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Related Variety, Unrelated Variety and Regional Functions: Identifying Sources of Regional Employment Growth in Germany from 2003 to 2008

*Matthias Brachert
Alexander Kubis
Mirko Titze*

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Authors: *Matthias Brachert*
Halle Institute for Economic Research (IWH)
Department of Structural Economics
E-mail: Matthias.Brachert@iwh-halle.de
Phone: +49 (0) 345 7753-870

Dr. Alexander Kubis
Institute for Employment Research (IAB)
FB A2 Prognosen und Strukturanalysen
E-mail: Alexander.Kubis@iab.de
Phone: +49 (0) 911 179-8978

Dr. Mirko Titze
Halle Institute for Economic Research (IWH)
Department of Structural Economics
E-mail: Mirko.Titze@iwh-halle.de
Phone: +49 (0) 345 7753-861

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Editor:
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Address: Kleine Maerkerstrasse 8, D-06108 Halle (Saale), Germany
Postal Address: P.O. Box 11 03 61, D-06017 Halle (Saale), Germany
Phone: +49 (0) 345 7753-60
Fax: +49 (0) 345 7753-820
Internet: <http://www.iwh-halle.de>

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Abstract

This article analyses how regional employment growth in Germany is affected by related variety, unrelated variety and the functions a region performs in the production process. Following the related variety literature, we argue that regions benefit from the existence of related activities that facilitate economic development. However, we argue that the sole reliance of related variety on standard industrial classifications remains debatable. Hence, we offer estimations for establishing that conceptual progress can indeed be made when a focus for analysis goes beyond solely considering industries. We develop an industry-function based approach of related and unrelated variety. Our findings suggest that related variety only in combination with a high functional specialization of the region facilitates regional growth in Germany. Additionally, also unrelated variety per se fails to wield influences affecting development of regions. It is rather unrelated, but functionally proximate variety in the groups “White Collar” and “Blue Collar Workers” positively affects regional employment growth.

Keywords: related variety, unrelated variety, regional functions, functional specialization

JEL Classification: D62, O18, R11, R12

Related Variety, Unrelated Variety und regionale Funktionen im Produktionsprozess: Die Identifikation von Quellen regionalen Wachstums in Deutschland von 2003 bis 2008

Zusammenfassung

Der vorliegende Beitrag widmet sich der Frage, welchen Einfluss verbundene Vielfalt (*Related Variety*), unverbundene Vielfalt (*Unrelated Variety*) und die Funktionen, die eine Region im Produktionsprozess innehat (Entscheidungs- bzw. Headquarterfunktionen, Forschungs- und Entwicklungsfunktionen, Fertigungsfunktionen), auf das regionale Beschäftigungswachstum ausüben. Die Argumentation folgt dabei den Aussagen der Related-Variety-Literatur, welche besagt, dass Regionen von der Existenz verbundener Wirtschaftsstrukturen in einer Region profitieren. Jedoch weisen neuere Arbeiten darauf hin, dass die alleinige Betrachtung der Verbundenheit regionaler Wirtschaftsstrukturen auf Basis der Klassifikation der Wirtschaftszweige unzureichend ist. Daher entwickelt der Beitrag einen Ansatz, der sowohl die Verbundenheit regionaler Wirtschaftsstrukturen basierend auf der Klassifikation der Wirtschaftszweige als auch auf Basis der Funktion, welche eine Region im Produktionsprozess ausübt, abbildet. Es zeigt sich, dass die Effekte der Verbundenheit regionaler Wirtschaftsstrukturen (*Related Variety*) nur dann positiv sind, wenn sie mit einer hohen funktionalen Spezialisierung der Region einhergehen. Unverbundene regionale Wirtschaftsstrukturen (*Unrelated Variety*, basierend auf der Klassifikation der Wirtschaftszweige) sind dann vorteilhaft, wenn gleiche Funktionen im Produktionsprozess, insbesondere im Bereich der Fertigungs- und Entscheidungs- bzw. Headquarterfunktionen, ausgeübt werden.

Schlagwörter: verbundene Vielfalt, unverbundene Vielfalt, funktionale Spezialisierung

JEL-Klassifikation: D62, O18, R11, R12

1 Introduction

The concept of related variety has attracted increasing attention in the discussion on the nature of localized knowledge spillover and regional growth (Frenken and Boschma 2007; Frenken et al. 2007; Boschma and Iammarino 2009; Bishop and Gripiaios, 2010; Eriksson, 2011; for criticism see Desrochers and Leppälä 2010). It questions the hypothesis that Jacobs' externalities per se generate knowledge spillover and argues that "knowledge will spill over effectively only when complementarities exist among sectors in terms of shared competences." (Boschma and Iammarino 2009, p. 290). The economic rationale behind this argument lies in the notion of sufficient cognitive proximity (Nooteboom 2000). Findings within this context show that large differences in existing and new knowledge prevent effective communications, whilst interactive learning works best when cognitive distance between partners is not too large (Nooteboom et al. 2007). Consequently, this line of thought focuses on the specific regional composition with industrial sectors and splits up the Jacobs externalities argument into the effects of related and unrelated variety (Frenken et al. 2007; Boschma and Iammarino 2009).

