IAW DISCUSSION PAPERS

iaw@iaw.edu | www.iaw.edu

IAW Diskussionspapiere | Nr. 93 Januar 2013 | No. 93 January 2013

Outsourcing Potentials and International Tradability of Jobs

Evidence from German Micro-Level Data

Tobias Brändle
Andreas Koch

Institut für Angewandte Wirtschaftsforschung e.V.
Ob dem Himmelreich 1 | 72074 Tübingen | Germany
Tel.: +49 7071 98960 | Fax: +49 7071 989699

ISSN: 1617-5654

IAW-Diskussionspapiere

Das Institut für Angewandte Wirtschaftsforschung (IAW) Tübingen ist ein unabhängiges außeruniversitäres Forschungsinstitut, das am 17. Juli 1957 auf Initiative von Professor Dr. Hans Peter gegründet wurde. Es hat die Aufgabe, Forschungsergebnisse aus dem Gebiet der Wirtschafts- und Sozialwissenschaften auf Fragen der Wirtschaft anzuwenden. Die Tätigkeit des Instituts konzentriert sich auf empirische Wirtschaftsforschung und Politikberatung.

Dieses IAW-Diskussionspapier können Sie auch von unserer IAW-Homepage als pdf-Datei herunterladen:

http://www.iaw.edu/Publikationen/IAW-Diskussionspapiere

ISSN 1617-5654

Weitere Publikationen des IAW:

- IAW-News (erscheinen 4x jährlich)
- IAW-Forschungsberichte

Möchten Sie regelmäßig eine unserer Publikationen erhalten, dann wenden Sie sich bitte an uns:

IAW Tübingen, Ob dem Himmelreich 1, 72074 Tübingen,
Telefon 07071 / 98 96-0
Fax 07071 / 98 96-99
E-Mail: iaw@iaw.edu

Aktuelle Informationen finden Sie auch im Internet unter:

http://www.iaw.edu

Outsourcing Potentials and International Tradability of Jobs

Evidence from German Micro-Level Data[1]

Tobias Brändle[2] and Andreas Koch[3]

IAW Tübingen

January 2013

Abstract

We analyze the offshorability of jobs using the German Qualifications and Career Survey. The paper differentiates between outsourcing potential and international tradability and systematically uses a large set of potential determinants of organizational and spatial relocation derived from the existing literature on offshoring. Applying principal component analysis, we are able to compute two indicators explaining both the outsourcing potential and the international tradability of an individual employee according to the characteristics of the job performed. The results show that there is significant variation along the two dimensions across tasks, occupations, and industries. We apply our results to analyze the effects of outsourcing potential and international tradability on individual income and find that especially the latter has a negative effect. Moreover, our computed indicators can be used to further investigate the economic effects of offshoring potential.

JEL-Classification: D23, F16, J24, O33

Keywords: Outsourcing, International Trade, Offshoring, Trade in Tasks

[1] This paper is part of the research project 'Trade in tasks – potentials for internationalization and their effects on the wage structure and composition of employment', funded by the German Research Foundation (DFG) (BO 2793/3-1). We thank our colleagues Bernhard Boockmann, Carina Dengler, Peter Eppinger and Katja Neugebauer, as well as the participants of the PhD Summer Workshop at University Hohenheim, the ETSG Conference, the SEEK workshop at ZEW Mannheim, the Brown Bag Seminar at University Tübingen, and the FIW-Seminar in International Economics at WIIW Wien for useful comments. Jane Dreyer, Patrick Maier, Elitza Milenkova, and Matthias Seckler are gratefully acknowledged for excellent research assistance. All errors are ours alone.

[2] Corresponding author; Institute for Applied Economic Research, Tübingen, Germany (www.iaw.edu); Phone: +49 7071 9896 16; Mail: tobias.braendle@iaw.edu.

[3] Institute for Applied Economic Research, Tübingen, Germany.

1 Introduction

In recent years, outsourcing processes, both on a national and on an international level, have not only been growing quantitatively, but they have also been undergoing profound qualitative changes. The technological advancements with regards to information and communication, declining costs of transportation, and thus a contraction of physical (and, partly, also cultural) distances (*global village scenario, death of distance*) has led to a substantial growth in the national and international trade of goods and services both within and between firms (see, for instance, Merino and Rodriguez, 2007). Simultaneously, production processes are observed to be more and more fragmented, affecting activities of national and international trade and resulting in a "new type" of trade: the offshoring of intermediate inputs, frequently referred to as "trade in tasks" (cf. Blinder, 2006 and 2009; Grossman and Rossi-Hansberg, 2006 and 2008; Lanz et al., 2011; Oldenski, 2012).[4]

In the course of this discussion, existing raw measures of tradability and outsourcing potentials based on rather general characteristics of industries or jobs (e.g. skill levels) have been displaced by finer methodologies drawing on the characteristics of jobs themselves, but data availability is still fairly scarce. Autor et al. (2003) conceive employment as a continuum of different tasks. They measure shifts in the employment structure of occupations no longer on the basis of indirect measures of qualification, but directly by their composition of tasks (cf. also Lanz et al., 2011). The implications from traditional trade theory that the highly skilled usually profit from trade and vice versa, might not be applicable when trade in tasks becomes increasingly important.

