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# Related Variety, Unrelated Variety, and Regional Growth: The Role of Absorptive Capacity and Entrepreneurship

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**Abstract**

This paper investigates the effect of related and unrelated variety on regional growth in West Germany. In particular, we analyze the role of regional absorptive capacity and new business formation for these effects. We find that West German regions benefit from both types of varieties. The positive effect of unrelated variety on growth is more pronounced in regions with higher levels of absorptive capacity in terms of R&D activities and with higher levels of new business formation. Such moderating effects cannot be found for related variety.

Keywords: Related variety, unrelated variety, knowledge spillovers, regional absorptive capacity, entrepreneurship, regional growth

JEL classification: R11, R12, D62

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## 1. Introduction[1]

The role of industry structures for economic development has been intensively discussed in the literature (Gleaser 1992; Henderson et al. 1995; Combes 2000). A key issue in this debate is knowledge spillovers. While a number of authors claim that knowledge spillovers are more frequent among specialized industrial structures (Marshall-Arrow and Romer externalities) others argue that a diversified industrial structure is conducive for innovation through a recombination of knowledge across sectors such as Jacobs externalities (Jacobs 1969). Empirical evidence is far from conclusive in this regard (Beaudry and Shiffauerova 2009, De Groot et al. 2009). Despite contradictory evidence, stylized facts seem to favor diversification rather than specialization for economic development (Duranton and Puga 2000; Noseleit 2013, 2015).

By disentangling diversification into related and unrelated variety, Frenken et al. (2007) claim that it is not diversification as such, but diversification in related industries that enhances knowledge spillovers and has positive effects on employment growth thus highlighting spillovers among sectors that are cognitively proximate. Despite a number of recent studies that have investigated the impact of related and unrelated variety on regional growth the picture is still unclear.[2] What is also unclear is the implications of these arguments and empirical findings for a policy that aims at stimulating economic growth. This pertains particularly to the 'smart specialization' concept of EU cohesion policy that clearly favors related variety and aims at steering regional industry structures into that direction (Foray 2015; McCann and Ortega-Argilés 2016).

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[1] We are indebted to Dieter Kogler for helpful comments on an earlier version of this paper.

[2] For an overview of recent studies see Content and Frenken (2016).

This paper deals with three main questions. First, we analyze what type of industry diversification—related or unrelated—promotes regional growth in West Germany. Second, we investigate if, and in how far the relationship between diversification and growth varies with a region's absorptive capacity as measured by the level of Research and Development (R&D) activity that might moderate the effect of knowledge spillovers on growth. And third, we examine the role of new business formation in the relationship between variety and regional development: are start-ups a significant channel by which variety is transformed into growth so that the effect of variety is more pronounced in more entrepreneurial regions?

There have been quite a number of applications of the variety concept to European economies.[3] However, to the best of our knowledge there is only one study by Brachert et al. (2011) that explores the impact of related and unrelated variety on regional growth in Germany. Brachert et al. (2011) find that both types of variety can be positively related to regional growth only if leading management functions of the firms are located in the same region. Due to considerable differences of the estimation approach, the results are not directly comparable to most of the other studies such as the seminal paper by Frenken et al. (2007).

The present study not only attempts to provide empirical evidence for the case of Germany that can be directly compared to the study by Frenken et al. (2007) but also extends the analysis in two respects. First, we incorporate the concept of absorptive capacity (Cohen and Levinthal 1990) by claiming that ability to benefit from related and unrelated variety in terms of economic growth is significantly shaped by regional R&D intensity. The underlying idea is that the larger the regional knowledge base in terms of

[3] E.g., Frenken et al. (2007) for Netherlands; Boschma and Iammarino (2009), Quatraro (2010) and Mameli at al. (2012) for Italy; Bishop and Gripaios (2010) for the UK; Hartog et al. (2012) for Finland; Tavasoli and Carbonara (2014) for Sweden; Boschma et al. (2011) for Spain; Cortinovis and van Oort (2015) for the regions of the EU.

R&D, the higher is the expected ability to absorb knowledge from other related and unrelated industries and the stronger the effect on growth. Second, we emphasize the role of entrepreneurship in the recombination of knowledge (Weitzman 1998) and experimentation in the economy (Kerr et al. 2014). Can entrepreneurship be regarded a mediator of the effect of industry variety on growth in accordance with the knowledge spillover theory of entrepreneurship (Acs, Audretsch and Lehmann 2013)? While existing studies show the importance of different types of diversity on economic growth, the role of entrepreneurs who combine the resources and introduce innovations to the market has generally been neglected so far.

The remainder is organized as follows. Section 2 provides an overview of the main theoretical concepts of the effect of regional variety on growth and develops the hypotheses to be tested in the empirical part. The spatial framework of the analysis, data and variables are described in Section 3. In the empirical part (Section 4) we first replicate the analysis of Frenken et al. (2007) and then extend the approach by accounting for regional absorptive capacity and entrepreneurship. Section 5 summarizes the results and concludes.

## 2. Concepts of industry structure and its link to regional growth

### 2.1 Previous research

One of the main questions in the regional growth and spatial externalities literature is whether firms learn more from other local firms in the same industry or from firms that are affiliated to other industries (Boschma et al. 2011). Namely, is it a rather specialized or a more diversified industrial composition that could foster knowledge spillovers and enhance growth? Historically, the debate on industry composition and its effect on growth can be traced back at least to the work of Marshall (1920) and Jacobs (1969) that have evolved into two theoretical concepts.

The first of these concepts assumes that firms may benefit from the presence or similar activities or industries in the region (Boschma 2010). Potential benefits are expected to come from large input and output markets with a rich supply of specialized labor and specialized suppliers as well as from intra-industry knowledge spillovers. Due to the conceptualization by Marshall (1920) and the later formalization by Arrow (1962) and Romer (1986) these types of positive externalities that are associated with a specialization on certain industries are commonly termed as Marshall-Arrow-Romer (MAR) externalities.