This paper resumes this discussion and has two objectives. First, it presents estimates on the effects of related and unrelated variety in Germany from 2003 to 2008. Following studies of Frenken et al. (2007), Boschma and Iammarino (2009) and Bishop and Gripiaios (2010), we test for respective effects at the level of labor market regions. Second, we pick up recent criticism on the related variety concept made by Desrochers and Leppälä (2010). They point out that sole reliance on industries in the analysis of the composition of a regional economy is debatable, and that it might be more appropriate to analyze localized knowledge spillover in terms of individual skills or know-how. We agree to this point and argue that conceptual progress can be made, when we bring together the concepts of related variety and the role of functions a region performs in the production process (Bade et al. 2004; Duranton and Puga 2005).¹ Koo (2005), Barbour and Markusen (2007) and Currid and Stolarick (2010) show that the functions a region performs in the production process can be different for different geographies. This can affect the regional economy in two ways. First, a high functional distance or strong functional asymmetry between industries in a region as well as a high cognitive distance prevents effective communication, thus negatively affecting the existence of localized knowledge spillover (Maggioni and Uberti 2007; Parjanen et al. 2010; Trippl 2010; Lundquist and Trippl 2011). Second, differences in the functional specialization of regions may limit the existence of localized knowledge spillover as non-routine tasks usually ascribed to headquarter and R&D functions show higher potentials for the generation of agglomeration economies (Bade et al. 2004; Duranton and Puga 2005; Robert-Nicoud 2008).

¹ For a discussion of functional aspects within the context of the ideal types of regional innovation see *Lundquist and Trippl* (2011).

To integrate functional aspects into the concept of related variety, we use an occupation-based approach in conjunction with the industry based regional analysis. This allows paying attention to the kinds of work the regional economy does as well as to the kind of products it makes (Thompson and Thompson 1985, 1987; Feser 2003; Koo 2005). Based on the idea that two regions with similar industry mixes can show differences in the functions performed in those industries (Koo 2005), the simultaneous evaluation of cognitive and functional aspects will allow a deeper insights into the nature of localized knowledge spillover and regional employment growth (Currid and Stolarick 2010).

The paper is structured as follows. The next section identifies main theoretical concepts explaining the sources of localized knowledge spillover, gives a special focus on the recent related variety controversy and presents complementarities between the related variety concept and the role of functions a region performs in the production process. The third section provides insights into the methodologies and variables used to develop an industry-function based related variety concept. Section four presents the results of the model, followed by the concluding remarks.

2 Knowledge Spillover and the Related Variety Concept

Localized knowledge spillover build an integral part of modern theories to explain regional economic growth (Romer 1986). Their very nature, however, has been a controversial issue (for recent reviews of the empirical literature see Rosenthal and Strange 2004; Beaudry and Schiffauerova 2009; de Groot et al. 2009; Melo et al. 2009). Theoretical literature mostly differentiates between three lines of thought (Glaeser et al. 1992). First, the Marshall-Arrow-Romer (MAR) approach emphasizes the sector specific role of knowledge and skills and argues that the important knowledge spillover mainly occur within industrial sectors (Marshall 1890; for formalizations see Arrow 1962; Romer 1986). Thus, regional specialization of economic activities is supposed to be the more innovative and growth enhancing setting (Desrochers and Leppälä 2010). The second approach is related to the works of Michael Porter (1990). Just as the MAR approach Porter stresses the relatively greater importance of sector specific knowledge spillovers, but additionally argues that local competition increases the pressure on firms to innovate with positive effects on their survival and growth (Porter 1990; Glaeser et al. 1992). The third approach offers an unlike position and can be found in the works of Jane Jacobs (1969). Jacobs also puts emphasis on the positive aspects of intense local competition, but her major point is that a diverse set of regional industrial sectors provides access to different knowledge bases beyond the individual industrial environment (see also Glaeser et al. 1992; Henderson et al. 1995). This diversity will spark knowledge spillover and result in more radical innovations, thus regional diversification is supposed to lead to positive effects on regional economic growth (Frenken et al. 2007; Boschma et al. 2010).

Recent literature, however, started advocating a more differentiated view on this classic dichotomy of regional specialization and diversification. Porter (2003) and Frenken et al. (2007) emphasize the role of relatedness of industries and point out that industrial sectors share commonalities in terms of technologies, knowledge bases, skills or inputs (see also Hildago et al. 2007; Boschma and Iammarino 2009; Eriksson 2011; Neffke et al. 2011). Such types of relatedness are supposed to allow knowledge to spill over more effectively with respective benefits for the regional economy. Relying heavily on the notion of “cognitive proximity” (Nooteboom 2000; Boschma 2005; Nooteboom et al. 2007) Frenken et al. (2007) argue that it is crucial to split up the generic diversity argument and analyze more deeply the specific composition of sectors within the regional economy (see also Boschma and Iammarino 2009; Boschma et al. 2010; Bishop and Gripaos 2010). To disentangle the effects of diversity, they distinguish between related and unrelated variety. Whereas the concept of unrelated variety is likely to capture a portfolio-effect and allows insights into the vulnerability of the regional economy, the related variety concept includes benefits from knowledge spillovers of different but complementary industries in a region (Essletzbichler 2005; Boschma et al. 2010; Eriksson 2011). Thus, the assumption is made that the higher the presence of related industries is in a region, the more opportunities exist for the effective transfer of tacit knowledge (Boschma and Frenken 2011; Eriksson 2011). Coming to the effects of unrelated variety, Frenken et al. (2007) assume that the higher the degree of unrelated variety is in a region, the higher is the ability to absorb sector specific shocks with likewise positive effects on regional growth.

