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The role of innovation and agglomeration for employment growth in the environmental sector

Jens Horbach
Markus Janser

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Jens Horbach (University of Applied Sciences Augsburg)
Markus Janser (Institute for Employment Research Nuremberg)

Mit der Reihe „IAB-Discussion Paper“ will das Forschungsinstitut der Bundesagentur für Arbeit den Dialog mit der externen Wissenschaft intensivieren. Durch die rasche Verbreitung von Forschungsergebnissen über das Internet soll noch vor Drucklegung Kritik angeregt und Qualität gesichert werden.

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Abstract

The environmental sector is supposed to yield a dual benefit: its goods and services are intended to help to tackle environmental challenges and its establishments should create new jobs. However, it is still unclear in empirical terms whether that really is the case. This paper investigates whether employment growth in ‘green’ establishments with ‘green’ products and services is higher compared to other establishments. Furthermore, the main factors determining labor demand in this field are analyzed. We use linked employment and regional data for Germany. The descriptive results show that the environmental sector is characterized by disproportionately high employment growth. The application of both a generalized linear mixed model and an instrumental variables regression reveals that especially innovation and industry agglomeration foster employment growth in establishments in the environmental sector. Establishments without green products and services show a smaller increase in employment, even if they are also innovative.

Zusammenfassung

Der Umweltschutzsektor verspricht einen doppelten Nutzen: seine Güter und Dienstleistungen sollen dazu beitragen, die ökologischen Herausforderungen zu bewältigen und gleichzeitig sollen dadurch neue Arbeitsplätze geschaffen werden. Ob dies wirklich der Fall ist, ist bislang jedoch nicht nachgewiesen. In unserem Artikel untersuchen wir zum einen, ob das Beschäftigungswachstum in "grünen" Betrieben tatsächlich höher ist als in anderen Betrieben. Zum anderen analysieren wir die Determinanten der Arbeitskräftenachfrage im Umweltschutzsektor. Wir verwenden verknüpfte Beschäftigten- und Regionaldaten für Deutschland. Unsere deskriptiven Ergebnisse zeigen, dass der Umweltschutzsektor durch ein überproportionales Beschäftigungswachstum gekennzeichnet ist. Unsere ökonometrische Analyse auf der Basis eines verallgemeinerten linearen gemischten Modells und einer Instrumentenschätzung zeigt, dass insbesondere Innovationen und Agglomerationseffekte das Beschäftigungswachstum in Umweltschutzbetrieben fördern. Betriebe ohne Umweltprodukte oder –dienstleistungen weisen dagegen ein geringeres Beschäftigungswachstum auf, selbst wenn es sich um innovative Betriebe handelt.

JEL classification: J23, Q52, Q55, R23

Keywords: Employment growth, environmental goods and services sector, green jobs, labor demand, innovation, eco-innovation, industrial agglomeration

1 Introduction

The environmental goods and services sector (EGSS) is supposed to yield a dual societal benefit. First, its goods and services help to tackle today's global challenges of climate change and environmental pollution. Second, the EGSS may create new jobs and could thus help to improve economic well-being. Because of these potential environmental and employment benefits, the EGSS has received a great deal of political attention in recent years and has become an essential element of many green economy approaches (Allen/Clouth 2012; OECD/cedefop 2014; United Nations Environmental Programme 2011). However, depending strongly on regulation and subsidies, the societal benefit of the EGSS – particularly in terms of employment - is an ongoing matter of discussion. Whereas green products and services are often seen as a driving force for employment growth, there are also claims that many private and public investments in these areas are inefficient, impair productivity and lead to employment decline.

In Germany, approximately two million people are employed in the EGSS (Edler/Blazejczak 2014; Federal Environmental Agency 2014) but this figure does not indicate whether the EGSS exhibits more dynamic employment growth compared to other sectors of the economy. Furthermore, the determinants of employment growth in the environmental sector have not been examined in detail to date.

This paper analyzes labor demand in the environmental sector empirically and compares it to other sectors of the German economy. Our research questions are as follows: (1) Do labor demand and employment growth differ between EGSS establishments and establishments that do not produce environmental goods or services? (2) Which determinants of labor demand foster employment growth and which determinants hinder it in the EGSS?

In addition to analyzing standard factors of a labor demand function, such as product demand, wages or export orientation, we also focus on the role of innovation and agglomeration forces for employment growth in the environmental sector compared to the German economy as a whole. As the environmental sector is not homogeneous, our econometric estimations take differences between environmental technology fields into account. Relatively new environmental technology fields such as renewable energies may be more dynamic compared to already established fields, e.g. filter systems to reduce air or water pollution. Furthermore, we consider barriers to employment growth: high competitive pressure may force firms to lower labor costs, or collective wage agreements accompanied by higher labor costs may decrease labor demand.

For our empirical analysis we combine three data bases: the IAB Establishment Panel, the Establishment History Panel, and statistical data of the Federal Employment Agency (Bundesagentur für Arbeit) at NUTS 3 level to capture the role of agglomeration forces. We estimate different regression models to analyze the development of employment in the EGSS compared to the rest of the economy. The data

bases permit analyses of the short-term (from 2009 to 2012) and the long-term (from 2002 to 2012) development of employment.

The paper is organized as follows: Section 2 contains a detailed definition of the EGSS (2.1) and summarizes the determinants of labor demand from a theoretical perspective (2.2). The data basis is presented in Section 3.1 followed by a descriptive analysis in Section 3.2. The results of different econometric estimations of our labor demand function are shown in Section 3.3. Section 4 concludes.

2 Employment development in the environmental sector: theoretical background and hypotheses

2.1 The environmental goods and services sector

Generally speaking, the environmental goods and services sector (EGSS) deals with the supply side of environmental protection and resource management activities. Whereas the national measurements of these activities are still heterogeneous, the international discussion concerning environmental-economic accounting, the measurement of green economy indicators and the approaches to create a statistical definition of green jobs have led to some acknowledged working definitions:

The System of Environmental-Economic Accounting (SEEA, United Nations 2014) defines the EGSS as follows:

'The EGSS consists of producers of all environmental goods and services. Thus, all products that are produced, designed and manufactured for purposes of environmental protection and resource management are within scope of the EGSS.' (United Nations 2014: 111).

The SEEA distinguishes between the following four types of environmental goods and services (United Nations 2014): environmental specific services (e.g. waste and waste water management and treatment services; energy- and water-saving activities), environmental sole-purpose products and services (e.g. catalytic converters, the installation of renewable energy production technologies), adapted goods (e.g. cars with lower air emissions, recycled paper), and environmental technologies: *end-of-pipe technologies*, e.g. air pollution filters (Eurostat 2009: 10); *cleaner/integrated technologies*, e.g. technical processes to avoid air pollution (Eurostat 2009: 12). There are considerable differences between end-of-pipe technologies and integrated technologies. Whereas end-of-pipe technologies are mostly regulation-driven, cleaner technologies are often more market-driven (e.g. as a source of cost savings) and triggered by general or environmental management systems (Frondel/Horbach/Rennings 2007).

