisis definitions. Since establishing the end of a crisis is more difficult than determining its starting point (Claessens et al., 2001; Holtermann and Hundt, 2018), we re-estimate our baseline model in Table 1 with an alternative crisis window, increasing the length of crisis by one year. Overall, the change in crisis duration does not alter our general findings (see Appendix A.7). Nevertheless, an interesting insight of this exercise is the fact that differences in growth effects of the tested determinants between crisis and pre-crisis diminish if the crisis period is extended. This motivates us to further subdivide the crisis period (2009-2011) into the national recession (2009) and the subsequent national recovery (2010-2011). Then, we calculate sales growth and TFE growth for the newly defined periods and employ them as dependent variables in a re-estimation of model (1) and model (2). The according results are presented in Table 5.

Most importantly, the subdivision of the crisis into a recession (2009) and a recovery period (2010-2011) reveals that phase-specific differences in the macro-to-micro transition are almost entirely driven by the actual recession in 2009. This becomes evident when comparing the cross-level interactions terms of the 'crisis' (column (2), Table 1) and the 'recession' model (column (2), Table 5) as the latter shows similar but then much more distinct results terms of effect size and statistical significance, at least in the case of sales growth. Consequently, the cross-level moderation of combinative capabilities and MAR externalities is fostering firm growth in a statistically meaningful way only in the 'recession', but not in the (longer) 'crisis' scenario. Hence, the presumed market power of larger and more knowledge-intensive firms (see section 5.1) seems particularly helpful during the immediate economic downturn.

Similarly, the previously insignificant (and smaller) interaction term between firm size and variety gains statistical significance when the 'recession' model is applied. As additional calculations[13] show, this can be explained by the related component of overall variety that, in turn, is assumed to amplify shock transmission and thus tends to increase the shock-sensitivity of more integrated large and knowledge-intense firms (see section 5.3).

[13] Due to lack of space the results are not reported in Table 5. They are, however, available upon request.

Table 5: Firm performance, combinative capacity, and cluster-specific externalities: separating national recession and recovery years

	Sales growth					FTE growth				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Pre-crisis (2004-2007)	Recession (2009)	Recession (2009) vs. pre-crisis	Recovery (2010-2011)	Recovery (2010-2011) vs. pre-crisis	Pre-crisis (2004-2007)	Recession (2009)	Recession (2009) vs. pre-crisis	Recovery (2010-2011)	Recovery (2010-2011) vs. pre-crisis
Firm-level										
Size	0.0180 ***	-0.0095 ***	-0.0275 ***	0.0113 ***	-0.0068 **	-0.0081 ***	-0.0003	0.0078 ***	-0.0003	0.0078 ***
	(0.0032)	(0.0018)	(0.0035)	(0.0020)	(0.0031)	(0.0023)	(0.0008)	(0.0018)	(0.0011)	(0.0023)
Knowledge base	0.0210 ***	0.0040	-0.0170 **	0.0013	-0.0196 **	0.0074 *	-0.0007	-0.0080 **	0.0036 *	-0.0037
	(0.0079)	(0.0026)	(0.0076)	(0.0039)	(0.0088)	(0.0041)	(0.0014)	(0.0038)	(0.0019)	(0.0046)
Cluster-level										
Variety (V)	0.0043	-0.0062 ***	-0.0105 **	0.0040	-0.0004	-0.0034	-0.0006	0.0028	-0.0007	0.0027
	(0.0048)	(0.0015)	(0.0053)	(0.0028)	(0.0061)	(0.0033)	(0.0007)	(0.0033)	(0.0014)	(0.0033)
MAR	0.0051	0.0002	-0.0049	0.0036	-0.0015	0.0043	0.0005	-0.0038	-0.0014	-0.0058 **
	(0.0046)	(0.0015)	(0.0052)	(0.0025)	(0.0057)	(0.0027)	(0.0006)	(0.0028)	(0.0016)	(0.0025)
Cross-Level Moderations										
Knowledge base * Variety (V)	0.0200 ***	-0.0011	-0.0211 ***	0.0026	-0.0174 ***	0.0136 ***	-0.0016	-0.0152 ***	0.0021	-0.0115 ***
	(0.0045)	(0.0018)	(0.0053)	(0.0030)	(0.0055)	(0.0037)	(0.0015)	(0.0033)	(0.0023)	(0.0041)
Size * Variety (V)	0.0078 **	-0.0066 ***	-0.0144 ***	0.0052 **	-0.0026	0.0014	-0.0002	-0.0017	-0.0017	-0.0031
	(0.0038)	(0.0014)	(0.0040)	(0.0022)	(0.0033)	(0.0020)	(0.0010)	(0.0014)	(0.0011)	(0.0023)
Knowledge base * MAR	-0.0052	0.0025 **	0.0077 *	0.0005	0.0057	-0.0027 *	0.0022 ***	0.0049 ***	-0.0003	0.0024
	(0.0037)	(0.0013)	(0.0042)	(0.0022)	(0.0046)	(0.0016)	(0.0008)	(0.0016)	(0.0012)	(0.0022)
Size * MAR	-0.0040	0.0037 ***	0.0077 ***	-0.0022	0.0018	-0.0017	-0.0001	0.0016	0.0007	0.0024 *
	(0.0026)	(0.0007)	(0.0025)	(0.0023)	(0.0025)	(0.0013)	(0.0004)	(0.0012)	(0.0006)	(0.0013)
Observations	16,166	16,166	16,166	16,166	16,166	16,166	16,166	16,166	16,166	16,166
F-test (p-value)	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***
Adjusted R-Squared	0.0563	0.0422	0.0694	0.0224	0.0252	0.0273	0.0093	0.0232	0.0113	0.01463