Regarding empirical results, Frenken et al. (2007), Boschma and Iammarino (2009) and Boschma et al. (2010) indeed find that a high degree of related variety has a positive effect on regional economic growth in the Netherlands, Italy and Spain. Additional insights are presented by Bishop and Gripaos (2010). They show that the impact of related variety is different across sectors with inconsistent signs. Within their study for Great Britain, related variety has a positive effect in only three out of 23 sectors and a negative effect in one. Empirical results for the regional effects of unrelated variety are more heterogeneous. While Frenken et al. (2007) show that unrelated variety is negatively related to unemployment growth and give support to the arguments on vulnerability and shock-resistance, Boschma and Iammarino (2009) and Boschma et al. (2010) only find very little evidence for the portfolio-effect and no other economic effects of unrelated variety. In their sectoral study, Bishop and Gripaos (2010) surprisingly observe positive effects of unrelated variety on employment growth for eight sectors, whereby these effects seem to be more present in manufacturing compared to the service sector. They finally conclude that the distinction between related and unrelated variety is of importance, but the effects differ significantly across sectors.²

² *Boschma and Iammarino* (2009) further shed the light on the role of the relatedness of international trade flows on the region. They find that regions benefit from extra-regional knowledge when it emanates from sectors that are complementary to those sectors in the region. However, a likewise study conducted for Spain could not confirm the results (*Boschma et al.* 2010).

3 The Related Variety Concept and the Role of Regional Functions

The concept of related and unrelated variety has also received criticism. While focusing on the specific composition of the regional economy with industrial sectors, it overlooks the limitations of industrial classifications schemes to reflect individual skills and know-how. Desrochers and Leppälä (2010) make the point that industrial classifications alone do not capture the variety of channels, through which ideas are used and transferred between industries and suggest that it is more appropriate to analyze the effects of diversification in terms of individual skills and know-how. We argue that conceptual progress can be made, when we integrate information about skills via the functions a region performs in the production process into the concept of related variety and unrelated variety. One way to capture individual skills is offered by the analysis of occupations and their respective classification into economic functions (Thompson and Thompson 1985, 1987; Florida 2002; Feser 2003; Bade et al. 2004; Markusen 2004; Koo 2005; Barbour and Markusen 2007; Currid and Stolarick 2010). This so called “occupational-functional approach” identifies what specific types of human capital a region possesses, thus directing attention to the kinds of work the regional economy does (Thompson and Thompson 1985, 1987; Feser 2003; Koo 2005). With knowledge spillover being a function of people and respective skills and occupations in a region, this allows to clarify the role of differences in regional functions in understanding localized knowledge spillover (Currid and Stolarick 2010).

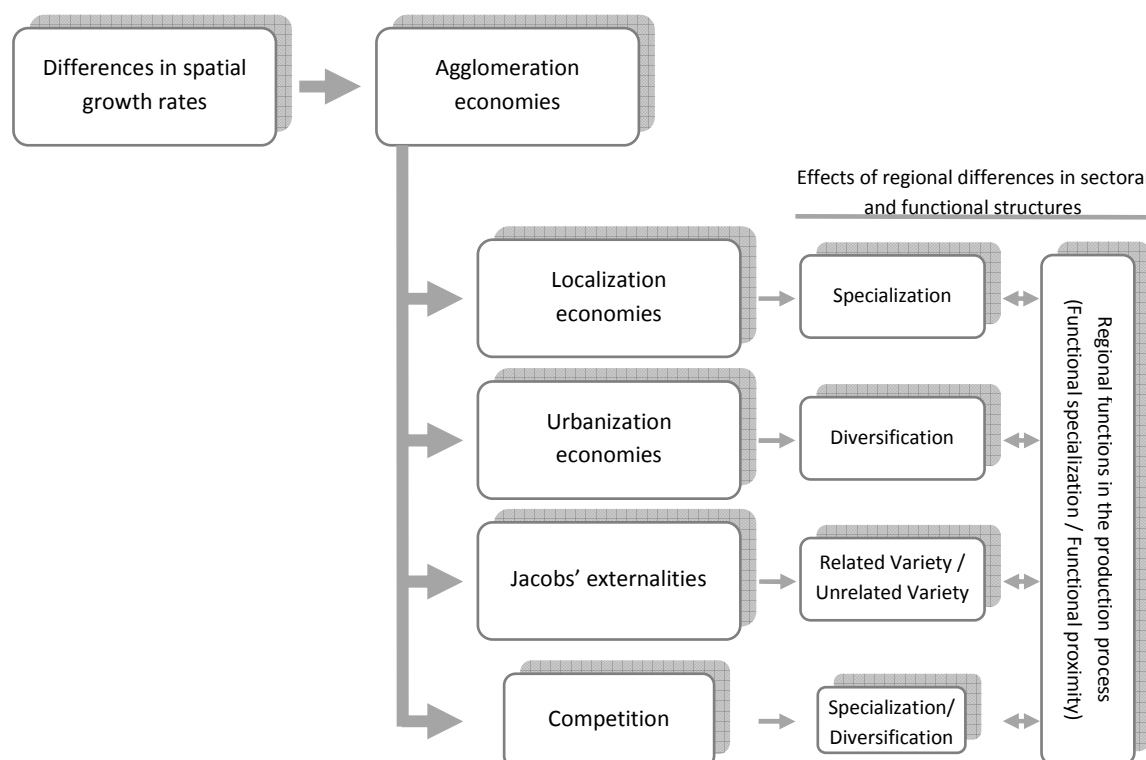
The “occupational-functional approach” is able to contribute to the concept of related and unrelated variety in two ways. First, it allows insights into a topic addressed only rarely in the empirical discussion on localized knowledge spillover: the functional distance or proximity of industrial sectors in a region (Trippl 2010; Lundquist and Trippl 2011). Being at least partially a result of the rise of multi-unit firms increasingly taking advantage of differences in agglomeration, cost and market advantages in varying regions (Chandler 1977; Kim 1999 for theoretical approaches see within the context of the new economic geography and regional functional specialization see for Duranton and Puga 2005; Fujita and Gokan 2005; Fujita and Thisse 2006; Robert-Nicoud 2008), this strand of literature shows that functions for the same industry can be different for different geographies (for empirical studies see Koo 2005; Defever 2006; Markusen and Schrock 2006; Barbour and Markusen 2007; Currid and Stolarick 2010). These differences in the structure of functions in a region, however, strongly affect the nature and existence of localized knowledge spillover. Trippl (2010) and Lundquist and Trippl (2011) pick out the functional distance between industries in a region (in their context measured by differences in the innovation performance between regions, in our case more fundamental by the existence and degree of related or unrelated economic functions like R&D, managerial or production tasks) as the major issue in the discussion on ideally types of integrated innovation oriented regional innovation system. They argue that a strong functional distance or asymmetry (or the non-existence of related or unre-

