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Industry space and skill-relatedness of economic activities

Comparative case studies of three eastern German automotive regions

Anne Otto
Antje Weyh

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Anne Otto (IAB Rheinland-Pfalz-Saarland)
Antje Weyh (IAB Sachsen)

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Abstract

The resilience and growth prospects of a region depend crucially on the extent to which industry-specific human capital can be redeployed across the industries of a regional economy. To this end, we present a toolbox to analyse a region's industrial structure, development prospects and economic resilience. With the help of this toolbox human capital similarities, or skill-relatedness, among industries are highlighted. The core of these analyses is the so-called industry space, a network that connects industries with similar human capital requirements. For the time period 1999 to 2008, a regional comparative analysis of three eastern German automobile regions, namely south-west Saxony (SWS), Eisenach region (EIS) and Leipzig region (LEI), is conducted. The objective is to highlight similarities and differences in the composition of the general automobile-oriented knowledge bases between these regions. In addition, the region-specific growth prospects of economic activities, in general and with a closer look at car manufacturers and automotive suppliers, are scrutinized and evaluated in greater detail for each region. This regional comparison is complemented by an investigation of the regional and industrial origins of labour inflows and by a simulation of labour shifts between shrinking and growing industries to figure out as to what extent redundant labour can be reallocated between skill-related pairs of industries in each region under examination.

In the following, the main outcomes of this regional comparison are summarized: The re-industrialisation process in the SWS and EIS regions was essentially brought about by the initial investments of the western German automotive groups VW, OPEL and BMW, while in the LEI region the automotive industries constitute a new core industry. It is unusual for a core manufacturing industry, associated primarily with the establishment of two major assembly plants, to develop in an urban region characterised by service industries. In fact, the location decisions of the two original equipment manufacturers (OEMs), Porsche AG and BMW AG, have proved advantageous as their factories are well embedded in this urban region as a result of the strong presence of skill-related services. It is by all means possible to speak of advantageous environment conditions for the motor vehicle manufacturers in the LEI urban region. However, this does not apply to the automotive suppliers to the same extent. The inadequate presence of skill-related manufacturing industries makes it more difficult for them to recruit specialists with the skills they require in their own region, such that the quality of the matching economies decreases for them. In the two other automotive regions, it is the automotive supplier industries which are quite well connected to other industries. The main difference between SWS and EIS can be seen in the embeddedness of the core industry of motor vehicle manufacturing. Whereas this industry is also very well embedded in the regional economy in SWS, in EIS the same industry cannot be seen to have either a high degree of embeddedness or of specialisation. The stability and the development potential of the automotive industry therefore appear to be largest in SWS.

As both the automotive suppliers and the motor vehicle manufacturers in all three regions are primarily production-related because the R&D activities are located at the headquarters in western Germany or abroad, there is presumably little need for utilising the knowledge of workers from related industries in the region for generating product innovation (Jürgens/Meißner 2008). Nonetheless, access to such knowledge, which has often been accumulated during many years of experience, also appears to be essential for implementing and preparing process innovations in the plants and at the supplier firms, which is why in particular the core industry of the automotive industry in EIS “should not miss the bus”.

Having a look at labour inflows throughout the observation period, it could be shown that the emergence of these new economic activities in the LEI region were sustained to a great extent by inter-regional labour inflows. This statement holds especially true for the car manufacturers, whereas the local labour market pool satisfied mainly the labour demand of the supplier industries. Intra-regional labour flows play a more important role for car manufacturers and automotive suppliers in the regions EIS and SWS, although inter-regional labour inflows are more relevant for all automobile industries in EIS. In addition, a greater part of labour inflows originates from related economic units in SWS than in EIS.

A complement to this comparative regional analysis was a simulation that was used to show whether or not the regional demand for labour in the industries in question can be met from skill-related industries. This simulation demonstrated that it would have been possible for the LEI region to shift a high share of redundant employment from shrinking to growing, but skill-related industries. These shares of simulated ‘related’ labour flows are smaller in the regions EIS and SWS, whereas this share is lowest in SWS. These outcomes indicate that Leipzig’s economy should have had adequate preconditions to anticipate a positive exogenous shock, namely the settlement of the production plants of the OEMs. However, the stronger specialization of the regional economies of EIS and SWS may explain that the more diversified urban economy of LEI is better prepared to anticipate diverging industrial demands.

Zusammenfassung

Die Resilienz einer regionalen Ökonomie hängt maßgeblich davon ab, inwiefern relevantes spezifisches Humankapital zwischen deren Wirtschaftsaktivitäten wieder verwertet werden kann. Zu diesem Zweck wird das Instrumentarium Industry Space, das sich auf die Ähnlichkeiten in der Nutzung von Humankapital bzw. Skill-Relatedness zwischen Branchen stützt, zur Beschreibung der Wissensbasis zwischen den vorhandenen Wirtschaftszweigen einer Region sowie zur Analyse von dessen Wachstumsperspektiven und Resilienz vorgestellt. Beim Industry Space handelt es sich um ein Netzwerk von Branchen, die skill-related sind. Das Instrumentartium Industry Space wird im Rahmen von drei vergleichenden Fallstudien der

ostdeutschen Automobilregionen Südwestsachsen (SWS), Eisenach (EIS) und Leipzig (LEI) eingesetzt für den Zeitraum 1999 bis 2008. Zum einen wird mit Hilfe des Industry Space die zwischen den regionalen Wirtschaftsaktivitäten vorhandene Wissensbasis in jeder Automobilregion dargestellt. Zum anderen wird die Einbettung der Automobilhersteller und der Automobilzulieferindustrie durch deren skill-relatedness mit anderen Wirtschaftszweigen jeder Regionen detailliert aufgezeigt. Die Fallstudien zeigen, dass die Reindustrialisierung in den beiden Regionen SWS und EIS im Wesentlichen durch die Initialinvestitionen der westdeutschen Automobilkonzerne VW, OPEL und BMW mit herbeigeführt wurden, während in der Region LEI die Automobilindustrien einen neuen Branchenschwerpunkt darstellen. Die Standortentscheidungen der beiden OEM's Porsche AG und BMW AG haben sich als vorteilhaft erwiesen, da ihre Werke durch die starke Präsenz von Dienstleistungen, mit denen sie skill-related sind, gut in diese Stadtregion eingebunden sind. Dies trifft allerdings nicht in dem Maße auf die Zulieferer zu. Die unzureichende Präsenz verbundener Industriezweige stellt für diese sicherlich ein Hindernis bei der Gewinnung von Fachkräften in der Standortregion selbst dar. In den beiden anderen Automobilregionen sind die Zulieferer recht gut eingebettet. Zwischen SWS und EIS liegt der Hauptunterschied in der Einbettung der Automobilhersteller. Während diese in SWS ebenso recht gut in die regionale Wirtschaft eingebettet sind, kann für diese Branche in EIS weder eine hohe Einbettung noch eine hohe Spezialisierung festgestellt werden. Die Stabilität und das Entwicklungspotenzial für die Automobilindustrie erscheinen demnach am größten in SWS. Da sowohl die Zulieferer als auch die Automobilhersteller in allen drei Regionen primär fertigungsbezogen sind, weil die FuE-Aktivitäten in den Stammsitzen in Westdeutschland oder im Ausland verortet sind, besteht vermutlich ein geringerer Bedarf für die Verwertung des Wissens von Arbeitskräften aus verbundenen Branchen vor Ort bei der Generierung von Produktinnovationen. Aber gleichwohl erscheint der Zugang zu solchem Wissen, das ja oftmals langjähriges Erfahrungswissen ist, essenziell auch für die Umsetzung und Wegbereitung von Prozessinnovationen in den Werken und bei den Zulieferern, weshalb vor allem die Kernbranche der Automobilindustrie in EIS „nicht den Anschluss verlieren sollte".

1 Introduction and research question

Many studies in regional science that analyse and explain differences between Germany's regions agree on the two following issues. First, even twenty-four years after reunification there is still a pronounced east-west divergence in Germany as regards key economic indicators. And second, there are considerable regional disparities within the old and within the new federal states (Blien et al. 2003; Lehmann/Ragnitz 2012). Economic geography and regional economics have shown that the causes of these regional differences are very diverse. The most important explanatory factors include the wage level, the labour force potential, locational advantages and disadvantages and the industry structure, which is the main focus of this paper. A broad discussion in these two disciplines concerns the question as to what economic structure is advantageous for a region in the long term (Glaeser et al. 1992; Henderson/Kuncoro/Turner 1995). A specialised industry structure, for example, enables the firms in a region to benefit from an overall division of labour and to invest in shared infrastructure (e. g. research and education institutions) (Cooke/Morgan 1998; Henderson 2003; Rosenthal/Strange 2003). However, when a region specialises too strongly on one or only a small number of economic sectors, it runs the risk of suffering from lock-in if the region's knowledge base is not renewed sufficiently (Grabher 1993; Martin 2010). A diversified regional industry structure reduces the risk of exogenous shocks because they can be absorbed by many industries.

As a complement to the discussion about the advantages and disadvantages of specialisation and diversification, evolutionary economic geography postulates a feasible alternative with the concepts of *related variety* (Frenken/Van Oort/Verburg 2007) and *related diversification* (Frenken/Boschma 2007; Boschma/Frenken 2011b). Regions can specialise in different but related economic activities. Industrial diversity possesses the advantages of variety as risk is spread over several industries and the variety itself entails a broad access to knowledge (*unrelated variety*). At the same time a joint *skill base* can develop in the region between the firms in the related industries (*related variety*).

This paper uses an analytical instrument that is quite new in terms of methodology and is primarily graphic. It involves an empirical application of this explanatory approach and has been used in only a few studies to date (see e. g. Otto/Nedelkoska/Neffke 2014; Neffke et al. 2010). Two different industries can be said to be related when they require manpower with similar qualifications and skills and when they share a common skill base. This relationship is called *skill-relatedness* (SR) (Neffke/Henning 2013). The most important element of this instrument is *industry space* and a *SWOT* analysis based on it. The analysis instrument of industry space comprises a general matrix of the skill-relatedness of all industries, which can also be used to examine the quality of the industry structure in connection with structural changes. In the SWOT analysis, assessments concerning the degree of embeddedness and specialisation of industries are combined in order to create a

basis for further statements about the advantages and disadvantages of the regional industry structure with regard to the region's growth prospects.

This analysis instrument is applied on the basis of a comparative analysis of three eastern German automotive regions. The regions of Eisenach (EIS) and south-west Saxony (SWS) are two industrial economic areas that have a long tradition in the automotive industry which was continued or revived after German reunification by western German end-product manufacturers establishing branches there. In contrast to the declining shares of manufacturing in overall employment and gross value added in Germany as a whole, these two regions, when re-industrialised, experienced the opposite trend, with this sector gaining in importance in economic terms. The automotive industry and its associated suppliers are major employers in both regions and constitute important drivers of regional economic growth due to their substantial export orientation. In contrast, the third automotive location under observation is the Leipzig agglomeration area (LEI), where a diversified tertiary sector has developed since reunification, is a fairly recent core industry that developed a few years ago as a result of new production plants being established there.

Analysing each of the three regions has two fundamental objectives. First, the industry space is to be used to show the nature of the coherence in the economic structure in the three regions, what potential there is for knowledge spillovers between the core industries in each region, and what other starting points exist for encouraging the exchange of knowledge between regional industries. Second, the SWOT analysis conducted for the automotive industry and its related sectors is to be used to develop a profile for each of the regions that permit statements regarding the potential for future development.

In order to achieve these objectives, the report is structured as follows: a discussion of the SR approach and a presentation of its technical implementation (Section 2) are followed by a detailed account of the data used and the empirical implementation (Section 3.1). The SR matrix determined in this way forms the basis of the industry space for Germany, which is the subject of Section 3.2. Section 4 contains the comparative case studies for the three eastern German automotive regions. Here the SWOT analysis instrument is first presented with regard to the embeddedness and specialisation of industries in the regions. This is followed by the SWOT analyses of the general economic structure of the regions (Section 4.3) and of the automotive industry in particular (Section 4.4). A conclusion with some final thoughts about approaches of regional funding policies rounds off the report.[1]

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[1] In the context of the European ORA Project T-RES we conducted the project 'Industry Space and skill-relatedness of economic activities. Comparative case studies of three eastern German automobile regions' on behalf of Rüdiger Wink, Leipzig University of Applied Sciences (HTWK). We thank Rüdiger Wink for the good cooperation, the helpful comments for this project report and for financing this project via the German Research Council (DFG).

2 The concept of skill-relatedness (SR)

2.1 The SR concept and related approaches in economic geography

A region with diversified industries that are related to one another can benefit from emerging *economies of scope.* In addition to risk being distributed across many industries, specialisation advantages may develop at the same time, for instance through learning from each other (Frenken/Van Oort/Verburg 2007). Another advantage is the diffusion of knowledge between the individual industries, i. e. opportunities to exchange knowledge arise in particular when the industries are technologically related. Such sets of industries are characterized by cognitive proximity (Noteboom 2000), meaning that there are partial overlaps in their knowledge bases, which facilitates communication between these industries yet still leaves enough scope for learning from one another. Knowledge spillovers are therefore effective above all between firms in technologically related industries (Cohen/Levinthal 1990; Noteboom 2000; Leahy/Neary 2007). The more variety there is between related sectors in a region, i. e. the larger the number of technologically related industries in a region is, the greater the potential for innovation and growth is.