Notes: Columns (1)-(5) show estimation results for firm performance measured by sales growth and columns (6)-(10) show results for analogous regressions with sales per FTE growth as performance indicator. The dependent variable in columns (1) and (6) is the firm performance in the pre-crisis period. The dependent variable in regressions (2), (4), (7), and (9) is firm performance during the crisis for alternative definitions of crisis years: national recession period (2009) and national recovery period (2010-2011). The dependent variable in columns (3), (5), (8), and (10) is the difference in firm performance between alternative definitions of crisis period and pre-crisis period. Sector and region fixed effects and additional controls are included but not reported. All metric explanatory variables are grand mean centered such that the coefficients of non-interaction terms can be interpreted as the marginal effects evaluated when all variables are at the sample mean. Heteroskedasticity-consistent standard errors clustered by region and sector are reported in parentheses. Statistical significance level: 1 % ***, 5 % **, 10 % *.

Studying the changes in firm performance in recovery vs. pre-crisis comparison, we find that most of the cross-level interactions, with the exception of the interplay between knowledge base and variety, lack statistical significance (see column (5)). This observation suggests that, from a statistical point of view, the basic mechanisms of the macro-to-micro transition are for the most parts not different between pre-crisis period (2004-2007) and recovery phase (2010-2011). Clear phase-specific differences, however, can be detected with regard to the combinative capabilities at firm-level where the imprint of the recession year is still visible in the recovery phase and leads to statistically significant coefficients in the direct recovery vs. pre-crisis comparison (also column (5)). But even here, tendencies of a pre-crisis reversion are recognizable as both coefficients return to positive signs and – in the case of firm size – regain statistical significance when being calculated for the recovery period (see column (4)).

We thus can conclude that, overall, the pre-crisis mechanisms, after being interrupted by the national downturn in 2009, are at least moderately, if not largely restored once the macroeconomic pressure diminishes. These findings suggest that the tested determinants and cross-level transmission channels fostering firm growth are to a certain extent robust against exogenous shocks while the objection that none of the factors regains its pre-crisis impact level (comparison of the effect sizes in column (1) and (4)) can be qualified by the short duration of the recovery period in our set-up.