lated R&D, managerial or production functions in a region) between industries can be seen as a factor limiting opportunities for effective communication and mutual exchange of knowledge (see also Maggioni and Uberti 2007; Parjanen 2010). When the functional distance is too large, knowledge does not flow easily, thus affecting the nature of localized knowledge spillover. To conclude, functional aspects may spur the effects of related and unrelated variety (Lundquist and Trippel 2011).

A second contribution can be found in the literature on the functional specialization of regions (Bade et al. 2004; Duranton and Puga 2005; Blum 2008; Robert-Nicoud 2008). This strand of literature argues that the functional specialization of regions leads to spatial differences in knowledge spillovers because headquarter functions and R&D departments show a strong affinity to metropolitan areas (Duranton and Puga see also Dohse et al 2005; Davis and Henderson 2008). Differences in the relative importance of regional functions contribute to differences in the content of tacit vs. codified information in regional transactions and thus the amount of localized knowledge spillover. This view is also advocated by Robert-Nicoud (2008). He discusses the possible range of spillovers arising from routine tasks (dominated by codified knowledge) and complex tasks (characterized by tacit knowledge) and finds it reasonable to assume that routine tasks generate fewer agglomeration economies.

Figure 1:

Research design – Agglomeration economies and effects of regional differences in sectoral and functional structures



Source: Own illustration, adopted from Geppert (2009).

Yet, we argue that the related variety concept can benefit from the integration of functional aspects of the regional economy. The combination of an occupation-based analysis with an industry-based analysis allows drawing attention to the kinds of work the regional economy does as well as to the kind of products it makes (Thompson and Thompson 1985, 1987; Feser 2003). Based on the idea that two regions with similar industry mixes can show differences in the functions performed in those industries (Koo 2005), the simultaneous evaluation of cognitive and functional aspects in an occupational-functional approach of the related variety concept will allow a deeper insights into the nature of localized knowledge spillover and regional development (Currid and Stolarick 2010). Figure 1 summarizes the basic research approach.

4 Research Design

Developing an occupational-functional approach of related and unrelated variety

The paper aims to integrate information about the functions performed by an industry in a region into the concept of related and unrelated variety and to identify the effects on regional employment growth. To develop such a framework that is able to reflect cognitive as well as functional aspects of the sectoral composition of a regional economy we rely on a categorization of occupations by functions introduced by Bade et al. (2004). Following Duranton and Puga (2001), Bade et al. (2004) differentiate between three broad functional categories (see also Bode 1998). “White Collar” workers hold executive functions in manufacturing industries but also in service and public sectors. In addition to that, workers holding typical headquarter functions like marketing or providing services related to the existence of headquarters in region are included in this category. “R&D occupations” are reflected by occupational groups of engineers, natural scientists and agricultural engineers and consultants. “Blue Collar” workers are characterized by diverse manufacturing occupations in all industries. Table 1 summarizes the occupation groups classified into the three different categories.