The second concept that dates back to the work of Jacobs (1969) highlights benefits that may arise from the presence of different activities or industries in a region. The basic idea behind this notion is that a diversified industry structure provides opportunities to interact and recombine different types of knowledge thereby fostering the generation of new ideas and innovations (Boschma et al. 2011). These types of inter-industry knowledge spillovers that are mainly associated with a diversified industry composition are commonly denoted as Jacobs externalities.

Attempts to empirically assess the importance of MAR and Jacobs externalities arrived at contradicting results (for a recent overview see de Grot, Poot and Smit 2015). For example, Glaeser et al. (1992) by analyzing employment growth in US cities between 1956 and 1987 found that industries grow faster in a diversified and highly competitive industrial environment indicating a significant effect of Jacobs externalities. According to this study, a specialized industrial setting tends to dampen regional employment growth thus rejecting a positive role of MAR externalities. In contrast, an analysis by Henderson et al. (1995) of growth in the US metropolitan areas between 1970 and 1987 found that a specialized industrial environment is conducive to growth suggesting the importance of MAR type externalities. Exceptions were new high-tech industries where Jacobs externalities appeared to be dominant. Combes (2000) in his analysis for France for the time period 1984-

1993 found distinct effects for the manufacturing and the service sector. According to this study, a diverse industry composition is beneficial for the development of the service sector whereas it is related with low growth in manufacturing.

Feldman and Audretsch (1999) are among the first who empirically linked the regional industry structure with innovative outcome. Using data on the US product innovations in 1982 they found a negative effect of specialization on innovative output. However, diversity of industries that share a common scientific knowledge base has a positive effect. Altogether, the findings of these empirical analyses and the results of many further studies[4] on the effect of regional industry composition on growth are inconclusive. This may be partly attributed to the diverse methodological approaches and levels of spatial and sectoral aggregations that have been applied (Beaudry and Schiffauerova 2009). Another reason may be that a distinction of sectoral structures into diversified or specialized is an oversimplification.

One of the first studies that theoretically and empirically pointed to such an oversimplification, particularly with regard to the concept of Jacobs externalities, is a contribution by Frenken et al. (2007). Frenken et al. (2007) emphasize the need to disentangle diversification based on the degree of relatedness, namely, to split it into a related and an unrelated part. According to Frenken et al. (2007) different types of variety can have distinct effects on a region's economic performance and should, therefore, be distinguished. A key hypothesis in this respect is that a diversified composition of related industries in a region is conducive to the emergence of knowledge spillovers that induce innovations thus creating positive effects on regional growth. In contrast, unrelated variety is less likely to generate such spillover effects due

[4] E.g., Mameli et al. (2008), Blien and Suedekum (2005), for an overview see De Groot et al. (2009).

to a larger technological and cognitive distance between actors in these industries.

Important differences may, however, exist between the types of innovations that are induced by spillovers between related and unrelated industries. Boschma and Capone (2014) assume that spillovers between related industries may primarily lead to incremental innovations while spillovers among unrelated industries are particularly conducive to radical innovation like completely new products (for supportive empirical evidence see Castaldi et al. 2015). If radical innovation creates stronger positive impulses for regional development as compared to incremental innovation, then it is an open question which of the two types of variety will be more important for growth: spillovers between related industries may be more frequent but with an only relatively small effect while spillovers between unrelated industries should be less frequent but may create a stronger positive impulse for development. A further advantage of unrelated variety is that it creates portfolio effects that make a regional economy more resilient with regard to negative sector-specific shocks.

The empirical application of the concept of related and unrelated variety by Frenken et al. (2007) to Dutch regions for the 1996-2002 period showed a significantly positive effect of related variety on regional growth of employment and productivity while the level of unrelated variety remained insignificant. Unrelated variety was, however, found to make regions more resilient against unemployment, while the measure for related variety remained largely insignificant in this respect.

This conceptualization of diversity and the empirical evidence for Dutch regions gave enormous rise to further investigations (for an overview, see Frenken 2016), however, with no entirely conclusive findings. Reasons for diverging results were partly attributed to the different methods of classifying industries into related and unrelated. Critiques of the empirical

application of the concept led to new approaches that could possibly better capture the level of sector relatedness within a region (see, for example, Neffke et al. 2011).

### 2.2 Hypotheses on the role of absorptive capacity and entrepreneurship

Two issues that have been largely neglected in the debate about the role of related and unrelated variety are the levels of regional absorptive capacity and of new business formation. It can be regarded critical preconditions for knowledge spillovers to occur and to become effective that the receiving party has sufficient absorptive capacity, i.e. the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990, 128). Because absorptive capacity requires some prior knowledge the existing knowledge stock of a region can be an important factor that moderates the spillovers between actors.

Cohen and Levinthal (1990) emphasize the importance of related knowledge for absorptive capacity ("learning performance is greatest when the object of learning is related to what is already known", 131) what could explain a higher likelihood of spillovers between related industries where cognitive proximity is relatively pronounced. At the same time, however, they also emphasize the importance of diversity ("diverse knowledge structures in the same mind provoke the sort of learning and problem solving that yields innovation"133; "interactions among diverse structures should lead to more novel linkages and associations", 133) what may point to the importance of existing knowledge from unrelated sectors for radical innovation. For these reasons one might expect that absorptive capacity of regional actors facilitates knowledge spillovers among related as well as of unrelated industries thereby contributing significantly to a positive effect of variety on regional employment growth. We will investigate such a moderating role of

absorptive capacity operationalized by the level of regional R&D activity in our empirical analysis.