6 Conclusion

In this paper, we model the macro-to-micro transition of externalities to firms through the interplay between combinative capabilities and localization resp. variety-driven economies. We then examine the impact of this interplay on firm performance in Germany and explore to what extent it is affected by changes in the macroeconomic environment. For this purpose, we combine two different strands of literature: regional science literature on agglomeration economies and the concept of regional economic resilience. To ensure a reliable representation of the entrepreneurial landscape in Germany and the sector-specific regional environments in which firms are nested, we merge micro-level employment data from the Mannheimer Unternehmens Panel (MUP) and data from Creditreform e.V. to compute the regional sector-structure at the five-digit level of the WZ 2008 industry classification. This unique dataset allows us to link firm performance to cluster-specific externalities and to compare the effects of cross-level interactions (macro-to-micro transition) between regimes of macroeconomic stability and instability.

Employing within-firm regression techniques, we estimate the impact of cross-level interactions between firm- and cluster-level determinants on phase-related differences in firm performance between the pre-crisis (2004-2007) and the crisis period (2009-2011). Firm performance is captured by two measures: sales growth and FTE growth. Our estimates are based on a sample of 16,166 firms from the manufacturing and business service sector that are nested in a total of 390 regions. Overall, we find three primary results. First, firms that possess a higher degree of combinative capabilities are better able to gain growth-stimulating impulses from the (unrelated) within-cluster variety of economic activities. The interactions between firm-level compe-

tences and cluster-specific externalities prove to be both statistically significant and economically relevant. Hence, our results indeed point towards the existence of a macro-to-micro transition that evolves best, however, in a stable macroeconomic environment (2004-2007). Another finding is that the presence of cluster-specific externalities alone does not foster firm performance; rather, firms require a minimum amount of combinative capabilities to internalize the prevailing externalities. Our results corroborate previous findings in the literature according to which influences of regional externalities affect firm performance heterogeneously as the capacity to internalize growth enhancing stimuli from the cluster-level environment depends on firm-inherent characteristics (e.g. Knoben et al., 2015). Second, the formerly working transmission of variety-driven externalities is supposedly interrupted by the crisis as we find no significant cross-level interactions during the period of macroeconomic instability (2009-2011). When comparing both macroeconomic regimes, we find that the crisis vs. pre-crisis reduction in growth rate is more pronounced for firms that benefit from cluster-level externalities during the pre-crisis period, because external growth inputs stemming from the cluster-level environment are no longer usable. Third, the crisis-induced interruption of the macro-to-micro transition is mainly restricted to the national recession in 2009. As soon as the macroeconomic pressure diminishes, we observe a reversion of the economic effects originating from the interplay of combinative capabilities and cluster externalities to the pre-crisis level. It is conceivable that the quick restoration of the transmission channels is to some extent influenced by the fast recovery of the national economy as a whole that in turn benefited from anti-cyclical stimulus measures and the re-strengthening of international demand for long-term investment goods (see, for instance, Pudelko et al., 2018). For this reason, future studies might compare firm-level results from other European countries to our findings, because the national institutional setting most likely plays an important role in shaping the economic effects of the macro-to-micro transition in different macroeconomic regimes. Likewise, as our study is focused on a banking crisis, it would be fruitful to investigate the impact of other types of economic distresses, such as currency crises or trade shocks.

To summarize, we interpret our results as evidence consistent with the existence of a macro-to-micro mechanism in our sample of German firms. In contrast to previous studies on this topic, this transition mechanism is not modeled as time-invariant. Instead, it is coupled to the prevailing macroeconomic regime. The results are robust to controlling for several potential sampling biases and employing various model specifications. Once again, however, it is worth mentioning that our sample is restricted to firms that survive the shock, thus all firms are characterized by a minimum degree of resilience.