Information about the spatial distribution of occupational functions can be obtained by official statistics. Moreover, the data provided by the Federal Employment Office of Germany within its Social Insurance Statistic allow the combination of an occupation-based analysis with an industry-based analysis and thus to identify the functions performed of an industry in a region. The Social Insurance Statistic builds on the NACE (Nomenclature générale des activités économiques dans les Communautés Européennes – NACE Rev.1) classification of economic activities and combines information about the individual industrial sectoral affiliation down to the five-digit level (1041 industrial sectors), the kind of the individual occupation down to the three-digit (369 occupational groups) and spatial attributes down to the community level. This high degree of disaggregation allows the simultaneous evaluation of cognitive and functional aspects by calculating function-specific degrees of related and unrelated variety at the regional level.

Table 1:
Description of the occupational groups that reflect the functions a region performs in production process

Categories of occupational functions	Number of occupational group ^a	Description of occupational group ^a
White Collar:		
Managerial and administrative functions	751	Entrepreneurs, Managers, CEOs, Business division heads
	76	Representatives, Employees with administrative or decision making authority
	881	Economists and Social Scientists
	882	Humanist Scientists
Other business-oriented services, Management consultants	752	Management consultants, Analysts
	753	Accountants, Tax consultants
	81	Lawyers, Legal advisors
Marketing	703	Advertising
	82	Publicists, Translators, Librarians
	83	Artists and related occupations
R&D Occupations:		
Technical services, R&D	032	Agricultural engineers and consultants
	60	Engineers
	61	Chemists, Physicists, Mathematicians
	883	Other natural scientists
Blue Collar:		
Manufacturing occupations	07 to 43	Diverse manufacturing occupations in all industries

^a According to the nomenclature of occupations, compiled by Federal Statistical Office of Germany in 1970.

Source: Own compilation, basic classification developed by Bade et al. 2004. One adjustment is made in the group “White Collar” (additional group 882).

Related variety, unrelated variety and regional functions – Calculation of the variety indices

To identify effects of functional proximity or distance on regional employment growth we first calculate function-specific degrees of related and unrelated variety. In line with Frenken et al. (2007), we use entropy at the two-digit level (industrial classification) to calculate the degree of unrelated variety. Related variety is determined by the weighted sum of the entropy at the five-digit level (industrial classification) within the two-digit class.³ Thus, we assume five-digit sectors sharing the same two-digit sector to expe-

³ Recent studies mostly assess diversity by the help of inverse Hirschman-Herfindahl index (Henderson et al. 1995; Combes 2000; Combes et al. 2004; Blien and Südekum 2005; for a recent application to Germany see Illy et al. (2011). However, this does not include related diversity into the analysis (Bischof and Gripaios 2010). The use of the entropy measure is preferred because of its decomposable nature. This allows introducing different digit-level

rience commonalities fostering learning and facilitating innovative advances (see also Frenken et al. 2007; Boschma and Iammarino 2009). Information about occupational-functions is taken into account by a division of the general variety indexes into the three categories of occupational functions as stated down in equation (1). Thus, we additionally assume that the higher the degree of functional proximity (in “White Collar”, “R&D” and “Blue Collar” functions) in a region, the easier is the communication between related but also unrelated sectors and the higher are the knowledge spillover with respective effects on regional employment growth.

The formal calculation from Frenken et al. (2007) changes as follows. If all five-digit sectors i of an category of occupational function j (where $j = 1, 2, 3$) fall solely under a two-digit sector S_{g_j} (where $g = 1, \dots, G$), it is possible to derive of two-digit shares P_{g_j} by summing the five-digit shares p_{i_j} .

$$P_{g_j} = \sum_{i \in S_{g_j}} p_{i_j} \quad (1)$$

The degree of unrelated variety (UV_j) for each of the three categories of occupational functions j is calculated by the entropy at the two-digit level.

$$UV_j = \sum_{g_j=1}^G P_{g_j} \log_2 \left(\frac{1}{P_{g_j}} \right) \quad (2)$$

The degree of related variety (RV_j) for each of the three categories of occupational functions is defined as the weighted sum of entropy within each two-digit sector.

$$RV_j = \sum_{g_j=1}^G P_{g_j} H_{g_j} \quad (3)$$

with

$$H_{g_j} = \sum_{i \in S_{g_j}} \frac{p_{i_j}}{P_{g_j}} \log_2 \left(\frac{1}{p_{i_j}/P_{g_j}} \right) \quad (4)$$

Functional Specialization

The discussion above additionally emphasizes the role of the regional functional specialization in the discussion on localized knowledge spillover (Bade et al. 2004; Duranton and Puga 2005). We integrate information about the functional specialization of regions by the ratio of “White Collar” (WC) and “Blue Collar” (BC) workers in region r normalized by its ratio at the national level ($FUNC_SPECIALIZATION_r$). Values greater than 1 indicate an above average concentration of “White Collar” activities in the region.

$$FUNC_SPECIALIZATION_r = \frac{WC_r/BC_r}{WC/BC} \quad (5)$$

degrees of related and unrelated variety into the regression analysis without causing necessarily multi-collinearity (Frenken et al. 2004) and identifying embedded relatedness of industries within the two-digit level. Avoiding controlling for these effects would contribute to an underestimation of Jacobs’s externalities because they would be measured as unrelated variety (Beaudry and Schiffauerova 2009).