Because new businesses tend to apply the knowledge that the founders have acquired in their former education institutions and workplaces they may be an important form of knowledge spillover (Acs et al. 2009; 2013). Particularly innovative start-ups that often recombine old ideas in new ways (Weitzman 1998) can have rather pronounced positive effects on regional development (Fritsch 2013). A frequent motivation for founders of innovative new firms to spin off from paid employment into self-employment is that the founder cannot realize an innovative idea in the incubator organization (Klepper 2009). A quite common pattern is that the management and the potential entrepreneur disagree about the realization of an idea, be it because of different perceptions of the economic potential of this idea and the risk involved in bringing the innovation to the marketplace, or for other reasons.[5] Because new knowledge is not easily communicated or traded on a market, it is frequently the employee who becomes the founder of a new innovative firm. For the employee, starting an own business is often the only way to exploit an idea that is being ignored by incumbents and would otherwise remain dormant and unused.

Since the economic value of an incremental innovation can be much easier assessed than the value of a more radical innovation, spin-offs may particularly play a role with regard to radical innovations that are based on ideas from unrelated knowledge fields. This matches the observation that many radical innovations are introduced by new firms (Baumol 2004), while incumbent firms tend to focus on incremental improvements. We anticipate that new business formation may have in general a moderating effect of transforming knowledge spillovers into growth. The rather pronounced role of

[5] Another reason may be that the firm does not want to compete against its own established products. A key reason for a spin-off from public research organizations can be legal restrictions of these organizations for commercial activity.

start-ups for the introduction of radical innovation leads us to expect that new business formation will be particularly important for spillovers among unrelated knowledge fields and industries. Hence, their moderating effect in transforming knowledge into growth should be particularly pronounced in regions that are characterized by high levels of unrelated variety.

## 3. Empirical modelling, data and spatial framework of the analysis

### 3.1 Modelling and estimation approach

The basic structure of our empirical models for analyzing the relationship between related and unrelated variety with regional growth is:

(1) $Growth_{i,t+5} = \beta_0 + \beta_1 RV_{i,t} + \beta_2 UV_{i,t} + \beta_3 Interaction_{i,t} + \beta' X'_{i,t} + \varepsilon_{i,t}.$

$Growth_{i,t+5}$ denotes employment change in region i over a five year period, $RV_{i,t}$ is the measure of related variety in region i in time period t, and $UV_{i,t}$ represents the level of unrelated variety in region i in time period t. $Interaction_{i,t}$ stands for the variables that are supposed to capture the moderating effect of absorptive capacity and entrepreneurship on the relationship between the two types of variety and growth. A significantly positive sign of the interaction variables would indicate stronger effect of variety for regions with higher levels of absorptive capacity and entrepreneurship, respectively. $X'_{i,t}$ is a vector of further variable including the two base variables that are interacted with the related and unrelated variety; $\varepsilon_{i,t}$ represents the error term.

Since our data allows us to construct a balanced panel, we apply fixed effects panel regressions in order to account for unobserved region specific characteristics. A problem could emerge insofar as industry related indicators as well as the regional start-up rate might be affected by regional growth and therefore, are to a degree of an endogenous character. For example, the

indicator of related variety could be influenced by an expansion of related industries. We attempt to mitigate such potential endogeneity problems by calculating the employment change for a five year period and measuring all independent variables at the beginning of this five year period.[6] An alternative approach to account for such potential endogeneity problems is the application of the dynamic generalized method of moments (GMM) estimators (Arellano and Bond 1991) that generates internal instruments based on the lagged differences and lagged levels of the explanatory variables. We use this approach as a robustness check to test for the presence of endogeneity in the base model.[7]

### 3.2 Spatial framework and data sources

The spatial framework of the analysis is the 71 planning regions of West Germany.[8] Planning regions are functional spatial units that consist of at least one core city and the surrounding area and are comparable to the labor market areas in the United States. Choice of planning regions over districts is justified by the fact that various effects (e.g., knowledge spillovers what are of the particular importance in this study) might be relevant for larger units of observation than districts and therefore could decrease potential presence of spatial autocorrelation in the empirical estimations. Furthermore, labor market regions are considered to be the most appropriate spatial unit of analysis for agglomeration research (Frenken et al. 2004). The analysis is restricted to

[6] E.g. Frenken et al. (2007) regard a time period of five years; Boschma et al. (2009) use a time period of eight years; Boschma et al. (2011) take a four year period; Bishop et al. (2010) analyze growth over seven years.

[7] This approach is also used in some other studies that link regional industry composition with growth; see for instance Hartog et al. (2012) and Boschma et al. (2013).

[8] There are 74 West German planning regions. For administrative reasons, the cities of Hamburg and Bremen are defined as planning regions even though they are not functional economic units. To avoid distortions, we merged these cities with adjacent planning regions. Hamburg is merged with the region of Schleswig-Holstein South and Hamburg-Umland-South. Bremen is merged with Bremen-Umland. Thus, the number of regions in our sample is 71.

West Germany because many empirical studies indicate that the East German economy in the 1990s was a special case with very specific conditions that cannot be directly compared to those of West Germany (see Fritsch 2004; Brixy and Grotz 2004).

Most part of the data used in this analysis, particularly data on regional industry composition, is obtained from the Establishment History File of the German Employment Statistics. This dataset contains every establishment in Germany that employs at least one person obliged to make social insurance contributions (Spengler 2008). This data contains information about the assignment of each establishment to its 5-digit level industry for the years 1999 to 2008 which is the period of analysis. Data on population density is from the Federal Institute on Building, Urban Affairs and Spatial Development (2015).