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Appendices

Appendix A.1: Summary statistics of firm performance indicators

Variable	Period	Min.	1. Qu.	Median	Mean	3. Qu.	Max.	SD
a) Sales growth	2004-2007	-0.5856	0.0000	0.0465	0.1135	0.2624	0.9338	0.2714
b) Sales growth	2009-2011	-0.5223	-0.0375	0.0000	0.0458	0.1252	0.8597	0.2176
c) Sales growth	2009	-0.3581	-0.0127	0.0000	-0.0121	0.0000	0.3449	0.0977
d) Sales growth	2010-2011	-0.0441	0.0000	0.0000	0.0580	0.1236	0.6581	0.1778
Difference in sales growth	b) minus a)	-1.1570	-0.2662	-0.0275	-0.0677	0.1054	1.2340	0.3418
Difference in sales growth	c) minus a)	-1.0840	-0.2763	-0.0487	-0.1158	0.2247	0.8018	0.2916
Difference in sales growth	d) minus a)	-1.1190	-0.2231	-0.0121	-0.0556	0.1054	1.0560	0.3079
e) FTE growth	2004-2007	-0.4055	0.0000	0.0000	0.0350	0.1133	0.5390	0.1671
f) FTE growth	2009-2011	-0.3087	0.0000	0.0000	0.0273	0.0606	0.4383	0.1263
g) FTE growth	2009	-0.1671	0.0000	0.0000	0.0039	0.0000	0.2036	0.0478
h) FTE growth	2010-2011	-0.2231	0.0000	0.0000	0.0208	0.0000	0.3460	0.0928
Difference in FTE growth	f) minus e)	-0.6230	-0.1178	0.0000	-0.0077	0.1002	0.5875	0.1990
Difference in FTE growth	g) minus e)	-0.5777	-0.1054	0.0000	-0.0261	0.0408	0.4603	0.1724
Difference in FTE growth	h) minus e)	-0.5960	-0.1054	0.0000	-0.0151	0.0816	0.5270	0.1839

Appendix A.2: Summary statistics of key explanatory variables

Variable	Min.	1. Qu.	Median	Mean	3. Qu.	Max.	SD
Firm level							
Entrepreneur	0.00	1.00	1.00	0.89	1.00	1.00	0.32
Patent applications per FTE	0.00	0.00	0.00	0.00	0.00	0.29	0.01
Age	5.00	11.00	18.00	26.91	32.00	191.00	25.42
Number of FTE	4.50	8.00	13.50	24.08	27.00	248.00	28.99
Share of tertiary workforce (%)	0.00	0.00	0.00	0.30	0.67	1.00	0.42
Cluster level							
Variety (V)	0.00	1.36	1.91	1.95	2.52	3.88	0.84
Related variety (RV)	0.00	0.38	0.78	0.81	1.16	2.83	0.54
Unrelated variety (UV)	0.00	0.50	1.04	1.12	1.76	2.60	0.72
Number of firms	1.00	37.00	84.00	242.50	202.00	7247.00	582.47
Average firm size	1.22	6.23	11.86	17.48	21.37	1826.00	24.32

Appendix A.3: Correlation table of key explanatory variables

	Entr.	Pat./FTE	Age	No. FTE	Sh. of tert. workforce	Variety	Related Variety	Unrelated Variety	No. Of firms	Avg. firm size
Firm level										
Entrepreneur	1									
Patents per FTE	-0.0057	1								
Age	-0.0014	-0.0206	1							
Number of FTE	-0.1930	0.0112	0.0796	1						
Share of tertiary workforce	-0.1272	0.0277	-0.1005	0.1192	1					
Cluster level										
Variety (V)	0.0033	0.0132	-0.0348	-0.0064	0.0616	1				
Related variety (RV)	-0.0196	0.0101	-0.0733	-0.0236	0.1959	0.5252	1			
Unrelated variety (UV)	0.0187	0.0077	0.0154	0.0106	-0.0775	0.7619	-0.1510	1		
Number of firms	-0.0343	0.0155	-0.0939	-0.0207	0.1191	0.0809	0.1643	-0.0311	1	
Average firm size	-0.0207	0.0063	0.0363	0.1307	0.0019	-0.0521	-0.1063	0.0203	-0.0902	1