In terms of data collection and the organization of data, the SEEA refers to Eurostat's data collection handbook, which provides a more precise definition:

'The environmental goods and services sector consists of a heterogeneous set of producers of technologies, goods and services that:

- *Measure, control, restore, prevent, treat, minimize, research and sensitise environmental damages to air, water and soil as well as problems related to waste, noise, biodiversity and landscapes. This includes 'cleaner' technologies, goods and services that prevent or minimise pollution.*

- *Measure, control, restore, prevent, minimise, research and sensitise resource depletion. This results mainly in resource-efficient technologies, goods and services that minimise the use of natural resources.*

These technologies and products (i.e. goods and services) must satisfy the end purpose criterion, i.e. they must have an environmental protection or resource management purpose […] as their prime objective.' (Eurostat 2009: 29)

Based on the SEEA definition of environmental goods and services, the International Labour Organization (ILO) emphasizes in their definition of *employment in environmental activities* the difference between employment in the production of environmental outputs and employment in environmental processes (ILO 2013a, 2013b, 2013c). Furthermore, the ILO introduces a tighter definition of *green jobs* by adding a *decent work dimension* to the *environmental dimension* (ILO 2012, 2013a, 2013b, 2013c). In the sense of the ILO definition, green jobs include only employment in environmental activities that fulfill the conditions of decent work[1].

At national level, another relevant definition of green jobs was developed by the Bureau of Labor Statistics of the U.S. Department of Labor (BLS). Their definition also involves the basic distinction between output and process. Whereas the output-related approach covers the *green goods and services*, the process approach *'… identifies establishments that use environmentally friendly production processes and practices …'* (Sommers 2013: 5).

As we will show below (Section 3.1), our analysis only captures the *environmental dimension* of the ILO definition. And within this dimension, we focus solely on employment in the production of environmental outputs. In other words, this paper focuses on the output approach in the sense of green jobs as defined by the BLS. Therefore, we do not deliver any conclusions for green jobs on the whole in this paper, but for employment in the EGSS, or, more precisely, for employment in the production of environmental outputs.

However – even using a standard EGSS definition – the problem still remains of where exactly the line should be drawn between EGSS and non-EGSS establishments. For example, many establishments do not produce or deliver only environmental goods and services. They often follow a multi-purpose strategy (e.g. technical facilities like pumps that can be applied both in biogas plants and in coal-fired power plants). It is also difficult to identify the EGSS share of employment, as many employees are not only engaged in EGSS-related tasks but also perform work for

[1] Decent work indicators according to the ILO; see ILO 2012.

non-environmental goods and services (in the case of multi-purpose firms). Moreover, the environmental impact of products and services may differ. There is a huge difference between the climate impact of a zero-emission e-car and a large SUV with a hybrid drive but still high fuel consumption. Nevertheless, both help to reduce air pollution and thus are regarded as environmental goods and services. To tackle some of these challenges, Eurostat (2009) published a data collection handbook for the EGSS, which contains some recommendations that we also used in our empirical work (see also Section 3.1).

2.2 Determinants of employment development

The notions of employment growth and employment dynamics are used differently in the literature. According to many authors (e.g. Carlsson/Eriksson/Gottfries 2013; Dauth 2013; Hyatt/Spletzer 2013; Konigsberg/Spletzer/Talan 2009), employment dynamics are seen as the growth or decline of employment between two dates, which corresponds to the concept of employment growth. Other authors (e.g. Bauer/Bender/Bonin 2007; Hamermesh/Hassink/Ours 1996; Kölling 2012) define employment dynamics in the sense of labor turnover or worker flows. In the paper in hand, we use the notion of employment growth as the increase or decline of employment between two dates or as *standard employment change* as defined by Hamermesh/Hassink/Ours (1996) in their *taxonomy of employment dynamics:* the standard employment (E) change measures the difference between the number of jobs available at the end of the period (J_{t+1}) and the jobs available at the beginning of the measurement period (J_t). For our estimations we use the growth rate of employment:

$$\frac{\dot{E}}{E} = \frac{J_{t+1} - J_t}{J_t} * 100\%$$

Our theoretical framework departs from the standard literature on labor demand (e.g. Hamermesh 1993) and human capital (Becker 1994; Lazear/Shaw 2007): the simple neo-classical labor demand function shows that the demand for labor depends on the development of real wages. The 'normal' case describes a situation where higher real wages lead to a reduction of labor demand. But the relationship is more complicated: successful firms (which are characterized by positive employment growth) are also more likely to pay higher wages. In econometric analyses, this causes endogeneity problems that have to be considered. For an empirical analysis, the concentration on wages is far too simple because a lot of other factors affect labor demand: According to Hamermesh (1993), the product market, or more specifically product demand, influences labor demand significantly. Ross/Zimmermann confirm these findings: *'Changes in labor demand seem primarily caused by exogenous changes of demand, whereas technological advance and labor costs place second and third.'* (Ross/Zimmermann 1993: 83). In addition, high productivity plays a key role in determining labor demand because it helps to improve a firm's (international) competitiveness, thereby leading to increased product demand.

Further labor demand factors are binding wage agreements, union membership (Dittrich/Schirwitz 2011), labor shortage (Horbach 2014a) as barriers to employment development, skills (Addisonet al. 2008), firm size (Kölling 2012), occupations and sectors of industry (Cörvers/Dupuy 2010). Finally, conditions of the establishment's organizational environment may also influence labor demand: regional effects (Fuchs/Weyh 2010; Fuchs 2011), regulation (Beise/Rennings 2005; David/Sinclair-Desgagné 2005), economic development activities (e.g. Kölling 2014), external shocks (e.g. economic crisis, see Bohachova/Boockmann/Buch 2011), industry structure (Cörvers/Dupuy 2010; Dauth/Suedekum 2014) and changes in factor markets (e.g. energy prices, see Hamermesh 1980).

Many recent studies have described innovation as major labor demand factor (e.g. Buerger/Broekel/Coad 2012; Capello/Lenzi 2011). The Oslo Manual (OECD/Eurostat 2005:46) defines innovation as: *'… the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organisation or external relations.'* and differentiates between four types of innovation: product innovations, process innovations, marketing innovations and organizational innovations.