Dependent variable

To determine the effects of related and unrelated variety as well as the role of functions performed by regions in the production process we use regional employment growth as dependent variable. Regional employment growth ($EMPL_GROWTH_r$) is computed by the approximate growth rate of employment (in full-time equivalents) L_r in region r between 2003 and 2008:

$$EMPL_GROWTH_r = \log (L_r^{2008} / L_r^{2003}) \quad (6)$$

The analysis is conducted at the level of labor market regions. The choice of labor market regions as spatial unit of analysis was based on arguments made by Eckey et al. (1990). They point out that regions defined on behavioral settings generally perform better than administrative units, because the former do reflect economic relations in terms of, for example, commuting flows. Moreover, their demarcation was confirmed to be suitable in different other studies (Kosfeld and Lauridsen 2004; Kosfeld et al. 2006).

Control variables

Size of the regional economy

The analysis considers central as well as peripheral labor market regions with respective differences in regional size. The size of a regional economy, however, can affect the existence of spillover effects irrespective of the sectoral composition of the regional economy (Combes 2000). Frenken et al. (2007) for example argue that it is the dense presence of economic, social, political and cultural organizations that influence the emergence of urbanization economies. This means that the level and quality of spillovers is positively affected by the number of complementarities between regional organizations (Ó hUallacháin and Satterthwaite 1992; Combes 2000). A second positive effect can be deduced out of the location decisions of firms if transports costs are greater than zero. Combes (2000) further points out that size effects may also negatively influence regional growth through the presence of pollution or transportation congestion. On the basis of recent studies on Germany (Illy et al. 2011), we measure the size of the regional economy by the employment density of a labor market region r ($SIZE_r$) and its square ($SIZE_SQ_r$).

Competition

As stated above, local competition is seen as a key determinant of regional growth (Jacobs 1969; Porter 1990). Empirical approaches offer varying indicators for measuring competition effects. While Glaeser et al. (1992) use average firm size to analyze the impact of local competition on growth; Combes (2000) applies the Hirschman-Herfindahl-Index (HHI) to the regional firm size distribution. In contrast to both, Blien and Südekum (2005) use the relative employment share in small firms to measure the effect of

local competition.⁴ We follow the arguments made in Combes (2000) use the Hirschman-Herfindahl-Index of the firm size distribution ($COMPETITION_r$) to identify the effects of productive concentration (see equation 6), where P_{n_r} is the share of employees in region r in group n , with $n = 1, \dots, 7$ reflecting the number of sub-categories in the establishment file of the Social Insurance Statistics (with the categories 1-5, 6-9, 10-19, 20-49, 50-99, 100-499 and more than 500 employees, see also Illy et al. 2011).

$$COMPETITION_r = \sum_{n=1}^7 (P_{n_r})^2 \quad (7)$$

Specialization

To test for the effects of regional specialization, we use the location quotient ($SPECIALIZATION_r$). This measure is defined as the weighted sum of sectoral location quotients at the two-digit level of region r (see equation 7), where P_{g_r} is the share of employment in sector g in region r and L_g/L stands for the share of employment in sector g at the national level.

$$SPECIALIZATION_r = \sum_{g=1}^G P_{g_r} \left(\frac{P_{g_r}}{L_g/L} \right) \quad (8)$$

Additional control variables

In line with other empirical studies, we integrate a number of additional independent variables into the regression analysis which are supposed to affect regional employment. This includes the average wage level ($AVERAGE_WAGE_r$) and the regional level of human capital ($HUMAN_CAPITAL_r$). Whilst the first is measured by the average compensation per employee in region r , human capital is reflected by the regional share of R&D employees on total regional employees normalized by its ratio at the national level. The independent variables are all calculated for the base year 2003 (Glaeser et al. 1992; Glaeser and Saiz 2004). Due to data restriction, the data used to calculate the $AVERAGE_WAGE_r$ are based on year 2004.

5 Estimation Technique and Spatial Autocorrelation

The analysis is carried out at the level of the German labor market regions. Although spatial interactions are expected to take place mainly within this area, we test for spatial autocorrelation using Moran's I and (Robust) Lagrange multiplier tests (LM) for spatial lag and spatial error dependence, as Moran's I is not able to distinguish between the two models (Anselin 2006). The weights matrix (W) is defined as a row standardized first order contiguity matrix. An entry is equal to one (before standardization) if regions r and s are neighbors and zero otherwise; the diagonal elements of W are set equal to zero. Thus, neighboring labor market regions are expected to exhibit a higher degree of

⁴ *Blien and Südekum* (2005, p. 2) argue that this measure is adequate because it „reflects local product market competition in the sense that competition is stiffer the higher is the employment share in small firms“.

spatial dependence than regions located far apart. The diagnostics for spatial dependence obtained for the basic OLS version of the model are reported in table 1. They show that the Moran's *I* Index from the regression residuals is highly significant. This supports the presence of spatial error autocorrelation. In a second step, we used the LM test to decide on the appropriateness of a spatial lag or a spatial error model for our analysis (Anselin and Florax 1995). Since both LM tests are highly significant, we use the robust tests to decide on the model specification. Therein, the Robust Lagrange multiplier test for spatial error dependence is no longer significant while the Robust Lagrange multiplier test for spatial lag dependence remains significant. Therefore we decide to apply a spatial lag model to our analysis. Table 2 sums up the diagnostic test for spatial dependence.