Appendix A.4: Robustness checks of baseline results

Crisis vs. pre-crisis	Sales growth						FTE growth					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Baseline model	MAR: empl.-based	Externalities: sales-based	Expl. Var.: 2007	Cluster FE	Patents appl. as moderator	Baseline model	MAR: empl.-based	Externalities: sales-based	Expl. Var.: 2007	Cluster FE	Patents appl. as moderator
Firm level												
Size	-0.0163 ***	-0.0165 ***	-0.0029	-0.0490 ***	-0.0170 ***	-0.0163 ***	0.0075 ***	0.0077 ***	-0.0032 **	-0.0351 ***	0.0080 ***	0.0076 ***
	(0.0032)	(0.0035)	(0.0029)	(0.0033)	(0.0036)	(0.0032)	(0.0020)	(0.0021)	(0.0013)	(0.0021)	(0.0024)	(0.0020)
Knowledge base	-0.0157 *	-0.0168 **	-0.0194 **	-0.0111	-0.0131	-0.0156 *	-0.0044	-0.0049	-0.0020	0.0031	0.0017	-0.0045
	(0.0082)	(0.0082)	(0.0080)	(0.0074)	(0.0102)	(0.0082)	(0.0042)	(0.0042)	(0.0040)	(0.0040)	(0.0065)	(0.0041)
Patents per FTE						0.1274 ***						0.1124
						(0.3471)						(0.2204)
Cluster level												
Variety (V)	-0.0066	-0.0065	-0.0080	-0.0065		-0.0066	0.0021	0.0021	0.0016	0.0020		0.0021
	(0.0064)	(0.0063)	(0.0073)	(0.0073)		(0.0064)	(0.0033)	(0.0033)	(0.0029)	(0.0033)		(0.0033)
MAR	-0.0013	-0.0012	-0.0017	-0.0009		-0.0013	-0.0053 **	-0.0046 **	-0.0051 **	-0.0037 **		-0.0053 **
	(0.0061)	(0.0046)	(0.0063)	(0.0062)		(0.0061)	(0.0025)	(0.0022)	(0.0023)	(0.0027)		(0.0025)
Cross-Level Moderations												
Knowledge base * Variety (V)	-0.0185 ***	-0.0165 **	-0.0208 ***	-0.0129 **	-0.0148 *	-0.0186 ***	-0.0131 ***	-0.0101 **	-0.0120 ***	-0.0025	-0.0195 ***	-0.0130 ***
	(0.0061)	(0.0066)	(0.0063)	(0.0063)	(0.0084)	(0.0060)	(0.0039)	(0.0047)	(0.0035)	(0.0043)	(0.0043)	(0.0039)
Size * Variety (V)	-0.0092 ***	-0.0065 *	-0.0013	-0.0113 ***	-0.0084 **	-0.0094 ***	-0.0034 **	-0.0018	-0.0021 **	-0.0045 ***	-0.0008	-0.0031 **
	(0.0034)	(0.0036)	(0.0039)	(0.0036)	(0.0037)	(0.0033)	(0.0015)	(0.0015)	(0.0010)	(0.0017)	(0.0015)	(0.0015)
Knowledge base * MAR	0.0082 *	0.0054	0.0087 *	0.0014	0.0041	0.0081 *	0.0046 **	0.0001	0.0040 *	0.0007	0.0016	0.0047 **
	(0.0049)	(0.0042)	(0.0048)	(0.0047)	(0.0068)	(0.0049)	(0.0023)	(0.0028)	(0.0021)	(0.0021)	(0.0039)	(0.0023)
Size * MAR	0.0055 **	0.0013	0.0038 **	0.0069 ***	0.0071 ***	0.0054 **	0.0023 *	0.0001	0.0019 ***	0.0020	0.0028 *	0.0023 *
	(0.0023)	(0.0027)	(0.0018)	(0.0024)	(0.0026)	(0.0024)	(0.0012)	(0.0014)	(0.0007)	(0.0013)	(0.0017)	(0.0012)
Patents per FTE * Variety						0.0083						-0.0166
						(0.0279)						(0.0140)
Patents per FTE * MAR						0.0129						-0.0025
						(0.0152)						(0.0057)
Observations	16,166	16,166	16,166	16,166	16,166	16,166	16,166	16,166	16,166	16,166	16,166	16,166
F-test (p-value)	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***
Adjusted R-Squared	0.0358	0.0353	0.0341	0.0490	0.0471	0.0357	0.0157	0.0150	0.0149	0.0358	0.0222	0.0158