A number of more recent empirical studies verify that a large degree of related industries in a region results in more dynamic growth (especially employment growth). Although these studies use different data, methods and definitions of industry-relatedness, similarly positive results are obtained by Boschma and Iammarino (2009) and Quatraro (2010) for Italy, by Boschma/Minondo/Navarro (2011) for Spain and by Hartog/Boschma/Sotarauta (2012) for Finland. A different study by Bishop and Gripaos (2010), however, does not find related variety to have any clear positive impact on the growth of industries in a region. In fact, their study shows heterogeneous effects on regional employment development in various industries in the secondary and tertiary sectors.

A region's industry structure is generally quite stable over time, with structural shifts occurring only in the long term. However, exogenous shocks can cause serious changes in the industry structure in the short and medium term. Boschma/Frenken (2011b) and Neffke/Henning/Boschma (2011) were able to show that diversification mainly occurs in economic activities that are technologically related to the core economic activities already in existence in the region. The likelihood of a new industry emerging in a region is higher the larger the share of existing industries that are technologically related to this new industry is. The overall industry structure in a region possesses a large degree of coherence because the technological relatedness between the industries is stable over time.

The concept of relatedness is also important for clusters and regional innovation systems (RIS). A cluster is defined by a multitude of links between firms in different industries, which are almost always orientated towards the value chain and the corresponding value creation. (Porter 1998; Porter 2003). But this disregards the fact

that industry relatedness can also go beyond this and that links with other clusters are very likely to exist. In this paper, industry relatedness is not regarded as a restricted cluster but as a network illustrating the complex links in an economy. The following section explains how industry relatedness is measured and calculated here.

2.2 Measuring industry relatedness in terms of skill-relatedness

Industry relatedness can be depicted in different ways. Three types of relatedness measures can be used. The first possibility is so-called classification-based measures. These are oriented towards the hierarchical structure of the systems used for classifying economic activities. For example, two industries that belong to the same five-digit class of economic activity are more closely related than those which only belong to the same three-digit class. Co-occurrence- or outcome-based measures are the second type. Here, industries are regarded as related if they can frequently be found together in the portfolio of the same production entities. The measure used in this paper, skill-relatedness, comes under the category of the third type of relatedness measures – resource- or input-based indicators. In addition to indicators based on input-output matrices (Fan/Lang 2000), this type also includes indicators which, for example, use information from patent data (Breschi/Lissoni/ Malerba 2003). The SR index (Neffke/Henning 2013) measures the degree to which human capital is exchanged between industries.

The exchange of human capital between industries generally occurs via labour flows between these industries. Human capital is one of the most important production factors (Grant 1996; Grant/Spender 1996) and is highly job-specific (Becker 1962). Performing a certain job usually requires special knowledge and experience. Recent literature also shows that this knowledge and experience is not restricted just to the job itself but also combines detailed knowledge about the firm and the industry. If an employee takes up a new job in a different industry in which his prior knowledge can no longer be fully utilised, he loses part of his human capital (Neal 1995; Parent 2000), his firm-specific human capital in any case. If the new firm also belongs to an industry that has nothing to do with the old industry, he also loses his entire industry-specific human capital. In order to keep such a destruction of human capital to a minimum, individuals therefore mainly switch between industries that are skill-related when changing jobs (Neffke et al. 2013).

However, labour flows also depend on various factors that characterise an industry and say nothing about its relatedness to other industries, e. g. the size of the industry, its growth or its wage level. Thus, in order to assess whether or not labour flows between industries are exceptionally large, a basis is required that takes the characteristics of the industries into account.[2] Such a baseline then refers to the expected number of job moves between industry i and industry j. If the actual number of job

[2] The exact calculation of this baseline is explained in Section 3.1.

moves observed is seen in relation to this, the measure for the SR of the two industries is obtained:

$$\text{Skill\_relatedness}_{ij} = \frac{\text{Flow}_{ij}}{\widehat{\text{Flow}_{ij}}},$$

where Flow_{ij} comprises the observed flows (aggregate data for the observation period) between industries i and j (one-way flows from industry i to industry j) and $\widehat{\text{Flow}_{ij}}$ the predicted job moves between industry i (original industry) and industry j (target industry). Industry pairs with an *SR* index greater than 1 are defined as related; if the value is smaller, they are considered to be unrelated.

3 Industry space for Germany

3.1 Data basis and calculation of the SR indicator

The data basis used for calculating the SR indicator and the industry space based on it is the Employment History (Beschäftigtenhistorik – BeH) of the Institute for Employment Research (Institut für Arbeitsmarkt- und Berufsforschung – IAB). The BeH covers all employees and trainees who are in employment subject to social security contributions; it does not include data on civil servants, self-employed people and regular students. All in all the BeH covers more than 80 percent of Germany's working population (Hethey-Maier/Schmieder 2013). For all employees covered by social security and marginal part-time employees (since 1999) the BeH contains all personal information such as date of birth, qualification level, wage, place of residence, place of work at the municipality level etc. These employees can also be matched with the establishments they work for. Establishment information is available, for example, about their location and industry affiliation. Using this information it is then possible to map every job move between different industries undertaken by individuals. For the following analysis all job moves are taken into consideration that took place between 30 June of the observation year and 30 June of the previous year during the observation period from 1999 to 2008.

Besides imputing the economic activities into a uniform classification system (see Neffke et al. 2013) for a description of the procedure), non-genuine job moves were also controlled for. Following a procedure developed by Hethey-Maier/Schmieder (2013), 'artificial' job moves associated with the rules governing the allocation of establishment identification numbers or with establishment restructuring processes were eliminated.[3] During the analysis period, an average of 1.73 million job moves between establishments in Germany took place between the reference dates of two consecutive years (Table 1). 73 percent of these, or 1.27 million job moves, were classified as 'genuine', whereas 27 percent, or 0.96 million moves, were 'non-genuine'. The majority of the 'non-genuine' job moves involved establishments with

[3] The criteria according to which it is distinguished between real and artificial job switches are to be found in Neffket et al. (2013).

five or more employees. The average figure of 1.27 million genuine moves relates to a total of 20.37 million full-time workers in Germany. These moves account for 6.2 percent of all full-time workers.

In the hierarchical classification of economic activities, NACE Rev. 1.1, 29 percent of the average of about 1.27 million genuine job moves took place between establishments in the same five-digit class of economic activity (so-called intra-industry moves). The vast majority of the moves occurred between different original and target industries (at the five-digit level) (so-called inter-industry moves). 57.5 percent of the inter-industry moves take place between five-digit classes of economic activity belonging to different sectors.

Table 1
Genuine job moves between industries in Germany*

		Number	as %
Inter-industry job moves	**Job moves between different 5-digit classes belonging to different …**	**904,146**	**71.3**
	... sectors	519,633	41.0
	… sub-sectors, but to the same sector	66,432	5.2
	... 2-digit classes but to the same sub-sector	79,534	6.3
	... 3-digit classes but to the same 2-digit class	112,940	8.9
	… 4-digit classes but to the same 3-digit class	59,045	4.7
	... 5-digit classes but to the same 4-digit class	66,562	5.2
Intra-industry job moves	**Job moves within the same 5-digit class**	**364,349**	**28.7**
Total		1,268,496	100.0

		Number	as %
Inter-industry job moves	**Job moves between different two-digit classes belonging to different …**	**665,599**	**52.5**
	... sectors	519,633	41.0
	... sub-sectors but to the same sector	66,432	5.2
Intra-industry job moves	**Job moves within the same two-digit class**	**602,896**	**47.5**
Total		1,268,496	100.0

* The three regions examined in this paper are not taken into account.

Source: Employment History (Beschäftigtenhistorik), own calculations.

At the level of two-digit classes of economic activity it can be shown that just under 48 percent of all job moves are of the intra-industry type, i. e. occurring between establishments with the same two-digit code. For the remaining, inter-industry, job moves it can be recorded that 78 percent of them take place between two-digit classes belonging to different sectors. All in all, this means that a good six out of ten job moves involve crossing the boundary of a sector.

In their study, Neffke et al. (2013) compared the actual distribution of job moves according to these levels of aggregation with a purely random distribution of industry choice when switching jobs. Their comparison reveals that the random distribution shows a larger share of moves between industries than the actual distribution. It can therefore be concluded that the distribution of job moves across the original and target industries is not random.

The real labour flows ascertained form the basis of the SR measure in the denominator. In order to calculate the baseline precisely, a zero-inflated negative binomial regression is used to relate the observed labour flows to the employment figures in industry i and industry j, to their growth rates of t-1 on t and to the wages in i and j.

In all of the years the logarithmised number of employees in industry i and industry j has a significantly positive impact on the size of the labour flows. The coefficients for the employment growth rate in industry i are found to have different signs. One possible reason for this is the strong heterogeneity of economic developments in the “industries of origin” i, such that the pressure to look for another job varies considerably due to the existence or the lack of prospects in the industry of origin. This means that the effect that growth in the industry of origin i has on the size of the labour flows depends on the period under observation. The sign for the target industry j, on the other hand, is relatively unambiguous: if this industry demonstrates large growth compared with the previous year, the labour flows are larger. The logarithmised wage of the industry of origin is negatively correlated with the labour flows: the lower it is, the larger the flows are. The wage in the target industry j only shows the expected positive correlation with the labour flows in one observation period. Apart from that this variable has no significant impact.

For all of the models it can be ascertained that a negative binomial model is preferable to a Poisson model, as zero is not included in the confidence interval for alpha. According to the Voung Test, a zero-inflated negative binomial regression would only have been superior to a normal NegBin regression as regards the model fit for the 2000/2001 period (Table 2). However, as the same estimation procedure was to be used for all of the years and as the variables were also significant in the “inflated” part of the regression, zero-inflated negative binomial regressions were used as the basis for the SR measure for all the periods.

Table 2
Results of the zero-inflated negative binomial regression

	1999/2000		2000/2001		2001/2002		2002/2003		2003/2004	
Variable	**Count data**	**Inflated**	**Count data**	**Inflated**	**Count data**	**Inflated**	**Count data**	**Inflated**	**Count data**	**Inflated**
log no. of employees in industry i	0.914 ***	-0.753 ***	0.928 ***	-0.901 ***	0.975 ***	-0.697 ***	0.945 ***	-0.850 ***	0.885 ***	-0.859 ***
log no. of employees in industry j	0.937 ***	-0.782 ***	0.929 ***	-0.781 ***	0.945 ***	-0.816 ***	0.918 ***	-0.817 ***	0.898 ***	-0.838 ***
log employment growth rate in industry i	2.656 ***		0.549		-1.150 *		-2.278 ***		-0.366	
log employment growth rate in industry j	6.768 ***		7.040 ***		5.203 ***		6.554 ***		2.885 ***	
log wage in industry i	-0.386 ***		-0.403 ***		-0.045		-0.298 ***		-0.103	
log wage in industry j	-0.046		0.230 **		0.210 **		-0.064		-0.103	
constant	-16.258 ***	14.709 ***	-17.280 ***	16.587 ***	-19.656 ***	14.264 ***	-16.797 ***	16.296 ***	-16.654 ***	16.777 ***
Chi²	4,044.24 ***		4,050.29 ***		3,954.58 ***		3,618.26 ***		3,237.56 ***	
no. of observations	3,422		3,422		3,422		3,540		3,540	
no. of zero observations	489		499		506		698		755	
alpha – confidence interval	lb: 1.036 ub: 1.159		lb: 1.003 ub: 1.120		lb: 1.115 ub: 1.250		lb: 1.167 ub: 1.306		lb: 1.277 ub: 1.430	
Voung Test	0.21		1.97 **		0.35		1.28		0.77	

	2004/2005		2005/2006		2006/2007		2007/2008	
Variable	**Count data**	**Inflated**	**Count data**	**Inflated**	**Count data**	**Inflated**	**Count data**	**Inflated**
log no. of employees in industry i	0.915 ***	-0.990 ***	0.918 ***	-1.058 ***	0.916 ***	-0.789 ***	0.894 ***	-0.919 ***
log no. of employees in industry j	0.916 ***	-0.931 ***	0.911 ***	-0.843 ***	0.921 ***	-0.916 ***	0.884 ***	-0.939 ***
log employment growth rate in industry i	-1.873 ***		-0.061		4.311 ***		2.065 ***	
log employment growth rate in industry j	1.308 **		2.393 ***		8.653 ***		6.923 ***	
log wage in industry i	-0.191 *		-0.298 ***		-0.546 ***		-0.467 ***	
log wage in industry j	-0.101		-0.126		-0.104		0.046	
constant	-16.971 ***	18.994 ***	-16.298 ***	18.417 ***	-15.457 ***	15.735 ***	-15.367 ***	17.905 ***
Chi²	3,266.95 ***		3,332.86 ***		3,698.51 ***		3,633.36 ***	
no. of observations	3,540		3,540		3,540		3,540	
no. of zero observations	758		722		684		667	
alpha	lb: 1.290 ub: 1.442		lb: 1.292 ub: 1.439		lb: 1.198 ub: 1.337		lb: 1.206 ub: 1.345	
Voung Test	1.46 *		1.08		-0.43		0.93	

*** significant at 1 % level, ** significant at 5 % level, * significant at 10 % level. lb lower bound, ub upper bound.

Source: Employment History (Beschäftigtenhistorik), own calculations.