Besides these standard types of innovation, the notion of eco-innovation has emerged in recent years. Kemp/Pearson (2008) define eco-innovation as follows:

'Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is ***novel to the organisation*** *(developing or adopting it) and which* ***results****, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use)* ***compared to relevant alternatives****.'* (Kemp/Pearson 2008: 7, the emphases are taken from the original).

Horbach (2008) identifies four main determinants of eco-innovation: improvement of the technological capabilities by research and development, environmental regulation, environmental management tools and general organizational changes. Kesidou/Demirel (2012) tackle a similar issue for the UK. The authors divide their findings into two parts: first, one general motivation for eco-innovation is to meet general expectations of the firm's stakeholders. However, this motivation does not influence the amount of investment in eco-innovation. The increased investments are stimulated by cost savings, organizational capabilities, and more ambitious regulations (Kesidou/Demirel 2012). Thus, eco-innovation and organizational performance are strongly related to environmental regulation.

According to the Porter hypothesis (Porter/van der Linde 1995), environmental regulation may result in better firm performance. Regulation may be accompanied by material and energy savings (*resource productivity*), which could in turn boost competitiveness. Consequently, the additional production costs due to regulation-triggered activities could be overcompensated. In the context of EGSS, eco-innovations seem to show a particular positive employment impact (Horbach 2010,

Horbach/Rennings 2013, Licht/Peters 2013, Licht/Peters 2014). Horbach/Rennings (2013) found that innovative firms have far more dynamic employment development than firms that do not innovate, i.e. implementing (eco-)innovations leads to workforce growth at the firm level. However, not every kind of eco-innovation has the same impact on employment: *'… the introduction of cleaner technologies as process innovations leads to a higher employment within the firm. The theoretical background of this finding is that cost savings induced by this type of process innovation improve the competitiveness of firms. … On the other side, air and water process innovations that are still dominated by end-of-pipe technologies have a negative impact on employment. … '* (Horbach/Rennings 2013: 158). According to the authors, particularly process-integrated resource- and energy-saving measures improve a firm's profitability and competitiveness, which may lead to an increase in the number of employees. On the other hand, innovations in the prevention of air and water pollution have only a small positive effect on workforce size. In the latter case, Horbach/Rennings (2013) regard the large share of end-of-pipe technologies in this field as consequence of regulation without further motivation to improve competitiveness.

The positive role of eco-innovation for the development of employment may be reinforced by the existence of agglomeration effects. Agglomeration in the sense of the *New Economic Geography* (e.g. Krugman 1998; Puga 2010) describes mainly the magnitude, causes and consequences of firms located close to each other. According to Duranton/Puga (2004), the causes of agglomeration are a more efficient sharing of the local infrastructure, a better matching between market partners – e.g. between employers and workers – and a better environment for inter-organizational learning. The latter includes the prerequisites for knowledge spillovers. The literature on spillovers (see e.g. Audretsch/Feldman 2004; Feldman 1999; Kaiser 2002) is closely related to innovation and agglomeration. Since knowledge is strongly linked to workers, innovation intensity increases when workers share their knowledge across firms. Although modern information and computer technology makes it possible to collaborate easily across large distances, physical proximity to those network partners is helpful for knowledge spillovers especially for so-called tacit knowledge, which requires face-to-face contacts (Horbach/Oltra/Belin 2013).

Agglomeration economies have been identified across a large range of different fields, including the US carpet production industry in the Georgian city of Dalton (Krugman 1991) and composers of classical music (Borowiecki 2013).

Agglomeration is recognized as a further important factor concerning labor demand (e.g. Alyan 1999; Morrison/Papps/Poot 2006; Mulligan/Reid/Moore 2014; Reggianiet al. 2011). However, there are only few articles available concerning the relationship between agglomeration and the EGSS or eco-innovation. Sensieret al. (2013) show that connections to local governments have positive impacts on the growth of small and medium-sized EGSS companies. On the other hand, the growth of these firms benefits from international networks with companies and universities outside the local region. The authors conclude that EGSS companies should be both locally and

globally oriented in order to be most successful. Horbach (2014b) provides further insights regarding regional determinants of eco-innovations: *'[…] external knowledge sources such as the regional proximity to research centers and universities are more important for eco-innovations compared to other innovations. Eco-innovations seem to be a chance for under-developed, 'disadvantaged' regions because regions characterized by high poverty rates are more eco-innovative.'* (Horbach 2014b: 34-35).

All in all, our theoretical considerations show the important role of high product demand, wages, innovation activities, agglomeration forces, competitive pressure and wage agreements for the development of a firm's employment. The empirical questions of whether EGSS establishments exhibit higher employment growth compared to other firms and what factors are crucial for such a development are yet to be answered (see Section 3).

3 Empirical analysis of employment growth in the environmental sector

3.1 Data

Our empirical analysis combines data from four sources in order to analyze the determinants of employment development: the IAB Establishment Panel survey, the Establishment History Panel (Betriebs-Historik-Panel – BHP), the IAB Employment History (Beschäftigtenhistorik – BEH) and regional employment statistics data at NUTS 3 level *(Landkreise* and *kreisfreie Städte*).

The Establishment Panel of the Institute for Employment Research (IAB) was set up in 1993 to obtain a representative picture of German establishments that have at least one employee subject to social security. The annual survey is characterized by very high response rates of more than 70 percent and covers over 15,000 German establishments[2]. It contains both a standard yearly program of questions and additional questions on special topics of current interest. As one of those specific topics, EGSS-specific questions were asked in the 1999, 2005 and 2012 waves. Those questions made it possible to identify and analyze EGSS establishments, their employment development and other organizational characteristics. Furthermore, the establishments are asked to report their share of turnover in the field of environmental goods and services. The answers to this question make it possible to calculate the share of EGSS-related employees, especially for firms producing multi-purpose goods or other products besides EGSS products.

15.4 percent (2,352 firms) of all the firms in the sample of the 2012 wave declared that they produce or deliver environmental goods and services. Similar filter ques-

[2] This study uses the IAB Establishment Panel waves of 2012, 2011, 2009, 2005 and 1999. Data access was provided by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB). For detailed data documentation see Ellguth/Kohaut/Möller (2014) and Fischeret al. (2009).

tions were introduced in 1999 and 2005. However, we cannot use the 1999 and 2005 waves for the econometric analyses, because the EGSS questions were changed between 2005 and 2012. Products associated with renewable energies and nature conservation were mentioned explicitly only in 2012. Because of these changes, comparisons of the results of 1999/2005 with those of 2012 are limited. A further restraint is due to panel mortality. Owing to the fact that too few of the EGSS establishments surveyed in 2012 were included in the previous waves, there are strong limitations when following the EGSS establishments surveyed in 2012 within the longitudinal set of the survey panel data. It is therefore not possible to conduct an econometric analysis of employment dynamics based on differences between 1999/2005 and 2012. Nevertheless, we report the descriptive results of the 1999, 2005 and 2012 waves by different environmental technology fields in section 3.2. The use of further waves (here: 2009 and 2011) of the Establishment Panel permits the inclusion of lagged independent variables to reduce endogeneity problems.