Table 2:
Diagnostics for spatial dependence

Weights matrix: First order contiguity matrix (row-standardized)			
	Statistic	df	p-value
Spatial Error:			
Moran's I	6.739	1	0.000
Lagrange multiplier	37.720	1	0.000
Robust Lagrange multiplier	1.478	1	0.224
Spatial Lag:			
Lagrange multiplier	51.500	1	0.000
Robust Lagrange multiplier	15.259	1	0.000

Source: Author's own calculation.

6 Results

The model is estimated using a spatial lag approach with robust standard errors. As it was indicated in equation six, the dependent variable *EMPL_GROWTH* is used in logarithms. Given that the values of *RELATED_VARIETY* and *UNRELATED_VARIETY* are highly correlated with those of the respective categories of occupational functions, we use a two-step procedure to cope with the problem of multi-collinearity. In a first step, we regress the variables *RELATED_VARIETY* and *UNRELATED_VARIETY* on the respective values of the categories of occupational functions. In a second step, we integrate the residuals into the regression model on regional employment growth. These residuals now include just that information that goes beyond the information on *RELATED_VARIETY* and *UNRELATED_VARIETY* (Urban and Mayerl 2008). The descriptive statistics of the variables can be found in table 3.

Table 3:
Descriptive statistics

Variable	No. Obs	Min	Max	Mean	Std. Dev.
EMPL_GROWTH	262	0.898	1.116	1.019	0.038
RELATED_VARIETY	262	1.326	3.447	2.658	0.300
UNRELATED_VARIETY	262	2.726	4.894	4.547	0.221
RV_GROUP_1 (resid)	262	-0.918	0.679	0.000	0.260
RV_GROUP_2 (resid)	262	-0.668	0.688	0.000	0.272
RV_GROUP_3 (resid)	262	-0.568	0.504	0.000	0.188
URV_GROUP_1 (resid)	262	-0.794	1.090	0.000	0.214
URV_GROUP_2 (resid)	262	-0.767	1.242	0.000	0.364
URV_GROUP_3 (resid)	262	-0.545	0.555	0.000	0.235
SPECIALIZATION	262	1.158	13.071	1.942	1.270
FUNC_SPECIALIZATION	262	0.124	3.281	0.730	0.457
SIZE	262	11.363	1046.076	93.924	140.636
HUMAN_CAPITAL	262	0.184	2.882	0.739	0.390
AVERAGE_WAGE (in €)	262	1879	3538.240	2557.988	311.019
COMPETITION	262	0.872	2.200	1.023	0.147

Notes: The analysis is conducted at the level of labor market region. Due to a reform of administrative boundaries in the Federal State of Saxony-Anhalt in 2007, it is in our case not possible to aggregate district level data to labor market regions for 9 out of 13 labor market regions for this federal state. We decided to exclude those labor market regions from the analysis and continued with the remaining 262 labor market regions.

Source: Author's own calculation.

The regression results for the level of labor market regions are presented in table 4. Therein, the parameter associated with the spatially lagged dependent variable (ρ) is highly significant. As a first result, regional employment growth at the level of labor market regions is strongly influenced by the performance of neighboring regions. Coming to the effects of related and unrelated variety, we find that neither *RELATED_VARIETY* nor *UNRELATED_VARIETY* *per se* affects employment growth at the level of German labor market regions. The coefficients for both variables remain insignificant. The effects are different when we consider the functions a region performs in the production process. The interaction term of *RELATED_VARIETY* and the variable *FUNC_SPECIALIZATION* is positive and significant. This gives support to both of the arguments made by Frenken et al. (2007) and Robert-Nicoud (2008), but our results indicate that regions only benefit from relatedness in economic structures when both phenomenon appear together, that is when they *RELATED_VARIETY* is connected to a high functional specialization of the region. The higher the degree of related non-routine tasks performed in a region, the higher is the content of tacit information in regional transactions and thus the amount of localized knowledge spillover with respective positive effects on regional employment growth. Sole *FUNC_SPECIALISATION* is not sufficient for regional employment growth. It even has negative effects on employment except it goes in line with relatedness of regional economic structures.

Table 4:
Results of the regression analysis on the determinants of employment growth in Germany for the period 2003-2008 (Spatial Lag Model)

Dependent variable: EMPL_GROWTH (log)			
	Coefficients	Robust Std. Err.	
RELATED_VARIETY	-0.00709	(0.01495)	
UNRELATED_VARIETY	0.00529	(0.01310)	
RELATED_VARIETY * FUNC_ SPECIALIZATION	0.03594	(0.01411)	**
RV_GROUP_1 (resid)	0.00623	(0.00998)	
RV_GROUP_2 (resid)	0.00231	(0.00747)	
RV_GROUP_3 (resid)	0.01432	(0.01065)	
URV_GROUP_1 (resid)	0.03447	(0.01032)	***
URV_GROUP_2 (resid)	-0.00691	(0.00699)	
URV_GROUP_3 (resid)	0.03681	(0.01352)	***
SPECIALIZATION	-0.00548	(0.00218)	**
FUNC_SPECIALIZATION	-0.10599	(0.04442)	**
SIZE	-0.00016	(0.00005)	***
SIZE_SQ	0.00000	(0.00000)	**
HUMAN_CAPITAL	0.01425	(0.00696)	**
AVERAGE_WAGE (LOG)	0.04778	(0.02947)	
COMPETITION	0.02522	(0.02011)	
CONSTANT	-0.37999	(0.22849)	*
rho (ρ)	0.49299	(0.06563)	***
Observations	262		
Log Likelihood	557.35892		
Variance ratio	0.359		
Wald test of rho=0	chi2(1) = 56.434 (0.000)		
LM test of rho=0	chi2(1) = 51.500 (0.000)		

Notes: ***, **, * indicate statistical significance on the 1%, 5% or 10% level. GROUP_1 indicates “White Collar” workers, GROUP_2 “R&D” workers and GROUP_3 “Blue Collar” workers.