The baseline determined by means of the zero-inflated negative binomial regressions thus represents the expected flows between industry i and industry j. In the next step the actual labour flows between the two industries are considered in relation to these expected flows. If the number of actual job moves between the two industries i and j between the two reference dates (30 June) of the years t-1 and t exceeds the expected number, the SR index is greater than 1. In this case skill-relatedness exists between the two industries. This measure was calculated for all pairs of industries that can be combined from the 60 industries at two-digit level in Germany so as to generate a matrix containing the values of the SR index for every two consecutive years (1999/2000 to 2007/2008) of the observation period. In addition, the skill-relatedness measure was standardised so that it takes on values between -1 and +1. A significance test checks whether the value of skill-relatedness between two industries i and j=0. If this test can be rejected, the two industries are skill-related. Initially, each of the total of nine matrices is asymmetric as the skill-relatedness between industry i and industry j may be large, but there may be only a low level of skill-relatedness in the opposite direction between industry j and industry i. However, this assumption was found not to hold as these laterally reversed SR values are highly correlated. This applies for each matrix in the observation period. The mean was therefore calculated for each pair of industries i and j. Subsequently the mean of the SR for each pair of industries i and j over the entire observation period from 1999/2000 to 2007/2008 and for the nine matrices for Germany as a whole (without the three regions under examination) was determined. Then an average was calculated across all the years to generate a matrix for the skill-relatedness of the two-digit industries in Germany for the entire period from 1999 to 2008.[4]

3.2 Initial network for the comparative regional analysis

The matrix generated in this way can then be portrayed as a network of industries: the so-called ‘industry space’ for Germany. The network nodes in Figure 1 are the industries (two-digit economic activities) and the lines connecting them indicate whether they are skill-related. The number of full-time equivalents (FTE)[5] and the industry’s sector affiliation are represented by the size and the colour of the network nodes. The nodes and their interconnections are mapped by means of an organic clustering algorithm using the software Cytoscape, whereby groups of nodes that are frequently linked are located close together in the industry space. For instance, if the ego network[6] for the economic activity “automotive industry” is of interest, then

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4 The structure of the SR between the economic activities is quite stable during this period as the nine matrices are highly correlated with one another (see Neffke et al. 2013 for more details on this issue).

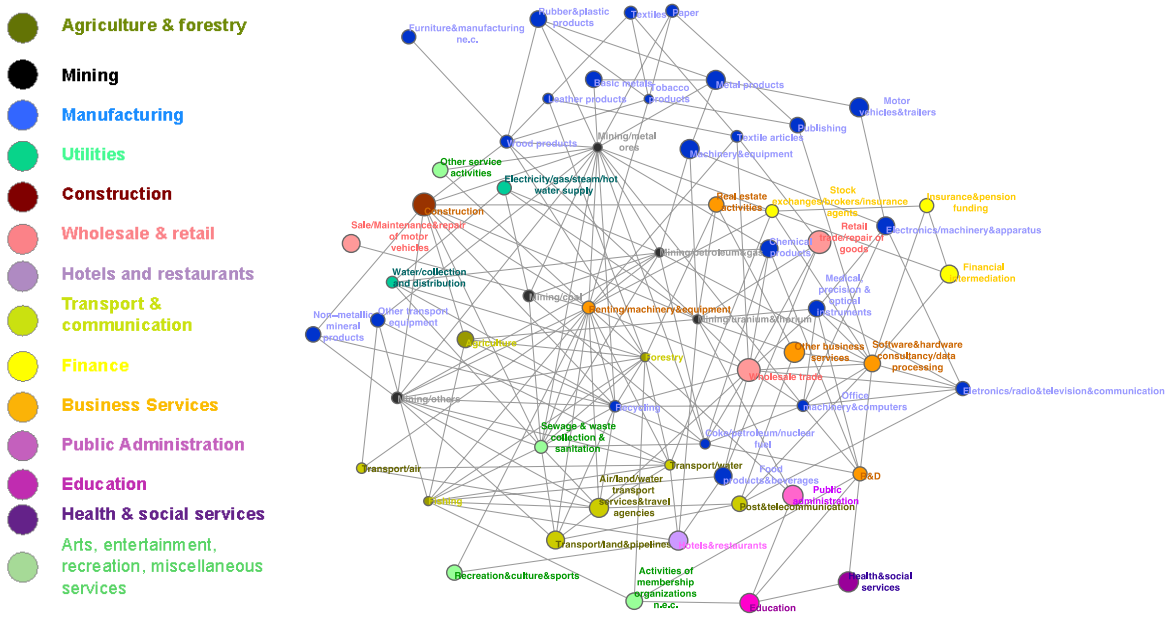
5 Employment is measured in terms of FTEs in this paper. In this connection a full-time job is equivalent to one employee, while a part-time job is weighted with the factor 0.5. In Germany as a whole employment, measured in FTEs, fell by an average of 0.8 percent in the period from 1999 to 2008.

6 The ego network comprises only the core industry (ego) and its direct links to other skill-related industries (alteri).

the nodes of those industries that are frequently linked with and via the automotive industry and very often with one another move close together. These nodes now always remain concentrated together in network graphs, irrespective of in which part they are found in the network graphs. Groups of nodes located close together in the network thus demonstrate a high level of skill-relatedness.

Figure 1 shows just an extract with the 184, or 5 percent, of the strongest links between the industry pairs i and j out of the total of 3,540 possible SR links. This extract from the overall network portrays the core of the industry space and also serves as the initial network for the subsequent comparison of the three regions. For this purpose Germany's industry space is filled with region-specific information. For example, the size of the network nodes (industries) reflects the employment volume of the industries in the particular region.[7]

Figure 1
Industry space, Germany 2008



Source: Employment History (Beschäftigtenhistorik), own calculations.

Two patterns can be recognised in the positioning of the network nodes and thus of the industries in the industry space. First, many industries from one sector are concentrated close to one another in a particular area of the industry space and therefore share a common knowledge base. Manufacturing activities are concentrated in the upper area, with capital- and technology-intensive industries (e. g. automotive, machinery and equipment, metal industries) on the right-hand side and traditional

[7] It would also be possible to calculate a region-specific matrix of skill-relatedness on the basis of the inter-industry job moves in each of the three regions. This would result in three different region-specific networks of skill-relatedness. First, however, the number of job moves between the industries in each region is generally too small to be used to calculate the regressions for the baseline that were explained in Section 3.1. Second, using Germany's industry space as the initial network makes it possible to compare the qualitative differences between the industry structures of the three regions in more detail.

manufacturing industries (e. g. textile, leather and furniture industries) on the left. These manufacturing industries are also skill-related with the wholesale and retail industry as well as construction and mining. Of the knowledge-intensive service industries, for example transport and communication services can be found in the lower area, and financial services as well as business services on the right-hand side of the industry space. Personal services, such as health and social services, public administration, education, and hotels and restaurants are located next to one another in the lower area of the industry space.

Second, there are groups of nodes that are close together in the industry space but belong to different sectors. Hotels and restaurants, for example, are skill-related with economic activities from different sectors (e. g. the food industry, transport, agriculture, and recreation and sports activities). Although these economic activities belong to different sectors, they require manpower with similar skills and share a common labour pool.

4 Comparative case studies of the automotive regions

4.1 Indicators and framework of the SWOT analysis

In addition to this national analysis level, it is possible to make more detailed statements concerning the skill-relatedness of industries in individual regions. To this end the instrument of industry space is extended to include region-specific and industry-specific indicators. These indicators are then linked with one another in a SWOT analysis. The first indicator, which shows whether a region has specialised disproportionately in one industry compared with the economy as a whole (Schätzl 2000: 65), is the location quotient of the respective industry i:

$$LQ_i^r = \frac{\frac{emp_i^r}{emp^r}}{\frac{emp_i^n}{emp^n}},$$

where emp_i^r stands for the employment *emp* in industry *i* in region *r*, emp^r the overall employment in region *r*, emp_i^n the employment in industry *i* in Germany as a whole *n* and emp^n the overall employment in Germany *n*. A value greater than 1 means a strong specialisation in industry *i* in region *r*.

As the degree of specialisation of an industry i depends on the degree of specialisation of the industries j with which industry i is skill-related, the so-called degree of embeddedness is calculated as a second measure:

$$LQ_i^r = \frac{\frac{emp_j^r}{emp^r}}{\frac{emp_j^n}{emp^n}}.$$

This shows whether the industries that are skill-related with a particular industry are more prevalent in a region than in the country as a whole on average. If the value is greater than 1, then industry i is well embedded in the corresponding regional economy.

What relationship is there between the degree to which a regional economy has specialised in an industry i and the extent to which that industry i is embedded in that region's economy? If an industry i is especially well integrated in the regional economy, several advantages open up to the establishments in that industry. As a result of their access to a disproportionately large pool of workers who are employed in skill-related industries, they have especially good options for meeting their staffing requirements within their own region. This is likely to improve the quality of the job matching in the establishments' own staff recruitment. The establishments can learn from these workers' collective work experience, their skills and their embodied knowledge such that they can increase their productivity (e. g. by means of innovations and by reducing production and product costs). Empirical evidence of this positive correlation is provided by Boschma/Eriksson/Lindgren (2009) and Timmermans/ Boschma (2013) for Swedish and Danish firms, respectively.[8] Furthermore, the firms in a well-embedded industry can benefit especially well from the cumulated insider knowledge that the workers have acquired in the region where they are located because this knowledge is place-specific. For the establishments in a well-embedded industry i, the utility from these advantages can be seen in particularly good growth conditions in their region. A well embedded industry i that exhibits an above-average LQ_j^r is therefore likely to develop more favourably in a region than in the average of the country as a whole. This leads to an increase in the LQ_i^r of this industry i and thus in the degree to which the regional economy has specialised in this economic activity. Taking Germany's regions as an example, Otto/Nedelkoska/Neffke (2014) prove that if an industry has a large degree of embeddedness, this has a positive effect in the medium term on the growth of the region's degree of specialisation.

For the region-specific examination, in the following a region's industries are analysed in a SWOT environment according to their respective degree of specialisation and embeddedness. The SWOT analysis (Table 3) categorises a region's industries into four areas. The first category comprises industries that demonstrate a low degree of both specialisation and embeddedness. The development opportunities for these industries are rather poor (weakness). Another category, which constitutes the opposite to the former (high degree of both embeddedness and specialisation), exhibits stable development conditions (strength). An industry with a high degree of embeddedness but a low level of specialisation has good growth prospects as it is able to benefit from other skill-related industries as regards knowledge and labour, due to its good embeddedness (opportunity). Industries with a low degree of embeddedness but a high level of specialisation could be fraught with risk as a tendency to decline is likely in this constellation (risk/threat).

[8] The reason for this positive relationship could be an improved match between the knowledge bases of the firms in industry i and the skills of the workers from related industries (Boschma et al. 2009). In contrast, they demonstrate that recruiting individuals who have acquired knowledge and skills in the same industry has a negative impact on firm-specific productivity growth.

Table 3
Categories of the SWOT analysis

		Regional degree of embeddedness of industry i	
		low $LQ_j^r \leq 1$	high $LQ_j^r > 1$
Regional degree of specialisation of industry i	low $LQ_i^r \leq 1$	Weakness	Opportunity
	high $LQ_i^r > 1$	Risk	Strength

Source: own design.

4.2 Historical background and economic structure of the automotive regions

The regional comparative analysis refers to three eastern German automotive regions. Two of the regions selected, Eisenach (EIS) and south-west Saxony (SWS), are both industrial regions with a rural character and are very similar as regards economic history, recent economic development and their industry structure today. The EIS region comprises the municipality of Eisenach and four neighbouring administrative districts (Landkreise) while the SWS region consists of the municipality of Chemnitz and three other districts (Figure 2).[9]

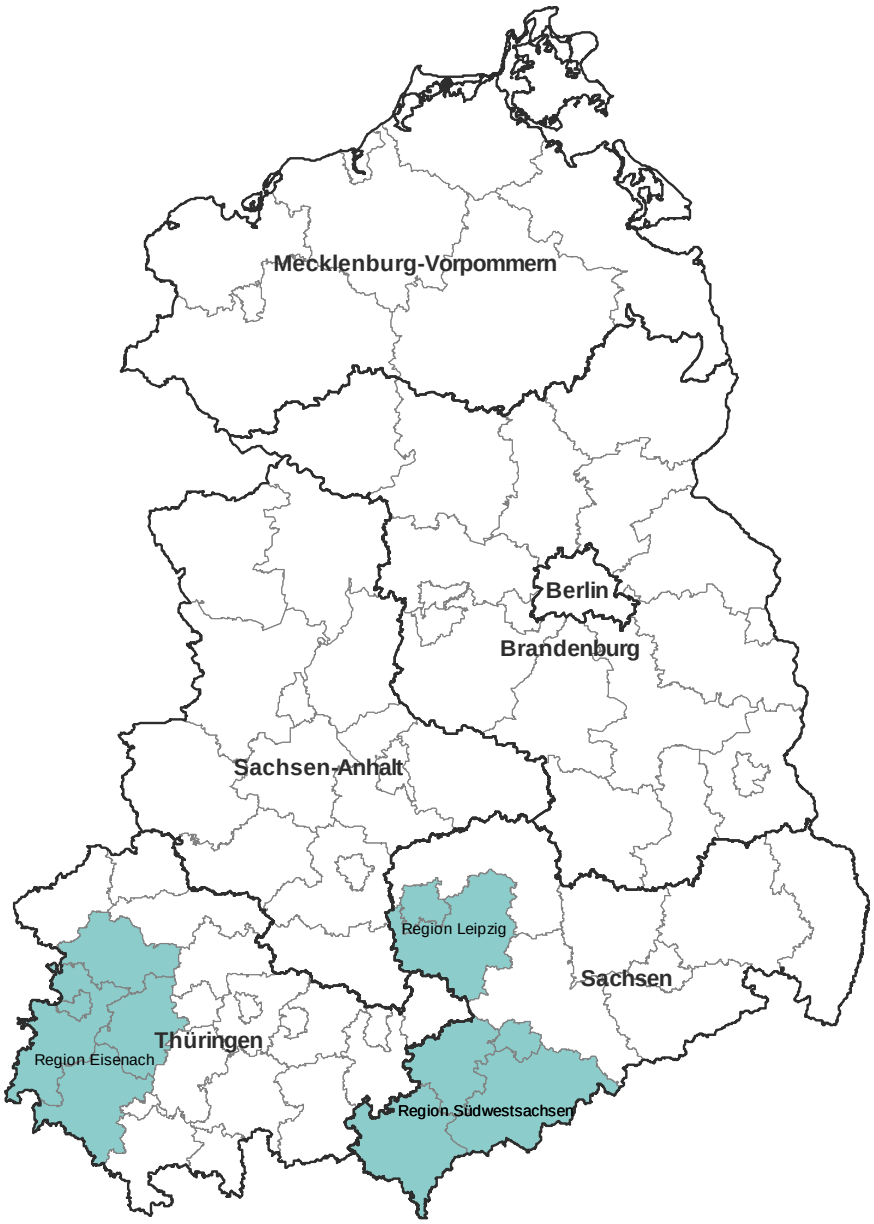
The EIS and SWS regions have in common that their automotive tradition began as early as the late 19th or early 20th century. In 1896 Heinrich Ehrhardt founded the *Fahrzeugfabrik Eisenach* in the EIS region. This plant was taken over by the BMW AG in 1928. In 1904 August Horch started with constructing motor vehicles with the brand names DKW and Wanderer in Zwickau. During the Second World War cars continued to be produced in both regions. In the socialist planned economy of the German Democratic Republic (GDR) the automotive enterprises were nationalised. The publically owned enterprise (Volkseigener Betrieb - referred to in the following as VEB) *VEB Automobilwerk Eisenach* started to build Wartburgs in 1955. The *VEB Automobilwerke* in Zwickau manufactured the Trabant. The *VEB Barkas*, which had sites in Chemnitz, Hainichen and Frankenberg, produced small buses and vans.