For the econometric analysis the question on the environmental goods and services in the 2012 wave is used to identify the firms belonging to the EGSS. Combining the 2009 and 2012 waves then enables us to calculate the development of employment in the environmental sector from 2009 to 2012. The limitation of this procedure is that it is not known whether a firm already offered environmental goods and services before 2012 because the filter question is only available for 2012. Therefore it may occur that the employment development of firms that did not offer environmental products or services in 2009 is analyzed.

Facing the limitations concerning EGSS panel data from the Establishment Panel, we merged the survey data with data from the German Establishment History Panel (BHP)[3] [4] in order to form an appropriate panel data set for our project. The BHP contains longitudinal data at establishment level that is obtained from mandatory employer notifications to the German social security system, which leads to highly accurate and reliable data. It covers all employees liable for social security contributions and those in marginal part-time employment. Consequently, all German establishments are included in the annual BHP data set, if they register at least one dependent employee as of the reference date of June 30. The BHP provides data about establishments' workforces, wage distributions, sectors and locations. The information about the workforce is available as total numbers and is also differentiated by gender, age, occupational status, qualification-level and nationality. It also includes quantiles of age groups and wages (for all employees and for full-time em-

[3] This study uses the Establishment History Panel (BHP) version 7510 (here: years 1993-2010). Data access was provided by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB). For detailed data documentation see Gruhl/Schmucker/Seth (2012).

[4] We would like to thank the data management team of the IAB department 'IT Services and Information Management' for their kind help; special thanks go to Ali Athmani, Steffen Kaimer, Jonas Krüger and Cerstin Rauscher.

ployees only). Regarding our econometric analysis, we used the BHP data for an analysis of the long-term development of employment from 2002 to 2012.

After merging the data sets of the Establishment Panel data, the BHP and the regional data at NUTS 3 level, our data file contains data on 15,544 establishments that participated in the 2012 Establishment Panel survey and could be identified within the administrative data of the BHP data. Our analysis of firm-level panel data gives us the opportunity to isolate the effects of different labor demand factors. Therefore, we can analyze those factors at firm and industry level as well as at regional level and over time. The following section provides an overview of the descriptive results based on this linked project data set.

3.2 Descriptive analysis

In 2012 the German environmental sector employed 1.47 million persons (Table 1). The largest share of these EGSS employees – almost two thirds – works in connection with the provision of services, while about one third works in the production of goods.

Table 1
Employment in the EGSS 2012 – number of employees

EGSS goods/services	Employees 2012	
	Number	Share
Environmental goods	520,516	35.5%
Environmental services	945,165	64.5%
Total	1,465,682	100.0%

Source: IAB Establishment Panel 2012, own calculations, projected results.

Table 2 shows the development of the employment shares between the panel waves of 1999, 2005 and 2012. Since the EGSS is a very heterogeneous sector, it is necessary to distinguish between different subfields within this sector. In 2012, the question on the composition of the different environmental fields was changed significantly such that the results obtained in 1999/2005 are not fully comparable with those obtained in 2012. The results document the considerable importance of the EGSS subfield of *climate protection and renewable energies* (2012: 35.6 percent) for employment whereas the shares of subfields such as water or recycling decreased (e.g. recycling from 29.8 percent in 2005 to 19.0 percent in 2012).

Table 2
Employment in the environmental sector by different EGSS subfields

EGSS subfield	Distribution of employment in %		
	1999	2005	2012
Prevention of water pollution, waste water treatment	18.9	13.0	12.3
Waste management, recycling	27.4	29.8	19.0
Air purification, climate protection	16.3	22.1	-
Air purification	-	-	3.8
Climate protection, renewable energies, energy saving	-	-	35.2
Noise abatement	2.3	2.1	4.5
Environmental remediation, soil conservation	3.7	5.4	1.6
Nature conservation, landscape management	-	-	9.7
Measurement, analysis and control technology	6.6	6.5	3.9
Analytics, consultancy, project planning	4.7	5.4	2.9
Environmental research, development and monitoring	1.5	4.7	2.0
Other environmental fields	18.6	11.0	5.1
Total	100	100	100

Source: IAB Establishment Panel 2012, Horbach/Blien/Hauff (2009), own calculations, projected results.

In a further step, we analyze the employment growth from 2009 to 2012. For this reason, we have to identify EGSS establishments based on questions from one wave of the IAB Establishment Panel. This enables us to trace these establishments in previous panel waves – if they had participated in those waves. We use the questions asked in 2012 to identify the firms in the environmental sector, as the filter questions in 2012 are not comparable to those asked in 2005 and 1999. Furthermore, it has to be borne in mind that firms may be incorrectly assigned to the environmental sector for the period from 2009 to 2011 if they had not yet provided environmental goods and services prior to 2012. Employment development denotes the growth rate of the total number of employees between 2009 and 2012.

Table 3 shows the employment growth from 2009 to 2012 by different EGSS subfields compared to non-EGSS establishments. Overall, employment growth is slightly higher in the EGSS as a whole (4.7 percent) compared to non-EGSS establishments (4.2 percent). Within the EGSS, pronounced differences between EGSS subfields are visible. The subfield of *environmental remediation, soil conservation* shows the highest value (16.8 percent), whereas *waste management, recycling* has the lowest value (0.6 percent). *Climate protection, renewable energies, energy saving*, the subfield with the largest employment share, grew by 6.2 percent, which is stronger than the EGSS average (4.7 percent).

Table 3
Employment growth from 2009 to 2012 by different EGSS subfields compared to non-EGSS establishments

EGSS subfield	Employment growth 2009 – 2012 in %
Prevention of water pollution, waste water treatment	2.7
Waste management, recycling	0.6
Air purification	12.0
Climate protection, renewable energies, energy saving	6.2
Noise abatement	6.1
Environmental remediation, soil conservation	16.8
Nature conservation, landscape management	1.2
Measurement, analysis and control technology	9.5
Analytics, consultancy, project planning	16.3
Environmental research, development and monitoring	14.0
Other environmental fields	11.7
EGSS establishments in total	4.7
Other establishments	4.2

Source: IAB Establishment Panel 2012, own calculations, projected results.

In the light of this employment growth, we want to know what qualification level the EGSS establishments demand and how the establishments differ in terms of innovation.