Source: Authors own calculation.

Coming to the effects of functional proximity within the three different categories of occupational functions, we do not find significant effects for *RELATED_VARIETY*. This changes when considering the effects of *UNRELATED_VARIETY*. While *UNRELATED_VARIETY* per se does not affect regional growth in this period, the coefficients for two of the three categories of occupational functions show positive and significant effects on regional growth. If unrelated sectors in region are characterized by a high functional proximity in the categories “White Collar” (*URV_GROUP_1 (resid)*)

and “Blue Collar” (*URV_GROUP_3 (resid)*) workers, we find positive effects on regional growth. This gives further support to the view that functions performed by a region in the production process matter for the nature and amount of localized knowledge spillover. First, it shows that regions can profit from a diverse set of “White Collar” tasks in a region. Theoretical reason for these positive effects can be seen in their likelihood to generate localized knowledge spillover. Second, it additionally indicates that regions benefit from a diverse set of “Blue Collar” tasks in a region. Theoretical reasons for that can be found in the literature on industrial district with labor mobility and a large pool qualified labor as sources of knowledge spillover and positive effects on regional growth. Furthermore, the results give support for recent studies that show that skill-relatedness between industries can be an important factor in regional structural change and development (Neffke and Henning 2009) as the use of skills is not restricted to sectoral boundaries, but to quite similar functions in the production process. To sum up, a high *FUNC_SPECIALISATION* is important to spur the effects of *RELATED_VARIETY*. A high functional proximity is important to generate positive effects out of *UNRELATED_VARIETY*.

Furthermore it is interesting to look at the effects of variables that reflect the structure of R&D occupations in the region. Both variables, *RV_GROUP_2 (resid)* and *URV_GROUP_2 (resid)*, remain insignificant. However, what is significant is regional share of R&D employees on total regional employees normalized by its ratio at the national level (*HUMAN_CAPITAL*). The higher the share of employees in R&D, the more positive becomes the effect on regional employment growth. This may let us conclude that it is having R&D functions in region that positively effects regional growth irrespective of its functional structure.

With respect to the other independent variables, we find *SPECIALIZATION* to have a significantly negative effect on regional employment growth. However, these results are line with recent results for Germany presented by Illy et al. (2011) for 2003 to 2007. They find evidence for a U-shaped relationship between specialization and regional growth at the level of free cities and planning regions, with positive effects of specialization attained only at a very high level of regional specialization. The effects of the pure size of a region (measured by *SIZE* and *SIZE_SQ*) are characterized by different signs of the coefficients. While the coefficient for *SIZE* indicates negative effects on regional growth, the variable *SIZE_SQ* has positive and significant sign. However, the net effects of both variables remains negative throughout the whole sample with regions showing a higher employment density experiencing less negative effects of size than regions with a lower employment density. Thus, the effect of size in this period is negative, but decreasing.

7 Conclusions

This paper had two main goals, first to present estimates of the effects of related and unrelated variety on regional growth in Germany from 2003 to 2008 and second to develop occupational-functional approach of the related variety concept to control for effects of functions a region performs in the production process. Functional proximity is measured by a differentiation of the related and unrelated variety indices into three categories of occupation functions (“White Collar”, “R&D” and “Blue Collar” workers). Functional specialization is determined by the ratio of “White Collar” and “Blue Collar” workers. Previous studies only applied an undifferentiated view on the effects of related and unrelated variety or did not test for their effects (Glaeser et al. 1992; Frenken et al. 2007; Boschma and Iammarino 2009). Future studies, however, could attempt to refine this classification of occupations to achieve more specific insights into the effects of functional proximity/distance or interactions of functions on regional growth.

The empirical results give support to the importance of controlling for regional functions in the production process when analyzing determinants of regional employment growth. A high regional *FUNC_SPECIALISATION* is important to spur the effects of *RELATED_VARIETY*. A high functional proximity is important to generate positive effects out of *UNRELATED_VARIETY*. The results show that a differentiation between related and unrelated variety is important and necessary and imply that a regional development policy aiming to support the relatedness of industries in a region is of less risk, because new and related industry can benefit from existing regional economic structures. However, what is also necessary is to shed further attention to the kinds of work a region does in the production process. “White Collar” tasks are characterized by a non-routine character and thus offer more potential for localized knowledge spillover. Therefore regional development policy should at least pay as much attention to support an upgrading of regional functions in the production process as to the increasing of related regional industrial structures. Furthermore regional policy needs to consider different types of relatedness. While relatedness of products is of importance, skill relatedness (measure via occupations in our terms) is of crucial importance when coping with increasing needs for flexibility in regional structural change and enabling cross-sectoral knowledge spillover.

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