In the early 1980s the firms in the automotive industry of the GDR expanded and invested in new production equipment. In 1984 the state government of the GDR

9 These are not administrative demarcations or labour market regions. In each region the district (equivalent to the NUTS 3 level) where the relevant western German automotive establishment is located (EIS region: Eisenach municipality; SWS region: Zwickau district) was selected. By including the respective neighbouring districts in the immediate location of the large automotive enterprises, spill-over effects (especially the indirect spill-over effects in the form of new firms in the same industry and in related industries settling in the area) are picked up indirectly. In almost all the surrounding districts the employment shares of the automotive industry as a proportion of all industries are also larger than average.

entered a cooperation agreement with Volkswagen (VW) AG for the licensed production of VW engines. Another factory was also built in Chemnitz, where VW four-stroke engines were produced under licence for the Wartburg and Trabant models in the late 1980s.[10] In the field of engine manufacturing there were therefore good conditions for adopting western German standards of technology and quality (Kirchberg 2000; Spiegel 1984a).

Figure 2
Demarcation of the three eastern German regions



Source: own representation.

[10] This location decision in favour of Chemnitz is connected with the origins of the two VW directors. Carl Hahn comes from Chemnitz and Horst Münzer from neighbouring Niederwiesa. Carl Hahn's father himself worked in the automotive industry in SWS from the early 1920s onwards (Spiegel 1984b).

After German reunification the former production enterprises in the two regions were either dissolved and shut down or were sold to investors. In the early 1990s in eastern Germany the motor vehicle factory *Volkswagen Sachsen GmbH Zwickau/Mosel* was founded as one of the first large factories of an original equipment manufacturer (OEM) for the production of the Polo and the Golf. Furthermore, VW AG built a factory for the manufacture of engine components in Chemnitz. In Plauen (SWS) NEOPLAN buses are produced on the former factory premises of *VEB Ikarus*, which already manufactured buses during GDR times. OPEL GmbH also built a large assembly plant in Eisenach immediately after reunification (Jürgens/Meißner 2008). The *Schmitz-Gotha Fahrzeugwerke GmbH* is located in Gotha and produces body tippers, container chassis and platform trailers. In addition, numerous automotive suppliers settled in the two regions. For instance, the *Robert Bosch Fahrzeugelektrik Eisenach GmbH* is the largest supplier in the EIS region. In the two factories the Just-In-Sequence (JIS) production system demands a spatial proximity to the system suppliers, especially as the production process in the two plants is more highly modular than is the case in western German factories.[11] Moreover, both regions moved into the geographical centre of new plant locations in eastern Germany (e. g. VW AG Dresden), established western German plant locations (e. g. BMW AG in Dingolfing and Regensburg) and more recent plants in Poznań, Poland, (VW AG) and in Bratislava, Slovakia, (Skoda). In addition to this geographical location advantage, there are other factors in favour of the two regions for supplier firms settling there. They include, for example, low location-specific costs, access to skilled labour with experience in the industry, business support through subsidies and specific programmes, and industry-specific network initiatives (Plum/Hassink 2013).[12] Unlike in the EIS region, in SWS there are two universities, Chemnitz University of Technology (TU Chemnitz) and Zwickau University of Applied Sciences *(Westsächsische Hochschule Zwickau)*, which offer degree courses tailored to the automotive industry, so highly qualified specialists are available.

The Leipzig area is the third region examined in this study. Before the Second World War LEI was above all an important trading centre (Leipziger Messe - Leipzig's trade fair centre), specialising among other things in manufacturing industries such as publishing, the printing industry, the foundry industry and machine construction. During GDR times this spectrum of economic activities expanded to include lignite extraction, the power generation associated with this, and the chemical industry.

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[11] In contrast to the Just-In-Time system, the JIS system demands not only the prompt delivery of the amount of modules required, their sequence is also specified a priori as each individual vehicle model is equipped differently according to the customer's wishes.

[12] Both for eastern Germany as a whole and at the levels of the federal states and the regions under examination there are clusters and networks that support the automotive industry specifically with a variety of activities (e. g. marketing, cooperation agreements, local trade fairs).

Table 4
Sectoral employment shares and growth rates, based on full-time equivalents, 1999 – 2008

	SWS region (n=313,900)		EIS region (n=145,200)		LEI region (n=212,100)		Eastern Germany (n=4,023,100)	
Sectors	Shares of total stock of FTEs, as percentages 2008	Annual growth rate, as percentages 1999 - 2008	Shares of total stock of FTEs, as percentages 2008	Annual growth rate, as percentages 1999 - 2008	Shares of total stock of FTEs, as percentages 2008	Annual growth rate, as percentages 1999 - 2008	Shares of total stock of FTEs, as percentages 2008	Annual growth rate, as percentages 1999 - 2008
Agriculture & forestry	2.0	-3.0	3.4	-3.7	1.3	-3.7	2.7	-3.5
Mining	0.3	-2.3	0.9	-2.2	0.2	-11.8	0.5	-2.6
Manufacturing	31.0	0.3	35.7	1.1	15.0	0.1	20.8	-0.1
Utilities	1.1	-4.9	0.7	-1.4	1.5	-3.3	1.2	-3.5
Construction	9.4	-8.2	9.2	-7.5	8.4	-9.0	8.6	-8.0
Wholesale & retail	12.4	-2.6	11.1	-2.5	11.9	-1.5	11.9	-2.2
Hotels & restaurants	2.4	-2.2	2.8	-2.1	3.0	0.0	3.5	-0.1
Transport & communication	5.7	-2.7	5.4	-1.6	7.7	0.3	6.6	-2.1
Finance	1.7	-4.6	1.4	-2.4	3.0	-4.7	2.0	-4.0
Business services	12.7	1.8	10.2	2.7	20.5	2.2	15.1	2.2
Public administration	4.4	-7.0	4.4	-3.9	5.0	-5.0	6.7	-4.8
Education	4.4	-4.4	3.0	-6.2	6.0	0.9	4.8	-3.0
Health & social services	8.5	-0.7	8.5	-0.3	8.7	-1.1	10.0	-0.8
Arts, entertainment, recreation & miscellaneous services	4.4	-2.3	3.4	-3.8	7.7	-0.9	5.6	-1.9
Total	100.0	-2.3	100.0	-1.6	100.0	-1.6	100.0	-2.1

* FTE: full-time equivalents

Source: Employment History (Beschäftigtenhistorik), own calculations.

As an urban region with a strong services sector, LEI is a completely new location for the automotive industry. Only a few years ago Porsche AG (2003) and the BMW Group (2005) set up branch operations there and have been manufacturing various vehicle models since then. In addition to the availability of subsidies, important factors for these plants locating there were above all the good infrastructure (e. g. logistics, airport), the existing supplier structures of the city of Leipzig and the availability of skilled specialists. Like in the two other regions, further supplier firms settled in LEI because of the necessary spatial proximity to the plants. The production facilities of both automotive groups have been expanded in recent years.[13]

This brief review of the economic history has shown that the economic structure of all three regions has undergone radical change since the early 1990s. For the second decade after reunification (1999 to 2008), which is the period of observation for this paper, these structural changes are outlined briefly below, taking employment as an example.

In the average of the 1999 – 2008 period the stock of FTEs decreased considerably not only in eastern Germany as a whole (-2.1 percent) but also in all three regions examined here. While this decline was larger than average in SWS (-2.3 percent), the drop in employment in the two other regions was somewhat more moderate (Table 4). In contrast to the declining employment trend in western Germany's manufacturing industry, employment in the manufacturing industry expanded in all three regions. The increase was highest in the EIS region, at 1.1 percent. Employment in the manufacturing industry in eastern Germany as a whole shows only a slight decline (-0.1 percent). In SWS and in EIS the employment shares of this sector are 10.2 and 14.9 percentage points, respectively, above the eastern German reference value, while the LEI region, as a services centre, exhibits a specialisation in business services.[14] Annual employment growth in the automotive industry is positive in all three regions but is below the reference value for eastern Germany (2.9 percent) in SWS (2.1 percent) and in EIS (1.6 percent). This high reference value could be attributable to the building of the two plants in Leipzig, which was associated with the creation of several thousand new jobs in that sector there. In contrast to the two established automotive regions, where this industry accounts for 3.9 percent of regional employment in each case, this share is lower in the LEI region (1.7 percent) but higher than the average for eastern Germany as a whole (1.1 percent). The au-

[13] In 2009, for example, the BMW Group opened a press shop; the construction of new buildings for the manufacture of emission-free electric cars has been underway since 2010 (http://www.bmw-werk-leipzig.de/leipzig/deutsch/lowband/com/de/index.html). In 2013 Porsche AG began to expand its previous assembly plant to a full plant in order to be able to manufacture a new vehicle model (http://www.porsche-leipzig.com/jobs/werksausbau.aspx).

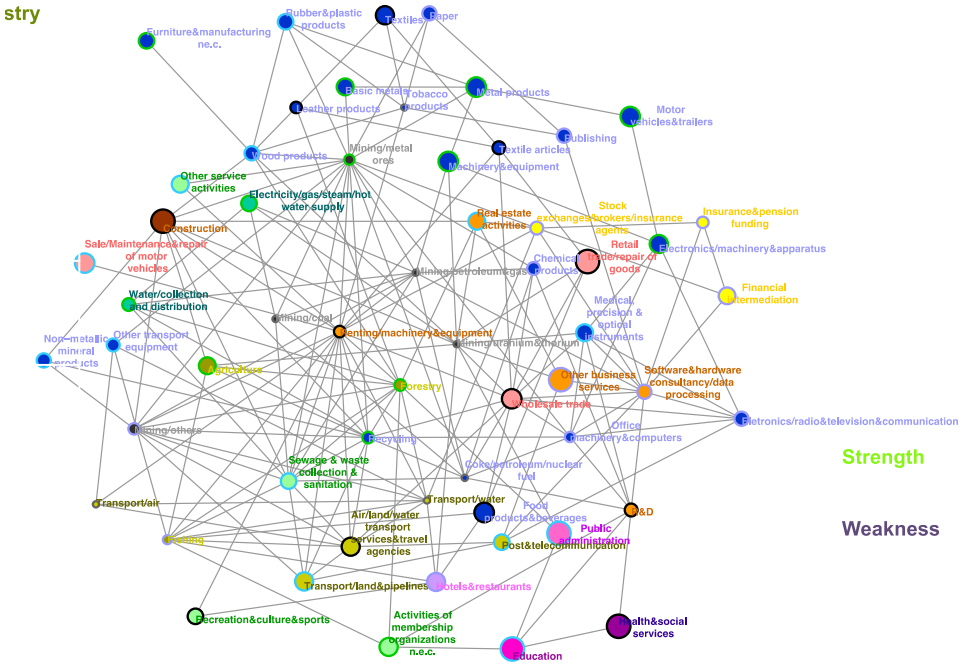
[14] Further evidence of re-industrialisation in all three regions is that the manufacturing sector accounts for increasing shares of gross value added: in SWS this share grew by 4.1 percentage points, to 24.9 percent (2008), compared to 1999, in the EIS region it grew by 6.3 percentage points to 33.0 percent (2008) and in the LEI region by 5.4 percentage points to 18.8 percent (1999 – 2008) (Statistische Ämter der Länder, 2011).

tomotive industry reinforces regional growth due to its high level of export orientation. The only other sector with a positive employment trend in all three regions is business services. Health and social services shows the smallest decline. All other sectors are characterised by high rates of decline. All in all it can be recorded that the structural changes in all three regions, especially in SWS and EIS, are characterised by a re-industrialisation trend.