Notes: (1): baseline results of differences in sales growth between both macroeconomic phases: specification (3) in Table 1. (2): as in column 1 but using the log of total number of employees instead of firms in the cluster to approximate MAR externalities. (3): as in column 1 but using micro-level sales data instead of employment data to calculate the regional externalities. (4): as in column 1 but all explanatory variables are measured one year prior to crisis outbreak instead at the beginning of sample period. (5): applying cluster-specific fixed effects instead of sector and region fixed effects. (6): additional interaction terms between agglomeration economies at cluster-level and patents per employee at firm-level are included in the model. Columns (7)-(12) report estimation results for analogous models that employ FTE growth as firm performance measure. Sector and region fixed effects and additional controls are included but not reported. All metric explanatory variables are grand mean centered such that the coefficients of non-interaction terms can be interpreted as the marginal effects evaluated when all variables are at sample mean. Heteroskedasticity-consistent standard errors clustered by region and sector are reported in parentheses. Statistical significance level: 1 % ***, 5 % **, 10 % *.

Appendix A.5: Heterogeneity across subsamples of firms

Crisis vs. pre-crisis	Sales growth		FTE growth	
	(1)	(2)	(3)	(4)
	Business services	Small firms (< 50 FTE)	Business services	Small firms (< 50 FTE)
Firm-level				
Size	0.0213 ***	-0.0265	0.0057	-0.0084
	(0.0070)	(0.0238)	(0.0123)	(0.0100)
Knowledge base	0.0115	0.0026	0.0141	0.0156
	(0.0274)	(0.0204)	(0.0253)	(0.0119)
Cluster-level				
Variety (V)	-0.0071	-0.0216	-0.0114	0.0075
	(0.0136)	(0.0562)	(0.0190)	(0.0177)
MAR	0.0024	0.0066	0.0039	-0.0170
	(0.0059)	(0.0240)	(0.0051)	(0.0140)
Cross-Level Moderations				
Knowledge base * Variety (V)	-0.0192	-0.0276	-0.0182	-0.0081
	(0.0300)	(0.0201)	(0.0131)	(0.0076)
Size * Variety (V)	0.0090	0.0150	0.0087	-0.0038
	(0.0067)	(0.0365)	(0.0061)	(0.0088)
Knowledge base * MAR	-0.0072	0.0014	0.0074	-0.0039
	(0.0105)	(0.0159)	(0.0057)	(0.0080)
Size * MAR	-0.0012	0.0041	-0.0035	0.0094
	(0.0041)	(0.0142)	(0.0026)	(0.0079)
Observations	16,166	16,166	16,166	16,166
F-test (p-value)	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***
Adjusted R-Squared	0.0361	0.0358	0.0159	0.0149

Notes: Table shows differences in coefficients between subsample of firms and remaining firms: (1) and (3) business service firms vs. manufacturing firms, (2) and (4) firms with less than 50 employees vs. larger firms. Differences between subgroups are estimated via dummy-interaction (dummy variable equal to one for firms that belong to subgroup and zero otherwise). Dependent variable is the difference in firm performance between crisis period and pre-crisis period. Sector and region fixed effects and additional controls are included but not reported. All metric explanatory variables are grand mean centered such that the coefficients of non-interaction terms can be interpreted as the marginal effects evaluated when all variables are at sample mean. Heteroskedasticity-consistent standard errors clustered by region and sector are reported in parentheses. Statistical significance level: 1 % ***, 5 % **, 10 % *.