Table 4 provides an overview of these two aspects. Again, we observe significant differences between EGSS subfields. Compared with the overall sample, most EGSS subfields have a larger share of employees with a university education and a smaller share of employees with no vocational training. This situation is reflected in the share of innovative establishments. In this case, all EGSS subfields show larger innovation shares than the overall sample. The subfields with the largest shares of innovative establishments (more than 50 percent) are *measurement, analysis and control technology*, *environmental research, development and monitoring, environmental remediation, soil conservation*, and *analytics, consultancy, project planning.* Among other things, the largest subfield, *climate protection, renewable energies, energy saving,* also has an above-average share of innovative establishments (44.7 percent).

Table 4
Qualification level of employees and innovativeness in the German environmental sector in 2011

EGSS subfield	Share of employees with …		Share of innovative establishments
	university education	no vocational training	
	in %	in %	in %
Prevention of water pollution, waste water treatment	13.4	17.4	49.3
Waste management, recycling	8.9	28.5	41.1
Air purification	8.6	21.3	37.8
Climate protection, renewable energies, energy saving	13.4	15.8	44.7
Noise abatement	13.1	26.2	49.3
Environmental remediation, soil conservation	9.5	15.9	58.5
Nature conservation, landscape management	12.8	22.8	32.2
Measurement, analysis and control technology	16.4	13.3	57.0
Analytics, consultancy, project planning	26.8	14.9	52.3
Environmental research, development and monitoring	38.4	13.8	50.5
Other environmental fields	12.1	23.3	54.2
All firms in the whole sample	9.9	24.2	31.2

Source: Horbach (2014a), IAB Establishment Panel 2012.

All in all, the EGSS accounts for a considerable share of employees and a large share of environmental services. The EGSS has grown more strongly than the sample average and most EGSS subfields have a larger share of employees with a university education and a smaller share of employees with no vocational training. Furthermore, all EGSS subfields show larger innovation shares than the overall sample. However, the EGSS is not homogeneous. In terms of both employment growth and other EGSS characteristics there are pronounced differences between EGSS subfields.

3.3 Econometric analysis

Our econometric analysis aims at exploring the determinants of employment development in the environmental sector compared to the German economy as a whole. In a first step, we analyze the short-term development of employment from 2009 to 2012. Combining the Establishment Panel with the so-called Establishment History Panel enables us to observe the firms belonging to the EGSS for a longer time period from 2002 to 2012, so we also estimate such a long-term model. Furthermore, separate models are estimated for all firms including environmentally relevant explanatory variables and for the EGSS alone.

As the baseline estimation, we use an OLS model with clustered standard errors at NUTS 3 level, because variables at the establishment and the regional level are considered. Furthermore, we apply a two-level mixed-effects linear regression. The two models take into account the problem that the employment growth of firms within a region may be correlated. The mixed-effects model contains both random and fixed effects. We have to consider a two-level model for a series of 411 clusters (411 regional German NUTS 3 units). The model reads as follows (StataCorp 2013):

$$empdev_{ij} = \beta_0 + \beta_1 reg_{ij} + \beta_2 inno_{ij} + \beta_3 pdem_{ij} + \beta_4 wagedev_{ij} + \beta_5 \psi_{ij} + \mu_j + \varepsilon_{ij}$$

for j = 1; …; 395 clusters, with cluster j consisting of i = 1; …; n_j observations. The random effect u_j serves to shift the regression line up or down according to the NUTS 3 unit (StataCorp 2013). Because of the small numbers of cases in many regions, a random intercept model was estimated assuming fixed slopes. The log-likelihood function is approximated by Gauss-Hermite quadrature (Cameron/Trivedi 2009). Following the theoretical analysis in Section 2, we consider vectors of regional variables (reg_{ij}), innovation ($inno_{ij}$), indicators for product demand ($pdem_{ij}$), the development of wages ($wagedev_{ij}$) and further control variables ψ_{ij} such as export shares, state of technical equipment, firm size, firm age, competitive pressure, qualification structure, sector dummies and dummies for the German *Länder* (NUTS 1 units).

To reduce the problem of endogeneity regarding wages, we already lagged this variable by one period. In fact, this endogeneity problem may be minor because the possibilities for a single establishment to alter wages are restricted due to the pressure from national and international competitors. Therefore, wages are probably influenced more by developments in specific industries than by single establishments. Nevertheless, as a robustness check, we also estimate an instrumental variable regression to take into consideration the endogeneity of wages. The model reads as follows:

(1) $$empdev_i = \alpha_0 + \alpha_1 wagedev_i + \alpha_2 x_{1i} + u_i$$

(2) $$wagedev_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + v_i$$

The employment development ($empdev_i$) of firm i depends on wages ($wagedev_i$) and further exogenous variables x_{1i}. $Wagedev_i$ as an endogenous regressor is instrumented on the exogenous regressors in equation (1) and a vector of further exogenous regressors x_{2i}. The zero-mean error terms u_i and v_i are presumably correlated. We apply a GMM estimator.

As a further robustness check, we estimate a treatment effects model regarding the environmental innovation intensity as an exogenous treatment variable. This model helps to answer the question as to whether firms with intensive innovation in the environmental sector demonstrate better employment growth compared to the economy as a whole. The so-called propensity score matching estimator uses the treatment model to calculate the conditional probability that an observation receives

a specific treatment given certain covariates. The unknown potential output without treatment is estimated using an average of the outcomes of similar subjects (StataCorp 2013).

Description of variables

For our econometric analysis, we use the following variables (for a precise definition see Appendix 1). *Empdev0912* describes the growth rate of the number of employees from 2009 to 2012, empdev0212, the respective development from 2002 to 2012.

The dummy variables *ecoinnointens, waterinno, recycinno, airclimateinno* and *natureinno* are given the value one if the firm belongs to the respective environmental field and has implemented a product or process innovation in the previous year. *Otherinno* captures firms that are innovative but not active in the environmental sector. *Age* describes the age of the firm, the variable has the value one if the firm was founded after 1990, zero otherwise. The state of a firms' capital stock is indicated by *capitalnew*. The value one characterizes modern capital stock. The dummy variable c*ompetition* denotes high competitive pressure perceived by the firm. The share of employees with a university degree in the firm's entire workforce is captured by *highqual*. The value one for *profitsituation* denotes the firm having a very good or good self-perceived profit situation in 2011. Besides the profit situation, o*vertime* is a further proxy variable for high product demand. If a firm made use of overtime in 2011, this variable is given the value one. *Size* denotes the number of employees in 2012. Furthermore, dummies for the German *Länder* and sectors were included. *Invest* has the value one if the establishment made investments in 2011. We also include the variables *popdens* and *secshare* at NUTS 3 level. *Popdens* denotes the population density of the respective NUTS 3 unit; *secshare* captures the sector share of the sector to which the firm belongs in the respective NUTS 3 unit, thus signaling localization advantages (or disadvantages).