4.3 SWOT analysis of the general industry structure

The network graph showing Germany's industry space serves as the initial network for the SWOT analysis of the economic structure of each of the three regions under examination. A network graph (industry space) based on this initial network is then created for each region. The size of the nodes provides information about the volume of FTEs that the particular economic activity exhibits in the region in 2008. The coloured rings around the nodes refer to the respective category of the SWOT analysis from the combination of the specialisation and embeddedness indicators for 2008 (see Figure 3). A grey ring around a node (industry) indicates that this industry does not exist in the region in question.

Figure 3
Industry space, south-west Saxony – SWOT analysis 2008



Source: Employment History (Beschäftigtenhistorik), own calculations.

The economy of SWS has specialised among other things in the primary sector, whose economic activities of forestry and agriculture are both well embedded. They are related, for example, to the activities of transport/land & pipelines, construction, recycling and wood products, so they share a common knowledge base with economic activities from various sectors.

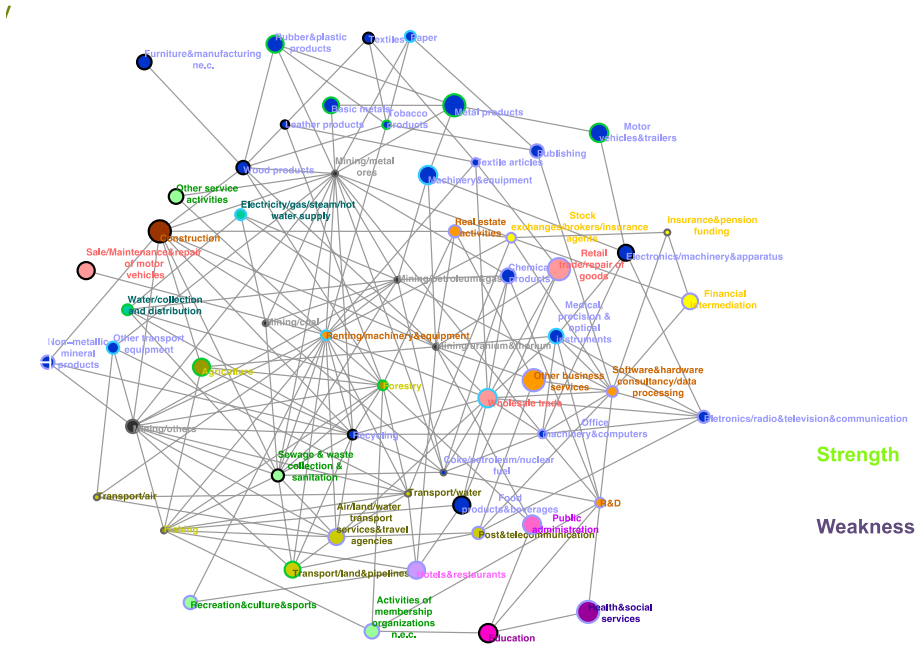
The strength of the manufacturing sector of SWS is its specialisation in five major manufacturing industries (basic metals, metal products, machinery & equipment, electronics/machinery & apparatus as well as motor vehicles & trailers), which demonstrate a high degree of embeddedness and are skill-related. There are favourable development conditions in this region not only for these large manufacturing industries but also for a number of strongly integrated small and medium-sized manufacturing industries with low levels of specialisation. These include the industries of rubber & plastic products, non-metallic mineral products, other transport equipment, medical precision & optical instruments and wood products. The basic conditions of the other manufacturing industries (e. g. manufacture of textiles, manufacture of food products) can be classed as rather poor due to their low degree of embeddedness. The firms in these industries are unable to benefit from the advantages based on access to a disproportionately large pool of labour with the required skills and knowledge.

There are only three service industries - they belong to utilities and the arts/entertainment/recreation & miscellaneous services - which show a high degree of specialisation and embeddedness. Only a few services (e. g. education, sale/maintenance & repair of motor vehicles) are well embedded - but they have good development prospects. Most of the finance and business services are only weakly embedded, so they have to be more active outside the region when recruiting skilled personnel. Many personal services are also weakly embedded, though this need not necessarily be a disadvantage. On the one hand, they have a low level of knowledge intensity, so a region-specific knowledge base is not necessarily important. On the other hand, some of these services are also highly specialised and highly skilled activities (e. g. doctors) for which recruitment generally takes place at national level anyway.

In the EIS region the degree of embeddedness is high in all of the major manufacturing industries: these include the manufacture of motor vehicles & trailers, the manufacture of basic metals, the manufacture of metal products and the manufacture of rubber & plastic products (Figure 4). Due to their high degree of specialisation and low degree of embeddedness, the development prospects for two other large manufacturing industries, the manufacture of electronics/machinery & apparatus and the manufacture of food products are poor, as, for example, they only have access to a disproportionately small pool of labour with the required skills and knowledge from related industries. As their degree of specialisation is low but their degree of embeddedness is large, favourable development prospects presumably exist above all for the manufacture of machinery & equipment, medical equipment & optical instruments, other transport equipment and for the manufacture of paper.

Most of the small manufacturing industries are only weakly embedded in the economy of the EIS region. Some of them are mature and traditional industries (e. g. the manufacture of textiles, clothes and furniture, and publishing) and some of them are young industries (e. g. the manufacture of office machinery & computers).

Figure 4
Industry space, Eisenach region – SWOT analysis 2008



Source: Employment History (Beschäftitenhistorik), own calculations.

Besides the primary sector, there are only two economic activities in the tertiary sector (water/collection & distribution, transport/land & pipeline) that constitute a strength of the regional industry mix due to high degrees of specialisation and embeddedness. Only a number of personal services (e. g. wholesale & trade, renting machinery & equipment) have good basic conditions because of their strong embeddedness. Finance and business services are characterised by a low degree of both specialisation and embeddedness. This also applies to most of the other services.

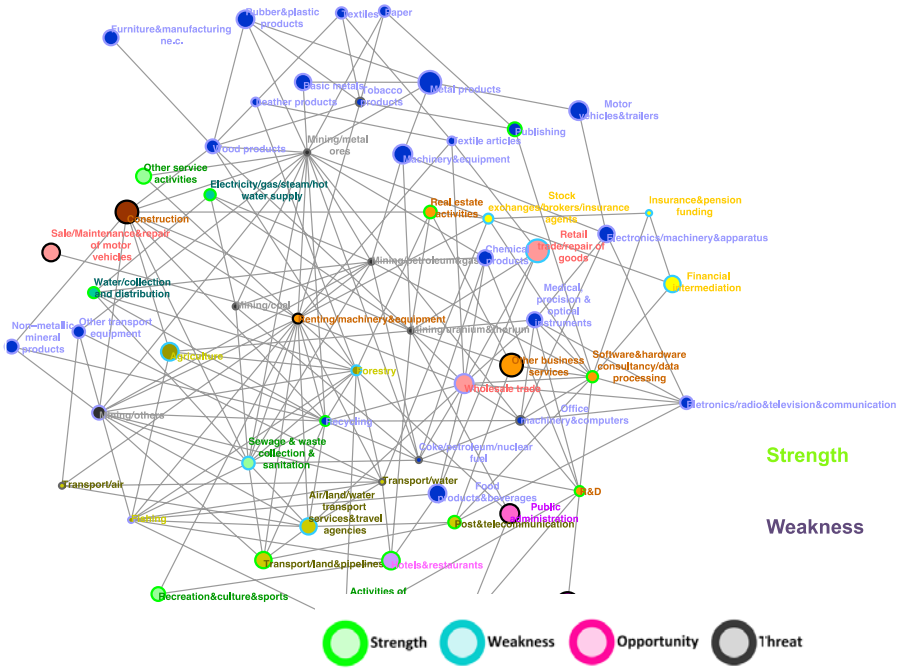
When these results of the SWOT analysis for the two regions are compared with each other, considerably more areas can be found in which the quality of the regional industry mix corresponds than areas where it differs. In both regions the manufacturing basis is composed of the same five large, skill-related manufacturing industries, which are strongly embedded in the regional economy. One important difference between the two regions is that all these industries demonstrate a high degree of specialisation in SWS but this only applies to three of the industries in the EIS region.

What does this mean for the regional economies of SWS and EIS? The firms of these manufacturing industries share with the related industries a common regional knowledge base and a disproportionately large labour pool composed of the employment in related industries. The firms therefore have good opportunities to learn from the knowledge and experience of the people employed in related industries if they hire them. This can be seen as a regional competitive advantage for the manu-

facturing firms in both regions, whereby the advantage is stronger in SWS. This structural strength of the two regions can turn into a weakness, however, if the demand for labour declines simultaneously in several of these large manufacturing industries such that employees who have been laid off have fewer adequate job alternatives in the regional manufacturing sector. In such a case the dismissed workers also have few opportunities to switch to skill-related jobs in the services sector, as these major manufacturing industries are skill-related with only a few service industries.

In contrast, the majority of the service industries in the two regions are only weakly embedded in the regional economy. This can lead to a disadvantage in inter-regional competition, however, especially for knowledge-intensive services (e. g. finance and business services), which produce tradable goods and depend to a large extent on the employees' embodied knowledge for the provision of the services. For firms in these industries, the weak degree of embeddedness in the regional economy means that they only have access to a small pool of labour.

Figure 5
Industry space, Leipzig region – SWOT analysis 2008



Source: Employment History (Beschäftigtenhistorik), own calculations.

The fact that in the LEI region, as a services centre, the manufacturing basis not only exhibits a low degree of specialisation but is also only weakly embedded in the local economy is not surprising (Figure 5). This result also applies to the manufacture of motor vehicles. The city of Leipzig's historical manufacturing tradition as a former printing centre is reflected in its specialisation in the well-embedded publishing industry. This also applies to the recycling industry.

In contrast to this, the SWOT analysis for the tertiary sector in LEI yields a more complex picture. Services in the sectors of transport & communication, utilities, education, hotels & restaurants and recreation are all well embedded in the local economy. Although the financial services have a low degree of specialisation, they are well embedded in this urban economy. The three business services of software & hardware consultancy, R&D and real estate activities constitute a structural strength (high degree of both specialisation and embeddedness). All of these services have good development prospects in this region. Other business services (other business services, renting machinery & equipment) and personal service industries (e. g. health & social services, wholesale & trade, public administration) do not possess such favourable basic conditions due to their low degree of embeddedness.

4.4 SWOT analysis of the automotive industry

The ego network of the manufacture of motor vehicles & trailers (34)[15] depicts an extract from the industry space network and therefore the skill and knowledge base of this manufacturing industry. At the two-digit industry level, this ego network is composed of the manufacture of motor vehicles & trailers (ego) and the seven economic activities related with this industry (alters) and the links between them. In order to distinguish between the skill bases of the OEMs and their suppliers, the ego networks at the disaggregated three-digit level are used. At this level the manufacture of motor vehicles & trailers (34) is split into three manufacturing industries: the ego network of the manufacture of motor vehicles (341), or the OEMs, covers five related economic activities, the manufacture of motor vehicle bodies (coach work) (342) is skill-related with 31 economic activities and the manufacture of motor vehicle parts (343) is skill-related with 21 industries as a supplier industry. The ego networks of the two automotive supplier industries overlap because they are each skill-related with the same 10 industries (alters).

Since the 1990s the share of value added of the vehicle part manufacturers has increased due to the introduction of lean manufacturing principles in the assembly plants, so the demands made on the suppliers of vehicle parts concerning the manufacture and development of products, services and systems have continued to grow (Scheuplein et al. 2007). This shift towards the manufacture of motor vehicle parts has been encouraged among other things by the intensive innovation dynamics in this industry during the last two decades. Both the increasing use of lean manufacturing in the OEMs and the shifting of the development work towards the automotive suppliers are reasons for the more extensive skill and knowledge base of the manufacture of vehicle parts compared with the manufacture of motor vehicles. This innovation activity is borne, for example, by the introduction of electronically assisted braking and steering systems, driver assistance systems or engine control systems. These require skills and knowledge, for instance, from the manu-

[15] In this section the numbers in parentheses correspond to German version of the NACE Rev. 1.1 (2- and 3-digit-level).

facturing industries of metals, machinery and equipment and electronics, which make up the majority of the industries related with the automotive supplier industries, and from engineering and technical services (Figure 6). In addition to the continued development of diesel and internal combustion engines, new lightweight construction concepts and materials have been integrated among other things to reduce fuel consumption, and work has been started on developing new drive concepts (e. g. hybrid drives, electromobility) (Barthel et al. 2010). Knowledge in dealing with lightweight materials, however, is not only required in the automotive supplier industries, but also in the manufacture of rubber & plastics and the manufacture of aircrafts.

The ego networks of the OEMs and the automotive supplier industries are combined into one network graph (Figure 6-8): to this end, the skill-relations between the three manufacturing industries (egos), which are represented by the diamond symbol, and their alters are first depicted. There are 47 economic activities (alters, circles) in total. Second, the 200 strongest skill-relations between these 47 economic activities are included. In the Figures 6 to 8 this network graph is filled in turn with specific information for each of the regions under observation. The size of the industries (nodes) corresponds to the volume of FTEs in 2008 (see also Table 5) and the colour of the rings around them correspond to the four SWOT categories, which were calculated on the basis of the degree of specialisation and embeddedness of each industry i for 2008. In addition, in Table 6 details are provided regarding the stock and growth of FTEs, the SWOT category and the embeddedness-growth indicator for the three automotive industries and for the industries most closely related with them.[16] This indicator shows how employment in skill-related industries is changing and therefore also the degree of embeddedness of industry i in the regional economy.