## 3.3 Variables

### 3.3.1 Measurement of variety

We follow Frenken et al. (2007) in measuring related and unrelated variety of regional industries. Frenken et al. (2007) assume that two digit industries are unrelated to each other because they are not cognitively proximate. Accordingly, their indicator of *unrelated variety* (*UV*) is the entropy across two digit industries, i.e.

$$\text{Unrelated variety} = \sum_{g=1}^{G} P_g \log_2 \left(\frac{1}{P_g}\right)$$

where $P_g$ is the share of employment in a two digit sector $S_g$ (g=1, …, G) over total regional employment. UV measures the degree to which employment shares are evenly distributed across two digit industries. The values of UV can vary from 0 (all employment is concentrated in only one two digit sector) up to $\log_2(G)$ when all sectors employ an equal number of employees. Since

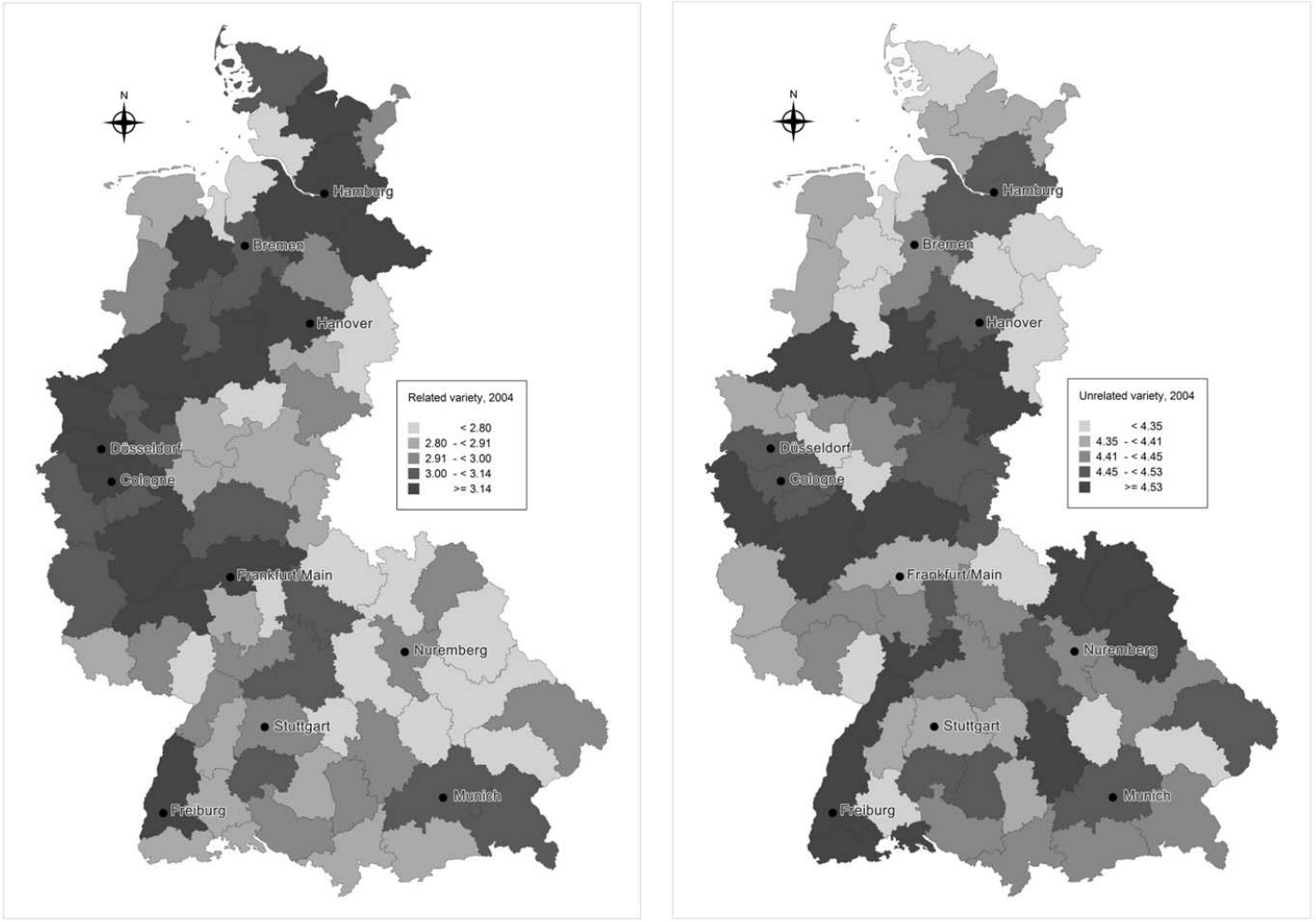
our empirical analysis is based on information for 41 two digit private industries the upper bound of the index is 5.36.

*Related variety* (*RV*) is measured as the weighted sum of entropy at the five digit level within each two digit sector. An assumption here is that industries within two digit industries are characterized by a high level of cognitive proximity so that knowledge spillovers between these industries are relatively frequent (Frenken et al. 2007). The indicator for related variety is calculated as

$$\text{Related Variety} = \sum_{g=1}^{G} P_g H_g \quad \text{where} \quad H_g = \sum_{i=1;\, S_i \epsilon S_g}^{I} \frac{p_i}{P_g} \log_2 \left( \frac{1}{p_i / P_g} \right).$$

$P_g$ is the share of regional employment in a two digit sector $S_g$; $p_i$ is the share of employment in a five digit sector $S_i$ (where I = 1, …, I) belonging to the same two digit sector $S_g$. The related variety index indicates the degree to which employment at the five digit level is evenly spread within the respective two digit sector. The values of the index range from 0 (employment in each two digit sector is concentrated in only one of its five digit industries) to log2(I)-log2(G), when all five digit industries within a two digit industry have an equal employment share (based on the entropy decomposition theorem by Theil 1972, as applied by Castaldi et al. 2015). The higher the value of the related variety index is, the more evenly is employment spread across the subsectors indicating a higher share of related industries in a region. Since our empirical analysis is based on 829 private five digit industries (I) within 41 two digit industries (G) the theoretical upper bound of the index is 4.34.[9]

[9] There has been a small change in the industry classification in the year 2003 which slightly affects the five digit level industries. Since data for 2003 is provided for both classification systems, we calculated the related variety index for this year according to both classifications in order to assess the effect of this change. We found a very high level of correlation (0.997) between the two measures at the regional level pointing to high robustness of the related variety index across the two industrial classifications.