Table 5
Determinants of employment growth from 2009 to 2012

Dependent variable: Empdev0912 - Employment growth rate from 2009 to 2012, in %

Regressors	All firms			Only EGSS
	OLS (clustered standard errors)	Two-level mixed GLM	IV-regression (GMM)	Two-level mixed GLM
Innovations				
Ecoinnointens	7.15 (2.26)*	7.10 (2.40)*	7.64 (2.18)*	6.64 (1.91)+
Otherinno	3.05 (3.62)**	3.04 (3.06)**	2.43 (2.04)*	-
Airclimateinno	3.93 (1.55)	3.88 (1.52)	3.37 (1.10)	3.38 (1.10)
Natureinno	-5.96 (-1.66)+	-6.04 (-1.06)	-4.97 (-1.26)+	-4.72 (-0.78)
Recycinno	0.57 (0.20)	0.51 (0.15)	1.04 (0.33)	-0.91 (-0.23)
Waterinno	-0.93 (-0.37)	-0.96 (-0.22)	0.61 (0.18)	-1.67 (-0.35)
Regional var.				
Popdens	0.00 (2.17)*	0.00 (0.46)	0.00 (0.34)	0.00 (1.05)
Secshare	0.16 (2.70)**	0.16 (2.28)*	0.16 (2.32)*	0.58 (2.90)**
Control var.				
Age	4.60 (4.87)**	4.71 (4.97)**	3.50 (2.04)*	4.87 (1.94)*
Capitalnew	3.02 (3.55)**	3.03 (3.34)**	2.94 (2.93)**	3.79 (1.59)
Competition	-2.68 (-2.90)**	-2.72 (-3.06)**	-2.66 (-2.71)**	-3.93 (-1.71)+
Exportshare	-0.13 (-0.53)	-0.01 (-0.52)	-0.02 (-0.59)	0.05 (0.77)
Highqual	-0.03 (-1.08)	-0.03 (-0.98)	-0.01 (-0.33)	-0.09 (-1.40)
Overtime	5.88 (6.22)**	5.88 (6.34)**	6.06 (5.64)**	5.27 (2.00)*
Profitsituation	7.40 (8.83)**	7.40 (8.45)**	7.26 (7.16)**	6.47 (2.89)**
Size	-0.00 (-0.36)	-0.00 (-0.11)	-0.00 (-0.59)	-0.00 (-0.58)
Tariff	-1.13 (-1.31)	-1.11 (-1.19)	-	-2.57 (-1.09)
Wagedyn0911	-0.00 (-0.06)	-0.00 (-0.11)	0.24 (1.05)	-0.05 (-2.15)*
German Länder				
Baden	4.00 (2.32)*	5.04 (2.37)*	4.41 (1.63)+	9.15 (1.61)
Bavaria	4.22 (2.26)*	5.23 (2.42)*	4.87 (1.92)*	6.62 (1.20)
Berlin	-	3.06 (0.87)	2.85 (0.65)	-0.22 (-0.02)
Brandenburg	2.33 (1.28)	3.00 (1.42)	3.46 (1.41)	9.50 (1.68)+
Bremen	-	3.99 (1.54)	4.90 (1.55)	10.5 (1.56)+
Hamburg	-	4.29 (1.06)	6.03 (1.38)	10.3 (0.85)
Hesse	2.45 (1.28)	3.41 (1.44)	3.29 (1.21)	10.2 (1.68)+
Lowsax	4.95 (1.70)+	5.80 (2.60)**	4.89 (1.67)+	19.6 (3.55)**
Meckpom	1.08 (0.52)	1.79 (0.79)	2.34 (0.87)	11.2 (1.80)+
Northwestf	2.50 (1.74)+	3.64 (1.75)+	3.14 (1.21)	5.88 (1.10)
Rhineland	5.65 (2.87)**	6.55 (2.69)**	4.98 (1.40)	15.7 (2.42)*
Saarland	2.77 (0.82)	3.69 (1.42)	4.34 (1.45)	7.45 (1.16)
Saxony	2.51 (1.58)	3.34 (1.67)+	4.34 (1.90)+	7.20 (1.43)
Saxonyanh	0.94 (0.50)	1.69 (0.81)	1.86 (0.81)	12.7 (2.54)**
Schleswig	7.61 (2.58)*	8.57 (3.17)**	9.14 (2.81)**	14.3 (2.14)*
	No. obs.: 6677	No. obs.: 6677	No. obs.: 6677	No. obs.: 1035
	F (48, 394) = 8.72**	Wald $\chi2$ (50) = 297**	Wald $\chi2$ (49) = 232**	Wald $\chi2$ (49) = 84**

Z-statistics are given in parentheses; +, * and ** denote significance at the 10%, 5% and 1% level, respectively. Sector dummies and constants are included but not reported.

Results of the short-term model

The estimation results of a model for all the firms in the sample show that highly innovative environmental technology fields such as measurement, analytics, engineering or environmental research (*ecoinnointens*) are significantly positively correlated with the employment development from 2009 to 2012. For the other, also innovative environmental technology fields, no significant positive effects on the employment development are detected. Other, not environmentally related innovations (*otherinno*) also trigger employment growth but the coefficient is clearly smaller compared to innovation-intensive eco-innovations (Table 5).

Table 6
Eco-innovation and employment growth from 2009 to 2012 – results of a treatment effects model

Dependent variable: Empdev0912 - Employment growth rate from 2009 to 2012, in %	
Treatment variable	Propensity score matching
	The propensity score of each subject is estimated using the following probit model:
	$Ecoinnointens_i = \beta_0 + \beta_1 size_i + \beta_2 invest_i + \beta_3 highqual_i + \beta_4 age_i + \beta_5 secshare_i + \beta_6 westeast_i + \varepsilon_i$
	Average treatment effect:
Ecoinnointens	9.87 (2.37)*
	Number of observations: 10138

For the other eco-innovation fields there are no observable significant treatment effects, so they are not reported.

To check the robustness of this interesting result that eco-innovativeness is crucial for employment, we also estimated a treatment effects model (see Table 6). The analysis shows that *ecoinnointens* as a treatment variable is highly significant, which confirms the finding that specific innovative technology fields in the EGSS, such as measurement technologies, are associated with higher employment. On the other hand, this is not the case for "older" technology fields, such as water or air purification technologies. For these fields, corresponding treatment effect models were not significant, which confirms the results of our regression models in Table 5.