Table 5
Average firm size in automobile industries (FTEs), 2008

	South-west Saxony (SWS)	Eisenach (EIS)	Leipzig (LEI)
Automobile industries	Average number of FTEs	Average number of FTEs	Average number of FTEs
341 Motor vehicles	634.1	431.4	638.2
342 Coachwork	56.8	28.5	19.5
343 Motor vehicle parts	69.5	132.9	48.1

FTE: number of full-time equivalents.

Source: Employment History (Beschäftigtenhistorik), own calculations.

[16] The growth of individual industries also changes the degree of embeddedness of other industries. The embeddedness-growth indicator EGI_i shows how employment in the industries related to industry i in region r has changed as a percentage: $EGI_i = \frac{emp_{irt}^{rel} - emp_{irt-1}^{rel}}{emp_{irt-1}^{rel}}$.

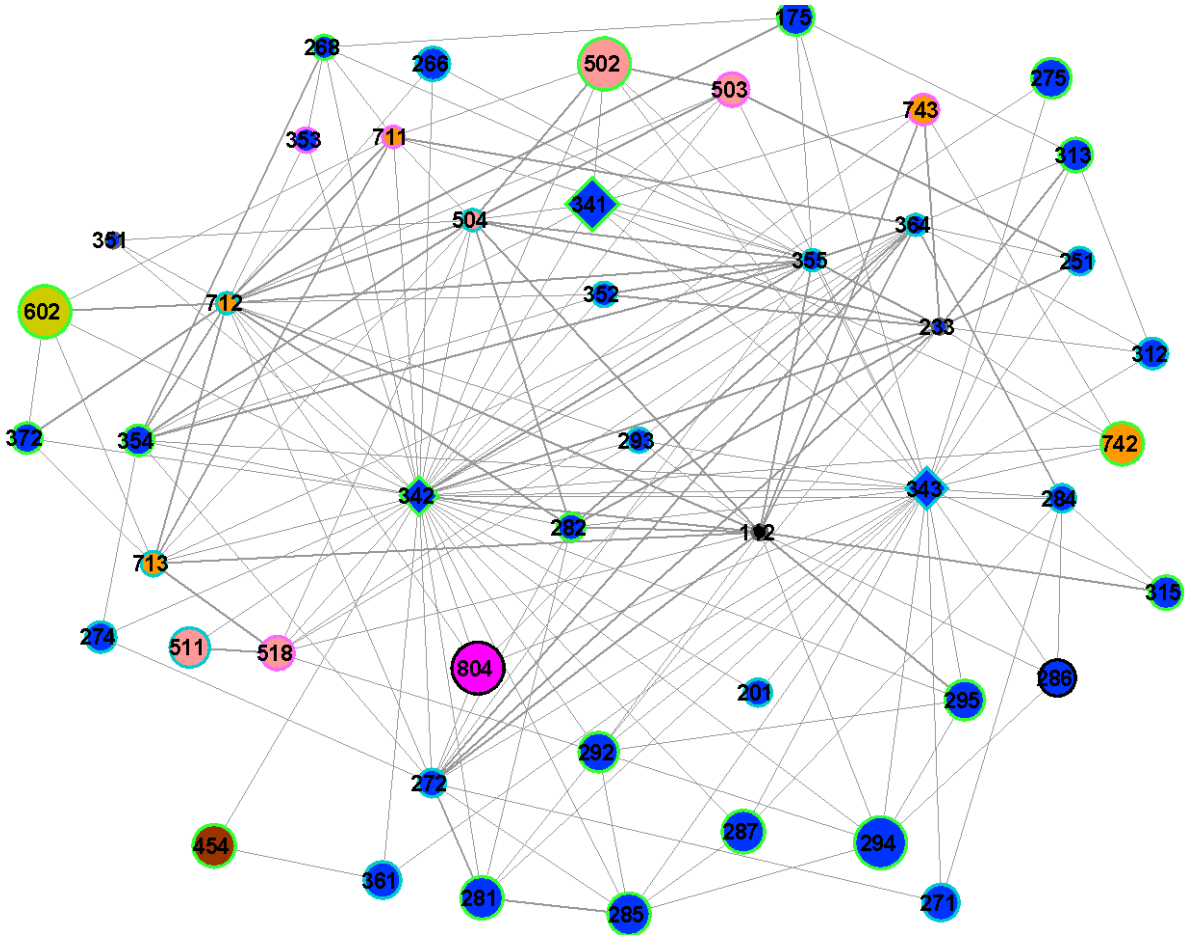
Table 6
Automotive industries and the top industries with the strongest skill-relatedness, employment, specialisation and embeddedness, 1999 – 2008

		South-west-Saxony				Eisenach region				Leipzig region			
		Number of FTEs	Δ emp, in %	EGI_i	SWOT	Number of FTEs	Δ emp I, in %	EGI_i	SWOT	Number of FTEs	Δ emp I, in %	EGI_i	SWOT
Industries i		**2008**	**1999 – 2008**		**2008**	**2008**	**1999 – 2008**		**2008**	**2008**	**1999 – 2008**		**2008**
341	Motor vehicles	8,177	1.7	2.7	S	1,996	-2.3	4.5	W	3,098	63.6	2.1	O
342	Coachwork	1,171	2.2	-0.1	S	488	-0.3	0.8	S	153	1.5	0.4	W
343	Motor vehicle parts	3,093	3.5	2.3	O	3,242	5.5	3.1	S	385	24.9	1.8	W
Top skill-related industries j													
502	Repair of motor vehicles	7,540	-2.2	0.6	S	2,538	-2.6	0.4	S	3,428	-2.4	1.6	S
602	Transport/other land transport	7,189	-1.4	-3.0	S	3,603	-1.5	-2.8	S	4,285	-0.7	-2.6	S
804	Adult and other education	12,926	-3.2	-2.4	R	6,315	-3.0	-1.8	R	10,252	1.6	-1.9	R
285	Metal treatment and coating	5,229	4.2	-1.8	S	3,447	1.6	-1.2	S	1,527	-1.4	-2.4	W
294	Machinery/machine tools	6,480	-0.5	2.6	S	1,723	3.2	3.2	S	636	3.9	1.9	W
454	Construction/building completion	5,368	-8.2	-2.8	S	2,590	-7.9	-2.6	S	2,847	-8.4	-2.9	S
287	Metal/other products	5,683	2.6	-2.2	S	5,779	3.4	-1.5	S	235	-1.8	-3.4	O
742	Architectural and engineering activities	5,101	-2.7	-3.0	S	1,255	-5.0	-1.7	W	4,754	-4.1	-1.7	S
281	Metal/structural metal products	5,076	-0.4	-2.0	S	1,539	-0.5	-0.8	S	2,226	-3.7	-3.0	R
295	Machinery/other special purpose	4,070	1.0	1.9	S	1,516	2.6	2.7	O	1,184	-0.6	1.6	W
511	Wholesale	3,118	-0.9	-2.1	O	1,055	1.2	-1.5	O	1,313	-0.5	-1.8	W
292	Machinery/other general purpose	3,017	2.8	0.2	S	1,210	0.8	1.8	O	1,245	-3.4	0.3	W
275	Casting of metals	2,368	1.8	6.1	S	854	10.6	5.3	S	1,327	3.6	4.8	R
286	Metal/cutlery and tools	1,412	1.6	4.1	R	1,548	-0.8	4.2	S	241	-2.1	2.3	W
361	Furniture	1,331	-7.2	-2.1	O	836	-5.0	-1.4	O	343	-4.7	-2.3	O
175	Other textiles	1,669	-4.8	0.0	S	99	-4.1	2.1	O	122	1.3	-1.5	W
271	Basic iron & steel	1,379	4.3	0.6	O	665	6.7	1.0	O	122	3.7	0.9	W
503	Sale of vehicle parts	751	-1.8	0.8	W	416	3.1	1.0	O	489	1.5	1.3	W

* FTE: full-time equivalents; Δ emp i: annual employment growth of industries i; EGI_i: embeddedness-growth indicator of industry i.

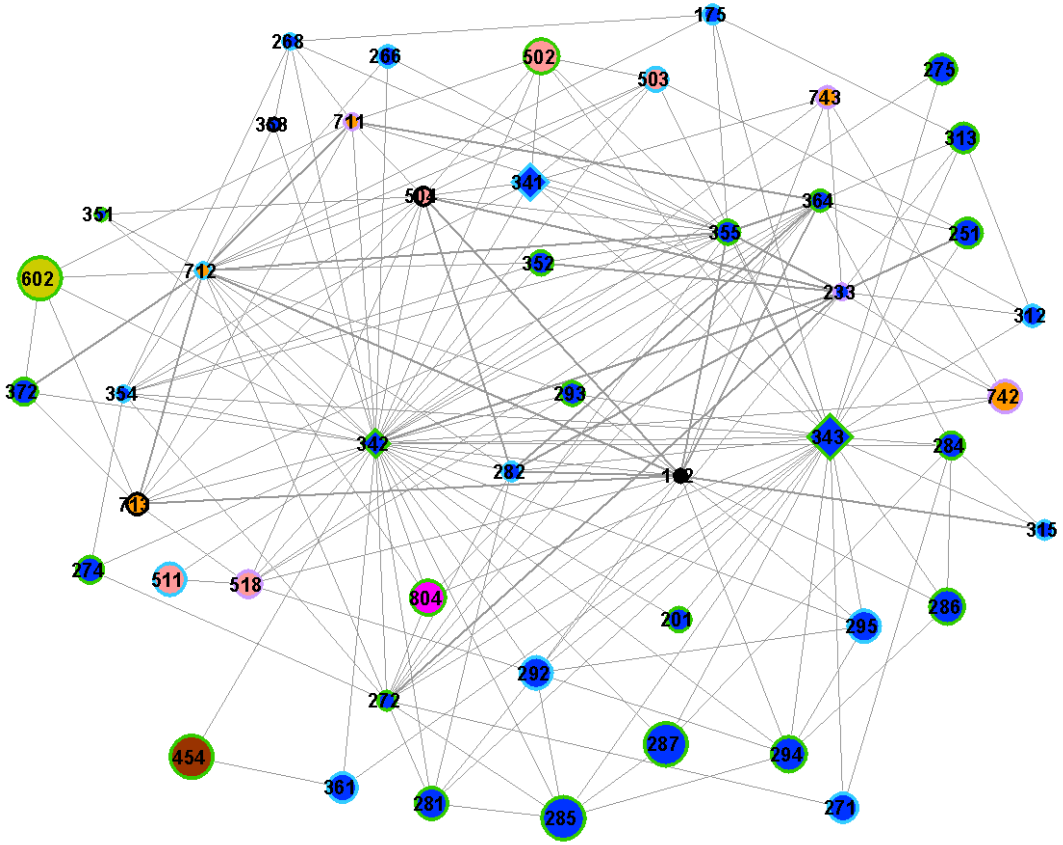
Source: Employment History (Beschäftigtenhistorik), own calculations.

Figure 6
Industry space, south-west Saxony – automotive industries 2008



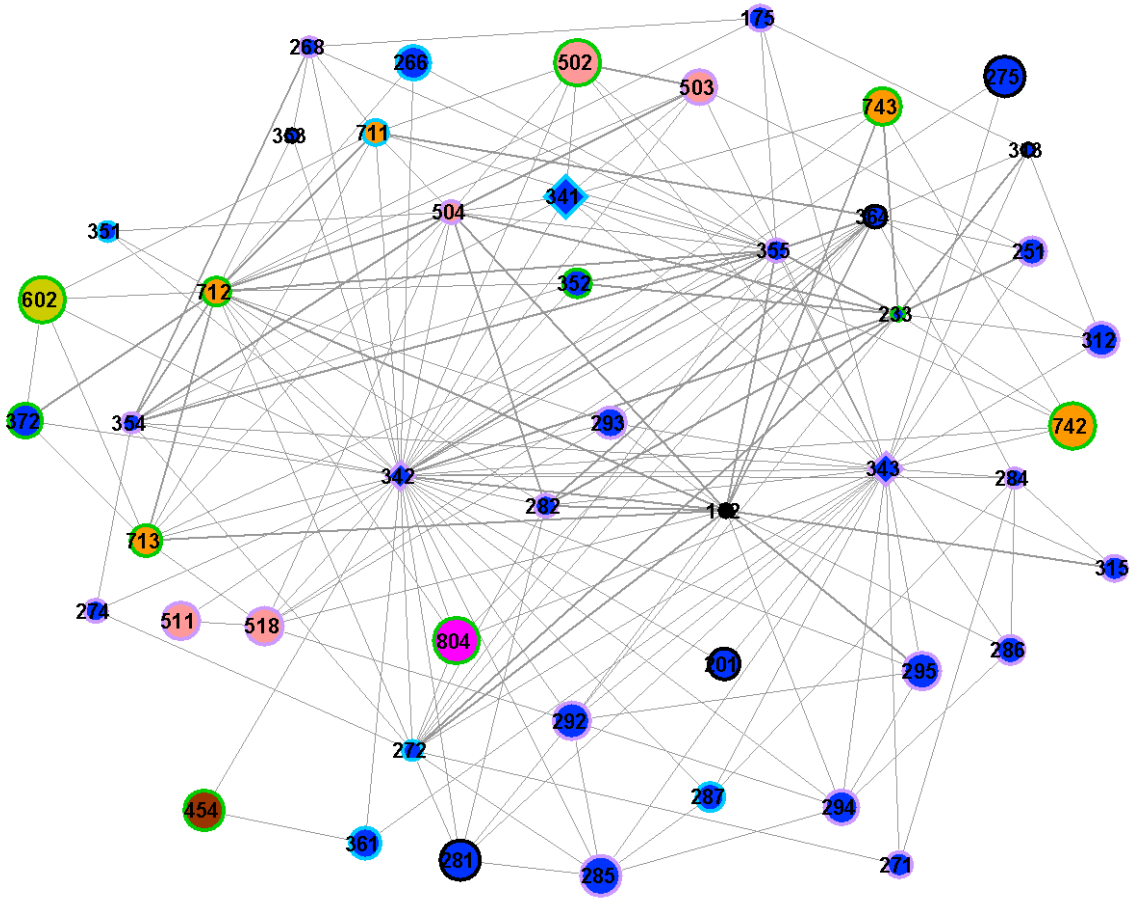
Source: Employment History (Beschäftigtenhistorik), own calculations.