According to theoretical considerations and empirical observations, not all jobs are equally tradable and there is an intensive discussion about which characteristics might influence the decision of a firm to perform a certain activity outside the firm, or abroad. First, various considerations at the firm level have an impact on the decision whether to provide the respective good inside the firm's boundaries or to purchase it on the market (make or buy).[5] Second, a choice has to be made whether to make or buy the good on the home market or abroad.

In contrast to former approaches to outsourcing, which emphasize cost factors, skills, or the nature of contracts as the underlying forces of these choices (e.g. Giuri et al., 2008), now characteristics of jobs themselves are identified as important determinants of outsourcing potentials and tradability (see, e.g. Becker and Mündler, 2012). Notable examples are communication intensity and interactivity (Blinder, 2006; Leamer and Storper, 2001), routines (Oldenski, 2012; Spitz-Oener, 2006) or the standardization of goods (Costinot et al., 2011).

However, several aspects of differentiating between outsourcing, i.e. buying intermediate inputs on the market instead of producing them inside the firm, and offshoring, i.e. producing inputs of goods in another country (no matter if in-house or outside the firm), have been widely neglected in the literature so far. Moreover, a systematic *empirical* classification of how easily jobs can be outsourced and/or traded internationally is missing. Instead, existing classifications of jobs into the above categories (outsourcing potential and international tradability) are usually based on rather subjective procedures. This results in somewhat arbitrary classifications, and/or classifications limited to a small

[4] Much of the scientific and political debate about offshoring is concerning its effects on labor markets (see Crinò, 2009 or Mankiw and Swagel, 2006 for recent overviews).

[5] In fact, this discussion is closely linked to the question of boundaries of the firm (cf. Coase, 1937; Grossman and Helpman, 2002, 2003 and 2005), where the determinants of outsourcing and offshoring are seen as a function of trade and transaction costs (Lanz et al., 2011; Spencer, 2005).

number of determinant characteristics, such as complexity or interactivity (cf. Blinder, 2006; Oldenski, 2012; Spitz-Oener, 2006).

The main contribution of the present paper is to complement existing lines of research by developing and testing a consistent measure of the international tradability and outsourcing potential of occupational activities. This goes beyond the level of tasks and assesses characteristics of jobs, such as working conditions, tools, and attributes of professional activities. First, we base our measurement on a portion of job properties which have been identified in the literature before and which are expected to have an impact on the outsourcing potentials and on the international tradability of jobs. Second, we differentiate between outsourcing and international trade by computing determinants of outsourcing potential and international tradability.

Using principal component analysis, we derive job-, task- or industry-specific indicators, that have been, in this form, not available in the literature until now. These can be linked to other datasets for further investigating the characteristics, the significance, the determinants, and the consequences of an increase in job offshorability. A direct empirical survey on the consequences of job offshorability on employment, types of employment, and wages structures in Germany has, to the best of our knowledge, not yet been conducted. Our approach mainly focusses on the data used by Spitz-Oener (2006) and Becker et al. (2009). However, this paper describes a new procedure to directly operationalize the dimensions of international tradability and outsourcing potential. This complements existing literature.

The empirical results of the paper reveal that there is considerable heterogeneity between outsourcing potentials and international tradability, independently of taking industries, occupations, or task groups as the level of aggregation. The inclusion of indicators into a Mincer (1974) wage equation shows that especially the international tradability of jobs is correlated with lower personal income.

The paper proceeds as follows: In Section 2 we lay out the literature dealing with the determinants of outsourcing and international trade – with a focus on trade in tasks. There, we present the principal theoretical considerations, empirical evidence, and the shortcomings of existing approaches. Section 3 introduces the data and the construction of variables, particularly focusing on the characteristics which potentially determine outsourcing potential and international tradability of jobs. The description of the methodology underlying the construction of two indicators (outsourcing potential and international tradability) represents the content of Section 4, whereas Section 5 includes a descriptive overview of the resulting indicators on various aggregation levels. In Section 6 we provide an application of our new indicators, analyzing their impact on employee income. Section 7 concludes.