Firms profiting from localization effects measured by a strong presence of similar firms in the NUTS 3 unit (*secshare*) are characterized by disproportionately positive employment growth. This is also the case for high product demand measured by the proxies *profit situation* and *overtime* (see Table 5). Firms equipped with modern capital stock (*capitalnew*) also exhibit better employment growth. Furthermore, the employment growth of younger firms (*age*) seems to be more dynamic, whereas high competitive pressure (*competition)* seems to force firms to reduce their employment. In both models (two-level mixed GLM and the IV-regression) no significant influence of the wage development (*wagedyn0911*) on employment is observable. The German *Länder Baden*, *Bavaria*, *Lower Saxony* (*lowsax*), *Rhineland* and *Schleswig* show a more dynamic development compared to *Thuringia* as the base category.

Concerning our different estimation approaches, the two-level mixed GLM and the IV-regression show only marginal differences and are also very similar to our OLS estimates with clustered standard errors.

A separate estimation restricted to the sample containing only firms in the EGSS shows some interesting specificities of the determinants of employment growth in this sector. The importance of localization effects seems to be higher for the EGSS, the respective coefficient for the variable *secshare* is more than three times higher in the model restricted to the sample of EGSS firms compared to the model with all firms. Furthermore, the EGSS seems to provide employment opportunities in some eastern German *Länder*, especially for Saxony-Anhalt but also for Brandenburg and Mecklenburg-Vorpommern, which confirms the results of a recent analysis by Horbach (2014b).

Specificities of the long-term models (2002-2012)

Combining the Establishment Panel with the Establishment History Panel allows a long-term analysis of the employment growth in the EGSS compared to the economy as a whole from 2002 to 2012. The main shortcoming of such an analysis is that the filter question of whether a firm belongs to the EGSS is only available in 2012, so firms may be assigned to the EGSS although they did not produce environmental goods and services in 2002.

All in all, the long-term models (2002-2012) corroborate our findings presented above for the short-term period from 2009 to 2012 (see Table 7). The result that highly eco-innovative technology fields lead to higher employment effects compared to the overall economy is also confirmed for the long-term period. Interestingly, in contrast to the short-term analysis, innovative firms operating in the field of nature protection also showed disproportionately large positive employment growth compared to the economy as a whole. Concerning the results for the German *Länder* (NUTS 1 level), there are some differences between the two time periods. In the long-term model, the EGSS did not yet provide a disproportionately large number of employment opportunities for the eastern German *Länder* because – in contrast to the short-term model - the dummy variables for Saxony-Anhalt, Brandenburg and Mecklenburg-Vorpommern remain insignificant from 2002 to 2012.

Table 7
Determinants of employment growth from 2002 to 2012

Dependent variable: EmpDev0212 - Employment growth rate from 2002 to 2012, in %		
Regressors	**All firms**	**Only EGSS**
	Two-level mixed GLM	**Two-level mixed GLM**
Innovations		
Ecoinnointens	13.91 (2.8)**	12.66 (2.18)*
Otherinno	4.19 (2.4)*	N/A
Airclimateinno	4.13 (0.99)	3.33 (0.67)
Natureinno	34.29 (3.3)**	38.36 (3.53)**
Recycinno	3.96 (0.72)	1.77 (0.29)
Waterinno	11.46 (1.59)	10.09 (1.31)
Regional variables		
Popdens	0 (0.74)	0 (-1.01)
Secshare	0.42 (3.43)**	0.34 (1.1)
Control variables		
Firm age	-1.29 (-11.9)**	-1.1 (-3.67)**
Capitalnew	9.22 (5.55)**	10.62 (2.69)*
Competition	-4.39 (-2.77)**	-4.43 (-1.07)
Exportshare	0.07 (1.69)+	0.17 (1.63)
Highqual	-0.2 (-3.1)**	-0.04 (-0.24)
Overtime	12.49 (6.99)**	15.48 (2.98)**
Profitsituation	13.02 (8.25)**	3.92 (0.98)
Size	0 (0.47)	0 (-1.39)
Tariff	-9.14 (-5.55)**	-12.53 (-2.79)*
Wagedev0111	0.02 (1.37)	0.04 (0.35)
German Länder		
Baden	18.04 (4.32)**	13.75 (1.39)
Bavaria	19.69 (4.75)**	7.01 (0.72)
Berlin	5.27 (0.79)	20.34 (1.25)
Brandenburg	-0.6 (-0.14)	-5.66 (-0.53)
Bremen	12.25 (2.56)*	13.49 (1.16)
Hamburg	26.5 (3.73)**	26.61 (1.45)
Hesse	16.04 (3.7)**	12.08 (1.17)
Lowsax	1.94 (0.46)**	16.24 (1.62)
Meckpom	21.15 (4.98)	-4.13 (-0.39)
Northwestf	23.07 (5.76)**	13.62 (1.5)
Rhineland	22.34 (4.81)**	14.6 (1.36)
Saarland	22.64 (5.13)**	21.79 (2.16)*
Saxony	5.93 (1.53)	-0.07 (-0.01)
Saxonyanh	0.08 (0.02)	-0.66 (-0.07)
Schleswig	24.11 (5.51)**	22.31 (2.22)*
	No. obs.: 5817	No. obs.: 1018
	Wald $\chi2$ (50) = 600.43	Wald $\chi2$ (49) = 131.87

Z-statistics are given in parentheses; +, * and ** denote significance at the 10%, 5% and 1% level, respectively. Sector dummies and constants are included but not reported.

4 Summary and conclusions

This paper provides an empirical analysis of labor demand in the environmental sector compared to other sectors of the German economy. Our research questions were: (1) Do labor demand and employment growth differ between EGSS establishments and establishments that do not produce environmental goods or services? (2) Which determinants of labor demand foster employment growth and which determinants hinder it in the EGSS?

For our empirical analysis we combined three data bases: the Establishment History Panel, the IAB Establishment Panel and regional data at NUTS 3 level (*Landkreise* and *kreisfreie Städte*). The main data source was the IAB Establishment Panel containing a detailed question on the environmental sector in 2012. The environmental sector comprises goods and services which prevent environmental damage in different fields such as air or water pollution. 15.4% (2,352 firms) of all the firms in the 2012 wave of the sample reported that they belonged to the environmental sector. Similar filter questions were introduced in 1999 and 2005, but unfortunately, the panel mortality due to the long time lags did not allow an econometric analysis of employment dynamics based on these questions. The question on environmental goods and services in the 2012 wave was used to identify the firms belonging to the environmental sector. Combining the 2009 and 2012 waves then made it possible to calculate the employment development in the environmental sector from 2009 to 2012. To ensure that the employment growth of almost all the firms of the 2012 wave was taken into consideration, we used the Establishment History Panel for the employment figures. The use of further waves of the Establishment Panel enabled us to include lagged independent variables to avoid endogeneity problems. To capture the role of agglomeration forces, we combined our two datasets with official data at NUTS 3 level.