1a) Related variety

1b) Unrelated variety

Figure 1: Related and unrelated variety in West German planning regions 2004

Average values of *UV* over the observation period lie between 4.42 and 4.43. Taking into account the theoretical upper bound of *UV* being 5.36, this indicates a rather diverse yet stable unrelated industry composition in West German regions. Such high stability might be explained by difficulties to attract or diversify into industries that are not technologically close to current regional activities (as shown by Neffke et al. 2011). While the level of unrelated variety as measured by *UV* remains largely unchanged over time, the measure for related variety (*RV*) reveals a continuous increase from 2.95 to 3.02. Figure 1 shows the distribution of related and unrelated variety across West German planning regions in the year 2004 which is the outset of the final period of our analysis. Most regions with high levels of related variety are located in the North and the West of the country while the regions with high levels of unrelated variety are more or less evenly distributed across the Middle and the South. Many of the regions with low levels of unrelated variety are rather rural but also some high-density regions such as the old-industrialized Ruhr area north of Düsseldorf as well as Frankfurt and Stuttgart show low levels of sectoral diversification (for a more detailed analysis see Kublina 2015).

### 3.3.2 Variables

The dependent variable for the study is regional employment change measured as the percent change in employment over a five-year period.[10] We use employment change instead of GDP change as indicator for growth because the employment figures are more reliable at a small regional scale. Moreover, a consistent time series of GDP for the relatively long period of analysis is not available.

[10] Hence, we have seven observations for each region relating to the time periods 1999-2004, 2000-05, 2001-06, 2002-07, 2003-08, and 2004-09.

All explanatory variables are measured at the beginning of the respective five year window. The two key explanatory variables are the indicators for the levels of related and unrelated variety explained above. The regional knowledge base (regional absorptive capacity) is measured as the share of R&D employees in private-sector employment.[11] An alternative indicator could be the share of employees with a tertiary degree in a region that is highly correlated with the regional share of R&D employment (the correlation coefficient is 0.86). We chose to use the share of private-sector R&D employees because it is more closely related to the concept of absorptive capacity. Population density is population per kilometer squared. Entrepreneurship is measured by the regional start-up rate. The start-up rate is the yearly number of new businesses in the private sector divided by the number of employees (in 1,000s)[12]. We identify start-ups in the data based on workflow analyses (for details see Hethey and Schmieder 2010). Population density is used as a catch-all variable of various regional characteristics (e.g., housing and land prices, infrastructure availability, market thickness, etc.) and is applied to control for the effect of urbanization economies. Furthermore, year dummies are included to control for time-specific effects.

Studies that explore the link between the regional industry structure and growth have shown that the potential effects from spillovers might differ across sectors (Combes 2000; Mameli et al. 2008; Bishop and Gripaios 2010). Bishop and Gripaios (2010) and Deidda et al. (2006) mention different levels of tradability of industry output across regions as one of the potential reasons for such diverse effects. Services as non-tradables are more geographically constrained since they tend to be located in close proximity to their customers whereas manufacturing is less restricted in this respect and,

[11] R&D employees are defined as those with tertiary degrees working as engineers or natural scientists.

[12] Start-ups in agriculture, mining and the public sector are not considered in the analysis.

therefore, can better take advantage of location externalities. To control for such effects we use the employment share in the manufacturing sector.

Table 1: Definition of variables

| *Variable* | *Definition* |
|---|---|
| Regional employment growth | Percent change of private sector employment (full time equivalents) over the respective five year period.[a] |
| Related variety (RV) | See Section 3.2.1.[a] |
| Unrelated variety (UV) | See Section 3.2.1.[a] |
| R&D intensity | Number of private sector R&D employees (those with tertiary degrees working as engineers or natural scientists) over total private sector employment.[a] |
| Start-up rate | Number of new businesses in the private sector (excluding agriculture) per 1,000 private sector employees.[a] |
| Share of manufacturing employment | Number of employees in the manufacturing sector over total private sector employment.[a] |
| Population density (log) | Total population per $km^2$.[b] |
| Market potential (log) | Distance-weighted sum of total population in all other regions.[b] |
| *Data sources:* a: Establishment History File of the German Employment Statistics; b: Federal Institute on Building, Urban Affairs and Spatial Development.. | |

Growth of a particular region may not only be affected by the characteristics of the same region but also by spatial proximity to other regions and their markets. The importance of such type of controls can arise from strong economic linkages across regions as well as the fact that the definition of regions is often shaped by administrative boundaries than geographic links (Bishop and Gripaios 2010). To account for such spatial dependencies in our analysis, a Harris-type market potential function is applied. The market potential variable is calculated as the distance weighted sum of the total population in all other German regions (Redding and Sturm 2008; Suedekum 2008). The idea for this type of control originates from the

market potential function of Harris (1954) according to which demand for goods from a particular location is a sum of purchasing power from other locations weighted by transportation costs (Hanson 2004).