Figure 7
Industry space, Eisenach region – automotive industries 2008



Source: Employment History (Beschäftigtenhistorik), own calculations.

Figure 8
Industry space, Leipzig region – automotive industries 2008



Source: Employment History (Beschäftigtenhistorik), own calculations.

In SWS the stock of FTEs (1999 – 2008) increased in all three automotive industries. These three industries account for 4.0 percent of overall employment (2008). The largest increase is recorded for the manufacture of motor vehicle parts. Only three of the total 47 related industries are not present in SWS; the related industries account for 30.4 percent of all FTEs in SWS in 2008. The degree of embeddedness of the manufacture of motor vehicles and the manufacture of motor vehicle parts in the regional economy has intensified due to the increase in employment in the industries with which they are skill-related (Table 6, Figure 6). As a result of their high degree of embeddedness, favourable development conditions exist for them in SWS because, for example, the regional pool of labour with the skills they require has grown. The regional employment share of the manufacture of motor vehicles is larger than the national reference value (high degree of specialisation). As the corresponding share for the manufacture of motor vehicle parts is below this comparison value, it is conceivable that the importance of this industry could increase still further due to the favourable basic conditions for SWS. The manufacture of motor vehicle bodies (high degree of embeddedness and specialisation) also has a stable development environment in SWS.

The manufacture of aircraft (low degree of specialisation) and the manufacture of metal cutlery & tools (high level of specialisation) are the only two weakly embedded manufacturing industries from the skill base of the automotive industries. All the other manufacturing industries sharing this skill base are well embedded. Firms belonging to these industries are therefore in a good position to recruit manpower with the required skills and knowledge from related industries in SWS and to learn from them. Owing to its high innovation intensity, the automotive industry is dependent on cooperating with external knowledge-intensive services (engineering activities, technical testing & analysis) for their research and development. However, in this respect good conditions only exist in the first-mentioned knowledge-intensive services in SWS (high levels of specialisation and embeddedness).

The share of regional total employment accounted for by the three automotive industries in EIS was 3.9 percent in 2008 (Table 6). Employment in the manufacture of motor vehicle parts expanded considerably, whereas it fell in the manufacture of motor vehicles. This decrease was larger than the decline of total employment in the region. Thousands of jobs were cut in the course of the restructuring and capital reorganisation of Opel's European plants (http://de.wikipedia.org/wiki/Opel). What is striking is that - like in SWS - only three of the total 47 related industries belonging to the skill base of the automotive industries are not present in the EIS region (Figure 7). The 44 related industries from the skill base accounted for 35.1 percent of the stock of FTEs in the EIS region in 2008.

All three automotive industries became more strongly integrated in the regional economy during the period from 1999 to 2008 because employment in the industries related with them increased overall. Nonetheless, the plants of the motor vehicle manufacturers were only weakly embedded in the economy of the EIS region in

2008 and their importance for overall employment was lower than the national average (low degree of specialisation). This low degree of embeddedness is due to the fact that not only the related industry of motor vehicle repair is considerably smaller in EIS than in the other two regions, but also the other related service industries. In the industries related to the manufacture of motor vehicles, the pool of labour with skills and knowledge also required by the motor vehicle manufacturers in the EIS region is therefore smaller than the national average. If these firms wish to recruit workers from the region on a large scale, they could run into hiring difficulties. In contrast, the strength of the skill base in this region is due to the large degree of specialisation in the manufacture of motor vehicle parts and vehicle bodies. These two industries are well embedded in the regional economy. The regional environment in EIS is therefore favourable for these two automotive supplier industries. This also applies for all other related manufacturing industries apart from two. On the one hand they are well embedded, but on the other hand they account for above- or below-average shares of regional total employment (high or low degree of specialisation). Their level of employment could therefore remain stable or expand.

The knowledge-intensive services of this skill base exhibit a low degree of both specialisation and embeddedness (engineering activities, technical testing & analysis). The conditions for inter-industry research and development activities in the region are therefore rather poor.

For the automotive industry in LEI, as a new core industry, the share of all FTEs in this region, at 1.7 percent, is quite substantial. After all, the corresponding share in each of the two other automotive regions is only double that. The manufacture of vehicle bodies is only sparsely present in LEI. In four of the total of 47 related industries in the skill base there are no employees. Just under a quarter (23.3 percent) of the stock of FTEs in this urban region is found in the economic activities related to the automotive industries. As the level of employment in these industries grew between 1999 and 2008, the degree of embeddedness of all three automotive industries has improved, especially that of the car manufacturers and the manufacturers of motor vehicle parts. The good degree of embeddedness of the manufacture of motor vehicles in 2008 is evidence that this new industry fits in well with the existing industry portfolio of LEI. For this region has specialised in economic activities that require labour with similar skills to those of the motor vehicle manufacturers. The industries related with them here include many large service industries (e. g. repair of motor vehicles, sale of motor vehicle parts & motorcycles, engineering activities, technical testing & analysis). The automotive supplier industries, whose regional employment shares are below the national reference values (low degree of specialisation), each demonstrate only a low degree of integration in this urban economy. These two manufacturing industries are mainly skill-related with other manufacturing industries that have only a limited presence in LEI compared with the other two regions. This means that the regional environment in LEI is currently even more unfavourable for the firms of the two automotive supplier industries as they are only able

to benefit to a lesser extent from the synergies of a knowledge base shared with the firms of other related industries.

In LEI many of the small related manufacturing industries either demonstrate a high degree of specialisation and a low degree of embeddedness or both specialisation and embeddedness are equally low. They therefore have rather poor development conditions here, as does this part of the skill base of the automotive industries. In contrast to the industrial regions of SWS and EIS, the strengths of the skill base for the automotive industries in LEI are found above all in the services sector. Almost all business services, the transport sector and the repair of motor vehicles are characterised by a high degree of both specialisation and embeddedness. The firms providing these services are presumably able to meet their staffing requirements quite well on the urban labour market, as there is a disproportionately large pool of workers with the skills they require in related industries.

So how are the development prospects of the LEI region's new core industry of motor vehicle manufacture and the manufacture of vehicle parts to be assessed? Due to the fact that the manufacture of motor vehicles, in other words, the car manufacturing plants of BMW AG and Porsche AG, is primarily skill-related with service industries that are strongly represented in LEI, there is a good match between this manufacturing industry and the region's urban industry mix. As the automotive suppliers mainly share a knowledge base with other manufacturing industries but their skill base is rather limited in this respect in LEI, this manufacturing industry, which is quite new to the region, is less well matched to the structure of the regional economy. The job matching quality within this region is therefore poorer for the personnel recruitment of these suppliers. This assumption is confirmed by the work of Hausmann/Neffke/Otto (2013), who show that firms in an industry that is new to a region find staff from skill-related industries in other regions but not in their own region. Personnel recruitment could therefore incur substantial costs for the Leipzig automotive suppliers if they require workers with related skills. The suppliers could cooperate with local service industries that show cognitive proximity in the industry space network in order to determine their overlapping human capital requirements. In the case of lay-offs in the automotive industries, this would then mean that especially employees of the supplier firms would have to seek employment more in unrelated industries. The loss of industry-specific human capital associated with this could become noticeable in reduced wages and may damage these workers' careers in the long-term, as the industry-specific human capital that they have accumulated previously in the automotive supplier industries is devalued in unrelated industries, thereby reducing their chances of being recruited again in the supplier industry.

There are only two fundamental differences between the skill bases of the automotive industries in the two regions SWS and EIS. In SWS all three of the automotive industries, the OEM plants and their suppliers, fit into the regional industry mix due to their high degree of embeddedness. These manufacturing industries therefore find good basic conditions for their future development in SWS. In EIS the manufac-

ture of motor vehicles does not fit into the regional industry structure so well because of its low level of embeddedness. In contrast, the automotive suppliers are well integrated in the regional economy. In the EIS region, there is also a stronger specialisation in the automotive supplier industry than in SWS. In EIS (35 percent) the industries in the skill base that are related with the automotive industries are more important for regional employment than is the case in SWS (30 percent).

On the whole, however, the economies of SWS and EIS each possess a well-equipped skill base for the automotive industries: this applies in particular for the manufacturing industries in this skill base, which are almost all well embedded. Workers can therefore switch jobs within the manufacturing sector of this skill base quite easily. In the EIS region the motor vehicle manufacturers are not able to benefit from the linked advantages to the same extent as the well embedded automotive suppliers due to their low degree of embeddedness. In contrast, in SWS the firms in the entire automotive industry are able to derive positive utility from the advantages of a good level of embeddedness. However, in both of these regions only a few of the service industries represented in the skill base are well embedded. It is presumably more difficult to change jobs between the automotive industries and the related service activities compared with the manufacturing sector. Of the knowledge-intensive services, only the engineering activities in SWS are highly specialised and well embedded. Against this background, the conditions for creating links for inter-industry research and development activities between the automotive industries and these services can be classed as rather unfavourable.

4.5 Regional and industrial origins of labour inflows

In section 4.4, it was concluded that the match between the car manufacturers and Leipzig's urban industrial mix is better than in the case of the automotive suppliers. These outcomes refer to the observation year 2008. At that time the new branch operations have already been established and the recruitment of the new workforce was completed. In this section, it is sought to reconstruct the emergence of this new workforce in these new and young economic activities from the outset of the car production in the LEI region. Therefore, the regional and industrial origins of labour inflows are scrutinized in this section in more detail. For this purpose, all job moves into the automotive industries are observed that took place between 30 June of the observation year and 30 June of the previous year during the observation period from 1999 to 2008. Table 7 depicts the regional and industrial origins of labour inflows for the manufacture of motor vehicles and automotive suppliers (manufacture of motor vehicle bodies + manufacture of motor vehicles/parts). In this respect, it is of particular interest to figure out as to what extent the staffing requirements of these new economic activities could be absorbed by the regional labour market. Are workers with previous working experience in the automotive industry (similar industry) or in skill-related industries hired to a larger extent from extra-regional labour markets compared to those with a background in unrelated industries?

Table 7
Industrial and regional origins of labour inflows into automobile industries, 1999 – 2008, percentage shares*

Manufacture of motor vehicle industry (341)					Automotive suppliers (manufacture of motor vehicles/parts (342) & manufacture of motor vehicle bodies (343)				
SWS region (n=1.884)	Similar industry	Related industries	Unrelated industries	*Total*	SWS region (n=3.991)	Similar industry	Related industries	Unrelated industries	*Total*
SWS region	9	49	23	*81*	SWS region	23	39	23	*85*
Eastern Germany	1	2	6	*9*	Eastern Germany	0	3	5	*8*
Western Germany	3	5	2	*10*	Western Germany	1	2	4	*8*
Total	*13*	*56*	*31*	*100*	*Total*	*24*	*44*	*32*	*100*
EIS region (n=448)	Similar industry	Related industries	Unrelated industries	*Total*	EIS region (n=2.199)	Similar industry	Related industries	Unrelated industries	*Total*
EIS region	5	22	39	*66*	EIS region	3	35	35	*73*
Eastern Germany	0	8	5	*13*	Eastern Germany	0	8	5	*12*
Western Germany	8	3	10	*21*	Western Germany	0	9	5	*15*
Total	*13*	*33*	*54*	*100*	*Total*	*3*	*52*	*45*	*100*
LEI region (n=2.230)	Similar industry	Related industries	Unrelated industries	*Total*	LEI region (n=447)	Similar industry	Related industries	Unrelated industries	*Total*
LEI region	0	11	10	22	LEI region	8	50	8	*66*
Eastern Germany	1	17	23	40	Eastern Germany	2	8	10	*20*
Western Germany	30	7	1	39	Western Germany	3	7	4	*14*
Total	*32*	*35*	*34*	*100*	*Total*	*13*	*66*	*21*	*100*

* n: total number of job switches between t and t-1 from 1999 to 2008.

Source: Employment History Panel (Beschäftigungshistorik), own calcuations.

The greatest part of workers (79 percent) that switched to the manufacture of motor vehicles in Leipzig originated from other regions, either from eastern Germany (40 percent) or from western Germany (39 percent). Only 22 percent of the job moves to this industry derived from the local labour market. The share of job switchers with similar industry experience among all labour inflows is 32 percent. This value exceeds the reference values in the other two regions under examination. Job movers with related and unrelated industry experience play a more important role for car manufacturers in SWS and in EIS. Almost all job changers that stem from western Germany obtained similar industry experience. In other words, they were employed by western German car manufacturers. To run such large branch operations the availability of experienced and skilled personnel is a prerequisite. A significant part of the new workforce was therefore trained on the job in western German production sites of the OEMs.[17] However, employees that gained previous working experience in eastern Germany's manufacture of motor vehicles were not hired by the OEMs in Leipzig at all. Job movers originating either from the region itself or from other parts of eastern Germany had mostly related and unrelated working experience.