For the estimation of a labor demand function the following drivers were considered: a proxy for product demand as one of the main drivers of labor demand; export shares to take into account the fact that the growth of international trade may boost employment in export-oriented firms and innovation activities. Furthermore, we analyzed the influence of wages on labor demand using lagged values for the wage growth rate. As the environmental sector is not homogeneous, the estimations took into account differences between environmental technology fields. We also explored the question of whether regional agglomeration forces foster employment growth in the environmental sector compared to the German economy as a whole. Barriers to employment growth, such as high competitive pressure and collective wage agreements were also analyzed.

We estimated different regression models to analyze the employment dynamics of the environmental sector compared to the rest of the economy. A general model including all firms in the sample shows that highly innovative environmental technology fields such as measurement, analytics, engineering or research show a significantly positive employment development from 2009 to 2012 compared to all other

firms in the sample. Other innovations also boost employment but the coefficient is lower compared to innovation-intensive eco-innovations. The environmental technology field of nature conservation and landscape management shows a negative employment development.

A regression restricted to environmental firms shows that agglomeration effects seem to be quantitatively more important for EGSS firms. Furthermore, the EGSS appears to provide employment opportunities for eastern German *Länder* – a reinforcement of positive localization effects in these regions may be advantageous.

A good profit situation as a proxy for demand is positively correlated with employment. As expected, high competitive pressure is negatively correlated with employment growth whereas the existence of positive agglomeration effects boosts employment significantly. Young firms exhibit more dynamic employment growth.

As a robustness check, we also estimated a treatment effects model to explore the employment growth of environmental firms compared to the economy as a whole. This model largely confirms the results of the regression analysis. Highly innovative firms in the environmental sector are characterized by more dynamic employment growth.

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Appendix

Table A-1
Descriptive statistics and definitions of the variables

Variables	Description	Mean	St. Dev.
Endogenous variables			
Empdev0912	Growth rate of number of employees from 2009 to 2012	6.69	36.26
Empdev0212	Growth rate of number of employees from 2002 to 2012	14.38	60.96
NUTS 3 level			
Popdens	Population density	753.81	1007.01
Secshare	Share of a firm's sector in the NUTS 3 unit	11.81	9.48
Innovation variables			
	Innovative firms (at least one innovation in 2011) in the environmental fields (1 yes, 0 no):		
Ecoinnointens	Measurement, analytics, project, research, noise, soil, other	0.02	0.14
Airclimateinno	Air, climate technologies, renewable energy, energy saving	0.03	0.17
Natureinno	Protection of nature, landscape management	0.01	0.07
Recycinno	Waste disposal, recycling	0.01	0.12
Waterinno	Water pollution, waste water treatment	0.01	0.09
Otherinno	Other innovative firms (at least one innovation in 2011) (1 yes, 0 no)	0.32	0.47
Control variables			
Age	Foundation of the firm after (1) or before 1990 (0)	0.58	0.49
Competition	High competitive pressure (1), little or no competitive p. (0)	0.34	0.47
Export	Export share of turnover (as %)	6.60	17.75
Invest	Investments carried out in 2011 (1 yes, 0 no)	0.65	0.48
Overtime	Overtime in 2011 (1 yes, 0 no)	0.63	0.48
Profitsituation	Good or very good profit situation in 2011 (1 yes, 0 other)	0.41	0.49
Size	Number of employees	136.23	867.46
Tariff	Existence of a wage agreement (1 yes, 0 no)	0.42	0.49
Wagedyn0911	Growth of wages per employee from 2009 to 2011	12.11	63.92
Wagedyn0111	Growth of wages per employee from 2001 to 2011	18.24	46.22
WestEast	Located in western Germany (1) or eastern Germany (0)	0.61	0.49
Technological capabilities			
Capstocknew	State-of-the-art capital stock (1), older capital stock (0)	0.65	0.48
Highqual	Share of employees with university degree (as %)	9.87	19.28
Sector dummies	*1 yes, 0 no (for all sector dummies)*		
Sec1	Agriculture, forestry and fishery	0.02	0.15
Sec2	Mining, quarrying of stones, energy supply	0.02	0.14
Sec3	Food products, beverages and tobacco	0.02	0.15
Sec4	Textiles, leather	0.01	0.10
Sec5	Wood, paper, printing	0.02	0.14
Sec6	Chemical industry, rubber and plastics, glass	0.04	0.19

Sec7	Basic metals and fabricated metals	0.05	0.21
Sec8	Electrical machinery and apparatus	0.02	0.14
Sec9	Machinery	0.04	0.19
Sec10	Motor vehicles and other transport equipment	0.01	0.12
Sec11	Furniture and other products	0.02	0.13
Sec12	Construction sector	0.08	0.27
Sec13	Wholesale and retail trade	0.15	0.35
Sec14	Transport and logistics	0.04	0.19
Sec15	Information and communication	0.02	0.14
Sec16	Services: banking sector, insurance etc.	0.17	0.38
Sec17	Architectural and engineering offices	0.03	0.16
Sec18	Public sector and other services	0.25	0.43
German Länder	*1 yes, 0 other Land*		
Baden	Baden-Wuerttemberg	0.07	0.26
Bavaria	Bavaria	0.08	0.27
Berlin	Berlin	0.05	0.22
Brandenburg	Brandenburg	0.07	0.25
Bremen	Bremen	0.06	0.23
Hamburg	Hamburg	0.02	0.12
Hesse	Hesse	0.06	0.24
Lowsax	Lower Saxony	0.07	0.25
Meckpom	Mecklenburg-Western Pomerania	0.07	0.25
Northwestf	North Rhine-Westphalia	0.10	0.30
Rhineland	Rhineland-Palatinate	0.05	0.23
Saarland	Saarland	0.04	0.20
Saxony	Saxony	0.07	0.26
Saxonyanh	Saxony-Anhalt	0.07	0.25
Schleswig	Schleswig-Holstein	0.05	0.23
Thuringia	Thuringia	0.07	0.25

Source: IAB Establishment Panel 2012, own calculations.

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Editorial address
Institute for Employment Research
of the Federal Employment Agency
Regensburger Str. 104
D-90478 Nuremberg

Editorial staff
Regina Stoll, Jutta Palm-Nowak

Technical completion
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For further inquiries contact the author:

Jens Horbach
E-mail jens.horbach@hs-augsburg.de

Markus Janser
Phone +49.911.179 5816
E-mail markus.janser@iab.de