Since the Federal States are an important level for policy we include dummy variables for the Federal States in order to capture these effects. Furthermore, we control for time-specific effects by including year dummies. Table 1 summarizes the definition of the variables that we use. Descriptive statistics and correlations between the independent variables are provided in Tables A1 and A2 of the Appendix.

## 4. Empirical analysis

### 4.1 Effect of related und unrelated variety on regional employment growth: the role of regional absorptive capacity

We estimate four different models to analyze the effects of related and unrelated variety on regional employment growth (Table 2). The base model (model I) is closely oriented at the study of Frenken et al. (2007). Model II contains some further controls for spatial dependence and the sectoral structure. Finally, models III and IV test whether different levels of absorptive capacity have a moderating effect on the relationship between variety and growth by including interaction variables of the two types of varieties with R&D intensity which is our indicator for regional absorptive capacity.

Results of all model specifications reveal significant and positive impacts for both types of industry variety on regional employment growth. The most striking difference compared to the results of Frenken et al. (2007) is the positive effect of unrelated variety on growth. This is in line with other studies such as the analysis of Mameli et al. (2012) for Italian regions and Bishop and Gripaios (2010) for the UK who find a positive effect of unrelated variety on growth in most of the manufacturing industries but no statistically significant

Table 2: Effect of related und unrelated variety on regional employment growth

| | I | II | III | IV |
|---|---|---|---|---|
| Related variety | 0.16*** (0.03) | 0.30*** (0.04) | 0.22*** (0.07) | 0.28*** (0.04) |
| Unrelated variety | 0.41*** (0.04) | 0.42*** (0.04) | 0.40*** (0.04) | 0.20** (0.09) |
| R&D intensity | 0.23** (0.10) | 0.16* (0.09) | -0.47 (0.45) | -2.60*** (0.98) |
| Population density (log) | 0.17 (0.18) | 0.02 (0.19) | 0.00 (0.19) | 0.04 (0.19) |
| Market potential | - | 1.13 (0.79) | 1.17 (0.79) | 0.98 (0.79) |
| Share of manufacturing employment | - | 0.96*** (0.16) | 0.95*** (0.16) | 0.97*** (0.16) |
| Related variety * R&D intensity | - | - | 0.23 (0.16) | - |
| Unrelated variety * R&D intensity | - | - | - | 0.63** (0.22) |
| Constant | -3.20*** (1.01) | -17.37*** (9.44) | -17.43* (9.42) | -14.60 (9.41) |
| Year dummies | Yes*** | Yes*** | Yes*** | Yes*** |
| Federal State dummies | Yes*** | Yes*** | Yes*** | Yes*** |
| Number of observations | 497 | 497 | 497 | 497 |
| R2 within | 0.89 | 0.90 | 0.90 | 0.90 |
| Mean variance inflation factor (vif) | 1.7 | 1.91 | 3.23 | 3.23 |

*Notes*: Dependent variable: change in regional employment; panel fixed effects regressions; standard errors in parentheses; ***: statistically significant at the 1% level; **: statistically significant at the 5% level, *: statistically significant at the 10% level.

effect of related variety. Calculating the measures for the two types of varieties separately for the manufacturing and the service sector, Bishop and Gripaios (2010) found that only unrelated variety in the manufacturing sectors has a significant positive effect on growth whereas in the service sector such a positive effect can only be found for related variety. In model I the share of R&D employees has the expected significant positive sign and the coefficient for population density is not statistically significant. Adding further controls in model II shows no statistically significant effect of market potential but a

highly significant positive effect for the employment share in the manufacturing sector.

We do not include both interactions of our indicator for regional absorptive capacity—the share of R&D employment—with the measures of related and unrelated variety into one model due to the pronounced multicollinearity that is obviously due to R&D intensity being included three times. While the interaction of R&D intensity with related variety (model III in Table 2) turns out to be not statistically significant we find a highly significant coefficient for the interaction with unrelated variety (model IV). This suggests that the effect of knowledge spillovers among unrelated industries on regional growth rises with the level of regional R&D activity. This clearly indicates that higher levels of regional absorptive capacity can facilitate the spillovers among different fields of knowledge but are not important for spillovers between related fields. The significantly negative coefficient of R&D intensity in model IV is probably due to high correlation with the interaction term. Accounting for the average value of UV (4.42) the magnitude of the overall effect of regional R&D intensity on growth as indicated by the coefficients estimated for the base variable and the interaction term is positive (-2.6 + 0.63 * 4.42 = 0.1846). This finding supports the hypothesis that regions with high level of absorptive capacity are better able to benefit from a high level of unrelated variety. Population density and the measure of market potential are insignificant in all model specifications.

### 4.2 The relationship between entrepreneurship and growth: role of related and unrelated variety.

The formation of new businesses can be an important mechanism by which knowledge is transformed into innovation and unfolds its effect on growth (see Section 2.2). We test for the relevance of such an effect by including the regional start-up rate and interact the start-up rate with our indicators for

related and unrelated variety. To keep consistency with the previous analysis, we include the same set of control variables.