In contrast, the regional labour market provided the majority (66 percent) of workers that switched to the automotive suppliers. Most of these regional job movers derived from related economic activities. The remaining labour inflows derived either from eastern Germany (20 percent) or from western Germany (14 percent). Most of these inter-regional labour inflows come from related and unrelated industries.

All in all, the emergence of these new economic activities in the region LEI could be seen as a positive exogenous shock. This positive shock could be anticipated by the urban economy of Leipzig only with the support of inter-regional labour inflows. This statement holds especially true for the car manufacturers whereas the local labour market pool satisfied mainly the labour demand of the supplier industries.

Car manufacturers that are located in SWS region hired 81 percent of their workforce on the regional labour market, primarily from related industries, but also from similar and unrelated economic activities. The major part of employees that switched to the automotive suppliers (85 percent) comes also from the regional labour market, too, mainly from related industries. One difference stands out with regard to the industrial origins: Similar labour inflows (24 percent) play a greater role for the automotive suppliers than for the car manufacturers (13 percent). The reason for this

[17] As the complexity of most new jobs in these branch operations is not expected to be too large, it is likely that such a training on the job did not last longer than a couple of months. This might explain the large shares of job inflows from western Germany deriving from the similar industry. However, having a look at job switches to the manufacture of motor vehicles between the year under observation (t) and two years before (t-2) yielded concurrent results: In most cases, job movers with prior working experience in the similar industry derive from western Germany. This result sustains our statement of the great relevance of qualified and experienced workers for the set-up of such new production sites.

difference is obvious: Job turnover is more intense among small- and medium-sized firms. The firm stock of the automotive suppliers is made up mainly by SMEs whereas the small set of car manufacturer plants in SWS are extremely large.

66 percent of the job moves to the OEMs in the EIS region come from the local labour market. The major part of these movers obtained unrelated industry experience whereas related working experience of regional switchers is also substantial, but less important. Automotive suppliers satisfied their workers needs to a greater extent from the local labour market compared to the car manufacturers. The share of regional labour inflows amounts to 73 percent whereas both kinds of working experience matter, those obtained in related and in unrelated industries. An outstanding result is that labour inflows that stem from similar economic activities are not substantial for automotive suppliers in EIS at all.

Inter-regional labour inflows play a more important role for the car manufacturers and automotive suppliers in EIS than in SWS. In addition, a greater part of labour inflows originates from related economic units in SWS than in EIS.

4.6 Reallocation of human capital from shrinking to growing economic activities

In case of an asymmetric shock it is essential for the resilience of a regional economy that labour shortages in shrinking economic activities can be reallocated efficiently to growing economic activities. To overcome such shocks, inter-industrial labour mobility is an important means to reallocate the production factor human capital for a regional economy. Neffke et al. (2013) demonstrate that a significant part of the German labour force chooses among a limited set of related industries when switching to another job. The authors conclude that labour flows are channelled through narrow paths on the German labour market. In this regard, the question rises whether this limited flexibility of workers to change jobs freely across industries may prevent regions from responding successfully to such shocks.

To provide an answer to this question it is necessary to find out to what extent skill-related industries do coincide in having similar growth rates. To reply to this question, Neffke et al. (2013) proposed to calculate the maximum reallocation potential of an economy. This method is applied in this section, too.

The first step consists of displaying the relatedness among 3-digit industries, respectively, for the entire German labour market, including all labour flows in the time period from 1999 to 2008. The formula to calculate the reallocation potential for each pair of industries is as follows:

$$POT_{ij} = \min(-S_i, S_j)\ if\ S_i < 0\ and\ S_j > 0$$
$$= 0 \qquad otherwise$$

where S_i is the employment growth (labour shortage), that industry i accumulates from 1999 to 2008. The maximum net flow of workers from industry i to industry j is denoted as the reallocation potential.

Diverging staffing requirements of two industries that exhibit dissimilar growth rates cause high reallocation potentials. In such cases labour shortages in a shrinking industry can be easily absorbed by expanding skill-related industries. In turn, concurrent employment dynamics of skill-related economic activities go along with a negative correlation between skill-relatedness and reallocation potential. In other words, there are not many pairs of skill-related industries available to shift redundant labour of industry i to a growing industry j.

Table 8
Correlations between skill-relatedness and high reallocation potential, 1999 – 2008

	Spearman rank correlation coefficients
Regions	3-digit industries
Germany	-0.018
Eastern Germany	-0.019
South-west Saxony	-0.035
Eisenach	0.000
Leipzig	0.001

Source: Employment History Panel (Beschäftigtenhistorik), own calculations.

The Spearman rank correlation coefficients between skill-relatedness and this reallocation potential are depicted in Table 8 for Germany and eastern Germany as well as for the three examined regions. All correlation coefficients exhibit only small values. The correlations are negative for the German economy as a whole and for the eastern German one, too. Both economies were apparently less capable of compensating diverging needs for workers among industries. However, these results are not surprising with regard to the overall decline of total employment in Germany and in eastern Germany in the time period under investigation. The correlation between skill-relatedness and reallocation potential is even more negative for south-west Saxony whilst Eisenach is characterized by a neutral coefficient value. Both regions possess a more specialized portfolio of economic activities. For this reason, both regions may have more difficulties to cope with different industrial labour needs. In contrast, reallocation potential and skill-relatedness are positively correlated in Leipzig. Skill-related industries exhibit opposite growth rates in this diversified urban economy. This region has got therefore less difficulties to cope with industrial shifts of labour demand compared to the other two automobile regions.

Table 9
Simulation of labour flows among shrinking and growing industries, 1999 – 2008

3-digit industries				
Regions	$\bar{R}_{ij}$	$\overline{SR}_{ij}$	**Shares in percent**	
			Unrelated flows	**Related flows**
Germany	0.47	0.54	15.1	84.9
East Germany	0.56	0.49	22.9	77.1
Region SWS	0.63	0.38	35.7	64.3
Region EIS	0.56	0.46	27.2	72.8
Region LEI	0.49	0.52	18.1	81.9

$\bar{R}_{ij}$: relative share of reallocation flows between skill-related pairs industries i to j until labor surpluses in the target industries i are satisfied.

$\overline{SR}_{ij}$: average SR value between those pairs of industries i and j among which these reallocation moves took place.

Source: Employment History Panel (Beschäftigtenhistorik), own calculations.

It is difficult to evaluate an economy's adjustment costs to shifts of industries in terms of employment. One possibility to get an impression of this severity is a simulation of inter-industry net labour flow patterns of skill-relatedness when dismissed workers are assumed to change to jobs that are most related to their current job (see for the method Neffke et al. 2013). The first step of this simulation consists of deflating all labour shortages in expanding industries that their sum equals the sum of labour surpluses in declining industries in order to focus on the simple reallocation of existing labour. The entries and exits of workers from the labour market are not taken into account.[18] The second step comprises a sorting of all industry pairs in descending order of skill-relatedness. Afterwards, going down this list of industry pairs, workers are transferred from declining to expanding industries, until all labour surpluses disappeared. On average, the $\bar{R}_{ij}$ of these "forced" reallocation labour flows amounts to 0.47 for Germany (Table 9). The average skill-relatedness $\overline{SR}_{ij}$ of these simulated labour flows is 0.54 in the period under investigation. The majority of job switches in the German economy (84.9 percent) took place between skill-related industry pairs. In the same period, the reference value for eastern Germany is 77.1 percent, this value is noticeable lower. For eastern Germany's economy, on average, the $\bar{R}_{ij}$ of these "forced" reallocation labour flows is 0.56 and the average skill-relatedness $\overline{SR}_{ij}$ amounts to 0.49. In general, one may conclude that the German economy is able to cope with varying workers' needs across industries whereas this capability is not as strong in the case of eastern Germany. In SWS $\bar{R}_{ij}$ (0.63) and $\overline{SR}_{ij}$ (0.38) exhibit the highest and lowest values, respectively, among all regional units. These results indicate that this regional economy of south-west Saxony

[18] Neffke et al. (2013) presume that all expanding industries satisfy their grown need for workers to the same extent with new employees. In addition, it is expected that the downsizing in all declining industries functions to the same extent through employees leaving the labour market.

was characterized by the highest share of labour flows between unrelated industry pairs (35.7). The relative share of job changes among related industry pairs in the EIS region (72.8) exceeds the reference value of SWS (64.3) significantly. For SWS, it might have been less easy to move labour shortages from shrinking industries to skill-related growing industries compared to the EIS region. One possible reason for this difference might be that the regional economy of SWS has undergone a more intense structural shift of employees between economic activities because its manufacturing base is more diversified than the production activities in EIS. Therefore, it is likely for SWS that excess workers could not be as easily transferred to jobs in skill-related industries. In the LEI region $\bar{R}_{ij}$ (0.49) and $\overline{SR}_{ij}$ (0.52) exhibit the lowest and highest value, respectively, among all three examined automobile regions. Consequently, the share of job moves between skill-related industry pairs is extremely high (81.9 percent) compared to the other two automobile regions and to eastern Germany. These outcomes indicate that Leipzig's economy should have had adequate preconditions to anticipate the positive exogenous shock, namely the settlement of the production plants of the OEMs. However, the stronger specialization of the regional economies of EIS and SWS may explain why the more diversified urban economy of LEI has got better region-specific preconditions to anticipate diverging industrial demands.

5 Conclusion

The re-industrialisation process in the SWS and EIS regions was essentially brought about by the initial investments of the western German automotive groups VW, OPEL and BMW, while in the LEI region the automotive industries constitute a new core industry. It is unusual for a core manufacturing industry, associated primarily with the establishment of two major assembly plants, to develop in an urban region characterised by service industries. In fact, the location decisions of the two OEMs, Porsche AG and BMW AG, have proved advantageous as their factories are well embedded in this urban region as a result of the strong presence of skill-related services. It is by all means possible to speak of advantageous environment conditions for the motor vehicle manufacturers in this urban region. However, this does not apply to the automotive suppliers to the same extent. The sparse presence of skill-related manufacturing industries makes it more difficult for them to recruit specialists with the skills they require in their own region, such that the quality of the job matching decreases for them. In the two other automotive regions, on the other hand, the automotive supplier industries are quite well embedded. The main difference between SWS and EIS can be seen in the embeddedness of the core industry of motor vehicle manufacturing. Whereas this industry is also very well embedded in the regional economy in SWS, in EIS the same industry cannot be seen to have either a high degree of embeddedness or of specialisation. The stability and the development potential of the automotive industry therefore appear to be largest in SWS.

As both the automotive suppliers and the motor vehicle manufacturers in all three regions are primarily production-related because the R&D activities are located at the headquarters in western Germany or abroad, there is presumably little need for utilising the knowledge of workers from related industries in the region for generating product innovation (Jürgens/Meißner 2008). Nonetheless, access to such knowledge, which has often been accumulated during many years of experience, also appears to be essential for implementing process innovations in the plants and at the supplier firms, which is why in particular the core industry of the automotive industry in EIS “should not miss the bus”.

Having a look at labour inflows throughout the observation period, it could be shown that the emergence of these new economic activities in the region LEI were sustained to a great extent by inter-regional labour inflows. This statement holds especially true for the car manufacturers whereas the local labour market pool satisfied mainly the labour demand of the supplier industries. Intra-regional labour flows play a more important role for car manufacturers and automotive suppliers in the regions EIS and SWS, although inter-regional labour inflows are more relevant for all automobile industries in EIS. In addition, a greater part of labour inflows originates from related economic units in SWS than in EIS.

A possible additional research question for this comparative regional analysis could thus be a simulation that could be used to show whether or not the regional demand for labour in the industries in question can be met from skill-related industries. This would make it possible to derive statements as to what part of human capital can be reallocated effectively in the regional economy and as to the quality of the regional economic structure required for this. Such a simulation was carried out in the last section of the comparative examination of the three eastern German automobile regions. Nevertheless, this simulation disregarded inter-regional shifts of labour. This simulation demonstrated that it would have been possible for the LEI region to shift a high share of redundant employment from shrinking to growing, but skill-related industries. These shares of simulated ‘related’ labour flows are smaller in the regions EIS and SWS whereas this share is lowest in SWS. These outcomes indicate that Leipzig’s economy should have had adequate preconditions to anticipate a positive exogenous shock, namely the settlement of the production plants of the OEMs. However, the stronger specialization of the regional economies of EIS and SWS may explain that the more diversified urban economy of LEI has got a more favourable local environment to anticipate diverging industrial demands. A further research issue for such a regional comparison is to investigate the relevance of skill-related and unrelated job moves in the individual regions and their impact on regional economic growth.

Furthermore, in connection with the results of this comparative analysis of the three automotive regions, two options arise that could form the basis for regional funding policies. First, corresponding human capital requirements between both the supplier industries and the motor vehicle manufacturers as well as between these industries

and those related to them could be specified more precisely, for example in the field of staff training. Second, where no links exist, for instance between industries with low cognitive proximity, such links may be established by means of project-related cooperation arrangements. Such cooperation arrangements could refer, for example, to joint R&D projects. In this way links could also be created between the motor vehicle manufacturers and other economic activities which are in turn skill-related with the automotive suppliers or perhaps between younger and older manufacturing industries from the skill base of the automotive industries.

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Editorial staff
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Technical completion
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For further inquiries contact the authors:

Anne Otto
Phone +49.681.849 207
E-mail anne.otto@iab.de

Antje Weyh
Phone +49.371.9118 642
E-mail antje.weyh@iab.de