Appendix A.6: Testing for potential non-linearities

Crisis vs. pre-crisis	Sales growth	FTE growth
	(1)	(2)
	Non-linear	Non-linear
Firm level		
Size	-1.7070 ***	0.8419 ***
	(0.3550)	(0.2124)
Size sq.	0.1534	-0.3648
	(0.3682)	(0.2319)
Knowledge base	-0.8826 **	-0.2586
	(0.4365)	(0.2132)
Knowledge base sq.	0.4275	0.2933
	(0.3726)	(0.2319)
Cluster level		
Variety (V)	-0.0064	0.0021
	(0.0063)	(0.0034)
MAR	-0.0014	-0.0054 **
	(0.0061)	(0.0025)
Cross-Level Moderations		
Knowledge base * Variety (V)	-0.9928 ***	-0.6822 ***
	(0.3238)	(0.2145)
Knowledge base sq. * Variety (V)	0.1879	-0.2986
	(0.3153)	(0.2399)
Size * Variety (V)	-0.9382 **	-0.3905 **
	(0.3757)	(0.1565)
Size sq. * Variety (V)	-0.0198	0.0416
	(0.4816)	(0.2490)
Knowledge base * MAR	0.4338	0.2332 *
	(0.2700)	(0.1333)
Knowledge base sq. * MAR	-0.0435	0.0081
	(0.2138)	(0.1397)
Size * MAR	0.5947 **	0.2213
	(0.2574)	(0.1425)
Size sq. * MAR	-0.1206	0.0171
	(0.2344)	(0.2019)
Observations	16,166	16,166
F-test (p-value)	0.0000 ***	0.0000 ***
Adjusted R-Squared	0.0355	0.0158

Notes: Sector and region fixed effects and additional controls are included but not reported. All metric explanatory variables are grand mean centered such that the coefficients of non-interaction terms can be interpreted as the marginal effects evaluated when all variables are at sample mean. Heteroskedasticity-consistent standard errors clustered by region and sector are reported in parentheses. Statistical significance level: 1 % ***, 5 % **, 10 % *.

Appendix A.7: Variation of crisis duration

	Sales growth		FTE growth	
	(1)	(2)	(3)	(4)
	Crisis (2009-2011) vs. pre-crisis	Crisis (2009-2012) vs. pre-crisis	Crisis (2009-2011) vs. pre-crisis	Crisis (2009-2012) vs. pre-crisis
Firm-level				
Size	-0.0163 ***	0.0006	0.0075 ***	0.0006
	(0.0032)	(0.0033)	(0.0020)	(0.0023)
Knowledge base	-0.0157 *	0.0029	-0.0044	0.0076
	(0.0082)	(0.0052)	(0.0042)	(0.0037)
Cluster-level				
Variety (V)	-0.0066	-0.0027	0.0021	-0.0023
	(0.0064)	(0.0041)	(0.0033)	(0.0019)
MAR	-0.0013	0.0010	-0.0053 **	-0.0028
	(0.0061)	(0.0044)	(0.0025)	(0.0027)
Cross-Level Moderations				
Knowledge base * Variety (V)	-0.0185 ***	0.0059	-0.0131 ***	-0.0027
	(0.0061)	(0.0060)	(0.0039)	(0.0047)
Size * Variety (V)	-0.0092 ***	0.0010	-0.0034 **	-0.0019
	(0.0034)	(0.0034)	(0.0015)	(0.0020)
Knowledge base * MAR	0.0082 *	0.0005	0.0046 **	0.0023
	(0.0049)	(0.0024)	(0.0023)	(0.0023)
Size * MAR	0.0055 **	-0.0009	0.0023 *	0.0019
	(0.0023)	(0.0024)	(0.0012)	(0.0011)
Observations	16,166	16,166	16,166	16,166
F-test (p-value)	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***
Adjusted R-Squared	0.0358	0.0263	0.0157	0.0143

Notes: Sector and region fixed effects and additional controls are included but not reported. All metric explanatory variables are grand mean centered such that the coefficients of non-interaction terms can be interpreted as the marginal effects evaluated when all variables are at sample mean. Heteroskedasticity-consistent standard errors clustered by region and sector are reported in parentheses. Statistical significance level: 1 % ***, 5 % **, 10 % *.