Table 3: Moderating effect of related und unrelated variety in the relation between the entrepreneurship and employment growth

| | I | II | III |
|---|---|---|---|
| Related variety | 0.29*** | 0.31*** | 0.28*** |
| | (0.04) | (0.05) | (0.04) |
| Unrelated variety | 0.41*** | 0.41*** | 0.30*** |
| | (0.04) | (0.04) | (0.06) |
| R&D intensity | 0.16* | 0.16* | 0.19*** |
| | (0.09) | (0.09) | (0.09) |
| Start-up rate | 0.01** | 0.03 | -0.10** |
| | (0.00) | (0.02) | (0.05) |
| Population density (log) | 0.06 | 0.03 | 0.08 |
| | (0.19) | (0.20) | (0.19) |
| Market potential | 1.38* | 1.58* | 1.22 |
| | (0.80) | (0.85) | (0.79) |
| Share of manufacturing employment | 0.98*** | 0.98*** | 0.92*** |
| | (0.16) | (0.16) | (0.16) |
| Related variety * Start-up rate | - | 0.00 | - |
| | | (0.01) | |
| Unrelated variety * Start-up rate | - | - | 0.02** |
| | | | (0.01) |
| Constant | -20.84*** | -23.26** | -18.46* |
| | (9.45) | (10.06) | (9.45) |
| Year dummies | Yes*** | Yes*** | Yes*** |
| Federal State dummies | Yes*** | Yes*** | Yes*** |
| Number of observations | 497 | 497 | 497 |
| R2 within | 0.90 | 0.90 | 0.90 |
| Mean variance inflation factor (vif) | 1.98 | 6.34 | 5.43 |

*Notes*: Dependent variable: change in regional employment; panel fixed effects regressions; standard errors in parentheses; ***: statistically significant at the 1% level; **: statistically significant at the 5% level, *: statistically significant at the 10% level.

In model I in Table 3 the regional start-up rate is added to the basic model of the previous section (model II in Table 2). In line with many other studies (see Fritsch 2013), we find that the start-up rate is statistically significant with a positive sign. All other variables remain rather unchanged.

An exception is that the indicator for market potential now becomes slightly significant in two of the three models. The interactions of the start-up rate with our indicators of related and unrelated variety are included in separate models in order to avoid multicollinearity problems. We find a significant interaction effect between the start-up rate and the level of unrelated variety (model III in Table 3) but not for the interaction between the start-up rate and the measure of related variety. This confirms our expectation that new business formation may play a particularly important role in transforming knowledge into growth in a regional environment that is characterized by a highly unrelated industry composition. As in the previous analysis of the effect of regional absorptive capacity the significantly negative coefficient for the start-up rate in model III is obviously caused by correlation with the interaction variable. The overall effect of entrepreneurship on growth is in this model (base variable and interaction effect times average value of unrelated variety, i.e. -0.10 + 0.025 * 4.42) is clearly positive with a value of 0.0105. Hence, a high start-up rate has a stronger growth enhancing effect at higher levels of unrelated variety. Therefore we conclude that entrepreneurship moderates the effect of unrelated variety on regional growth.

Since regional characteristics tend to change rather slowly over time, the overlapping 5-year time-periods for successive years that we use in our analysis might involve some over-determination of the model. As a robustness check we have estimated our models based on 5-year time intervals starting only every second year (see Tables A3 and A4 in the Appendix). This reduces the number of observations per region to four time periods. The results of these estimations correspond closely to the results or the yearly time period (Table 2 and 3) but the significance of the interactions becomes weaker which is probably due to the considerably lower number of observations. In order to account for a potential endogeneity bias, we also estimated the models with GMM but did not find any great differences (see

Table A5 in the Appendix). This indicates that our estimations should not suffer from endogeneity problems.

## 5. Conclusion

We have investigated the effect of related and unrelated variety on employment growth in West German regions. Moreover, we have analyzed the moderating roles of regional absorptive capacity (measured by the share of R&D employees) and of new business formation for the effects. The empirical analysis showed that regions in West German benefit from both types of varieties, related and unrelated, but that the effect of unrelated variety tend to be more pronounced. Investigating moderating effects of absorptive capacity by interacting the respecting indicator with the two types of varieties we found only the interaction with unrelated variety to be statistically significant. This indicates that regional R&D activities may stimulate knowledge spillovers and knowledge recombination between unrelated industries but not among related industries. A corresponding result was found for a moderating effect of new business formation with the two types of variety. Again, only the interaction of the start-up rate with the level of unrelated variety proved to be statistically significant indicating that entrepreneurial experimentation is only important in transforming unrelated variety into growth.

Our finding that any type of industry diversity is conducive to regional growth contradicts policy concepts that favor a certain type of variety such as the EU smart specialization strategy that focusses on related variety (Foray 2015; McCann and Ortega-Argilés 2016). In contrast to such steering policy concepts that discriminate against certain types of economic activity our analysis suggests that the promotion of regional R&D and of regional entrepreneurship are much better suited to stimulate regional development. Since new business formation is a main generator of industry diversity in a

region (Neffke, Henning and Boschma 2011; Noseleit 2013, 2015), stimulating regional entrepreneurship will contribute to regional industry diversity *and* to the magnitude of its positive effect on growth.

The general recommendation for policies that aim at stimulating growth is to focus on developing opportunities for spillovers and to stimulate these spillovers rather than promoting ideas of diversity as such (Bishop and Gripaios 2010). This points the attention towards the ways in which knowledge flows among related and unrelated sectors emerge and how this knowledge is converted into economic success. Recent empirical research provides strong indication that entrepreneurship can play a key role in this respect, but still more should be known about this issue in much more detail.

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## Tables and Figures

Table A1: Descriptive statistics of explanatory variables

| *Indicator* | Number of observations | Mean | Median | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Employment change | 497 | -0,02 | -0,02 | 0,08 | -0,19 | 0,25 |
| Related variety | 497 | 2,98 | 2,99 | 0,26 | 2,02 | 3,55 |
| Unrelated variety | 497 | 4,42 | 4,44 | 0,15 | 3,89 | 4,69 |
| R&D intensity | 497 | 0,32 | 0,28 | 0,13 | 0,10 | 0,74 |
| Start-up rate | 497 | 5,21 | 5,00 | 1,08 | 3,10 | 9,40 |
| Population density (log) | 497 | 5,46 | 5,33 | 0,65 | 4,36 | 7,12 |
| Market potential | 497 | 12,49 | 12,50 | 0,23 | 11,89 | 12,99 |
| Share of manufacturing employment | 497 | 0,46 | 0,47 | 0,10 | 0,22 | 0,66 |

Table A2: Correlation matrix of explanatory variables

| | *Indicator* | I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|---|
| I | Employment change | 1,00 | | | | | | |
| II | Related variety | -0,19 | 1,00 | | | | | |
| III | Unrelated variety | -0,08 | 0,49 | 1,00 | | | | |
| IV | R&D intensity | 0,08 | 0,10 | 0,30 | 1,00 | | | |
| V | Start-up rate | -0,28 | 0,24 | 0,05 | -0,10 | 1,00 | | |
| VI | Population density (log) | -0,10 | 0,44 | 0,23 | 0,52 | -0,05 | 1,00 | |
| VII | Market potential | -0,06 | 0,19 | 0,15 | 0,19 | -0,20 | 0,61 | 1,00 |
| VIII | Share of manufacturing employment | -0,01 | -0,52 | -0,14 | -0,15 | -0,47 | -0,30 | 0,10 |

Table A3: Effect of related und unrelated variety on regional employment growth (time periods starting every second year)

| | I | II | III | IV |
|---|---|---|---|---|
| Related variety | 0.14*** | 0.29*** | 0.24*** | 0.27*** |
| | (0.04) | (0.05) | (0.09) | (0.05) |
| Unrelated variety | 0.43*** | 0.43*** | 0.42*** | 0.22* |
| | (0.05) | (0.05) | (0.05) | (0.12) |
| R&D intensity | 0.17 | 0.09 | -0.29 | -2.46* |
| | (0.13) | (0.13) | (0.59) | (1.32) |
| Population density (log) | 0.09 | -0.03 | -0.04 | 0.00 |
| | (0.23) | (0.26) | (0.26) | (0.25) |
| Market potential | - | 0.77 | 0.80 | 0.60 |
| | | (1.03) | (1.03) | (1.03) |
| Share of manufacturing employment | - | 0.95*** | 0.94*** | 0.97*** |
| | | (0.22) | (0.22) | (0.22) |
| Related variety * R&D intensity | - | - | 0.14 | - |
| | | | (0.21) | |
| Unrelated variety * R&D intensity | - | - | - | 0.59* |
| | | | | (0.30) |
| Constant | -2.78*** | -12.59 | -12.66 | -9.71 |
| | (1.31) | (12.20) | (12.22) | (12.21) |
| Year dummies | Yes*** | Yes*** | Yes*** | Yes*** |
| Federal State dummies | Yes*** | Yes*** | Yes*** | Yes*** |
| Number of observations | 284 | 284 | 284 | 284 |
| R2 within | 0.89 | 0.90 | 0.90 | 0.90 |
| Mean variance inflation factor (vif) | 1.6 | 1.91 | 3.43 | 3.43 |

*Notes*: Dependent variable: change in regional employment; panel fixed effects regressions; standard errors in parentheses; ***, **, *: statistically significant at 1%, 5% and 10%, respectively.

Table A4: Effect of related und unrelated variety on regional employment growth (time periods starting every second year)

| | I | II | III |
|---|---|---|---|
| Related variety | 0.27*** | 0.29*** | 0.26*** |
| | (0.05) | (0.06) | (0.05) |
| Unrelated variety | 0.42*** | 0.42*** | 0.32*** |
| | (0.05) | (0.05) | (0.08) |
| R&D intensity | 0.07 | 0.08 | 0.11 |
| | (0.13) | (0.13) | (0.13) |
| Start-up rate | 0.01** | 0.03 | -0.08 |
| | (0.01) | (0.03) | (0.06) |
| Population density (log) | 0.05 | 0.02 | 0.07 |
| | (0.26) | (0.26) | (0.26) |
| Market potential | 1.13 | 1.38 | 0.95 |
| | (1.04) | (1.13) | (1.04) |
| Share of manufacturing employment | 0.95*** | 0.94*** | 0.89*** |
| | (0.22) | (0.22) | (0.22) |
| Related variety * start-up rate | - | 0.00 | - |
| | | (0.01) | |
| Unrelated variety * start-up rate | - | - | 0.02* |
| | | | (0.01) |
| Constant | -17.64 | -20.66 | -14.95 |
| | (12.34) | (13.40) | (12.40) |
| Year dummies | Yes*** | Yes*** | Yes*** |
| Federal State dummies | Yes*** | Yes*** | Yes*** |
| Number of observations | 284 | 284 | 284 |
| R2 within | 0.90 | 0.90 | 0.91 |
| Mean variance inflation factor (vif) | 1.96 | 6.36 | 5.59 |

*Notes*: Dependent variable: change in regional employment; panel fixed effects regressions; standard errors in parentheses; ***, **, *: statistically significant at 1%, 5% and 10%, respectively.

Table A5: Dynamic GMM model estimation

| | |
|---|---|
| Employment growth (t-1) | 0.75*** |
| | (0.12) |
| Related variety | -0.05 |
| | (0.07) |
| Unrelated variety | 0.20** |
| | (0.10) |
| Share of private sector R&D employment | 0.01 |
| | (0.10) |
| Start-up rate | 0.03* |
| | (0.02) |
| Population density (log) | -0.01 |
| | (0.02) |
| Year dummies | Yes |
| Number of instruments | 27 |
| Hansen test (p value) | 0.45 |
| Arellano-Bond second order serial correlation test (p value) | 0.99 |

*Notes*: Dependent variable: change in regional employment; robust standard errors in parentheses; ***, **, * statistically significant at 1%, 5% and 10% respectively. All explanatory variables except year dummies are assumed to be endogenous, year dummies are assumed to be predetermined. The maximum number of lags is limited to 3 in order to reduce the number of instruments.