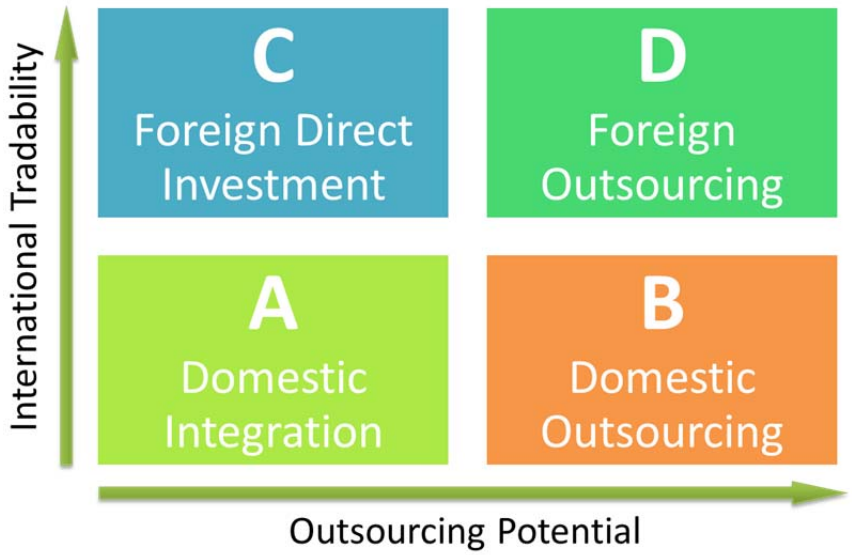
2 Literature Review

2.1 Operationalizing Offshoring

The literature on trade in tasks (and, more generally, on offshoring) has so far addressed offshoring decisions as one-dimensional processes: Firms either perform a job within their own firm and country or they offshore. In our approach, however, we are able to address the two dimensions of this process, which might be influenced by different factors: First, the feasibility of organizationally

relocating activities, i.e. of "make or buy", designated here as the *Outsourcing Potential*. Second, the potential of spatially relocating activities across international borders, designated as *International Tradability* (see Figure 1, cf. also Antras and Helpman, 2004; Federico, 2012).

Figure 1: Organizational and Spatial Dimensions of Job Offshorability



Source: own illustration

On the basis of this operationalization, barriers or stimuli to international trade, as well as barriers or stimuli to outsourcing can be distinguished and identified. In this context, various characteristics of activities can be captured. The four cells displayed in Figure 1 are dependent on each other, but the categorization allows drawing conclusions on firm strategies regarding the relocation of jobs on different organizational and spatial levels:

- Cell A refers to activities which are vertically integrated and produced in-house (*make*) in the home country because they are subject to international trade barriers. Therefore, the probability of organizational and spatial relocation is low.
- Activities classified in cell B are characterized by a high potential for organizational relocation (*buy*), but similarly to cell A, barriers to international trade are significant. These activities are likely to be outsourced on the national or even on the regional level.
- In contrast, activities allocated to field C are likely to be vertically integrated; however, barriers to international trade pertaining to these activities are low. Therefore, they are likely to be relocated spatially within the firm via foreign direct investment (FDI).
- Finally, field D covers activities with both a high organizational and spatial relocation potential. These activities are most likely to be subject to international outsourcing (offshoring).

In addition to traditional (one-dimensional) concepts of offshoring, this two-dimensional perception of job offshoring allows us to fully capture determinants that potentially affect only one of the two dimensions, or both. We are thus able to address whether such determinants really influence offshoring as a whole. It also helps in distinguishing between determinants that affect the home

country labour demand or wages directly (spatial relocation), and determinants that only have indirect effects (organizational relocation). Such a distinction has rarely been addressed explicitly in the literature so far; a recent exception can be found in Federico (2012), who analyzes the choice of firms between integration and outsourcing in the home country or abroad. In the following, this concept will be described in more detail, with respect to the question of which factors and characteristics of activities might have an impact on their outsourcing potential and international tradability.

2.2 Determinants of Job Offshorability

A sound empirical assessment of the international tradability and the outsourcing potential of tasks, jobs, and/or economic activities first and foremost requires an adequate operationalization of the relevant job characteristics. Based on the existing literature, this section identifies possible determinants of outsourcing potentials and international tradability of jobs and activities. In our view, however, this literature is restricted in two regards: First, the majority of studies do not distinguish between factors determining the outsourcing potential of jobs and factors determining their international tradability (see Section 2.1). Second, the majority of the available studies is restricted with regard to the number of factors and builds on limited sets of potential determinants.

Based on a survey by the *Ferderal Institute for Vocational Education and Training* (BIBB) – which we also use and explain later in this paper –, Spitz-Oener (2006) examines the changes in jobs due to technological development. She introduces a classification of tasks into five categories: 'non-routine analytic', 'non-routine interactive', 'routine cognitive', 'routine manual', and 'non-routine-manual' – i.e. she classifies tasks according to categories of routines, interaction, and blue-collar/white-collar activities. Using the same dataset, Becker et al. (2009) establish a link to internationalization, adding 'interactive' and 'non-interactive' tasks to the already mentioned 'routine' and 'non-routine' tasks. Non-routine tasks are defined as ones that cannot be simply repeated, while interactive tasks require interaction inside the workforce, or with clients or collaborators. Becker et al. (2009) have found that offshoring is accompanied by significant shifts to non-routine and interactive tasks in the home country.

Although these and most other assessments referring to the tradability and to the outsourcing potentials of tasks are based on rather subjective and somewhat arbitrary assignments, three bundles of factors are of particular relevance in this respect: Complexity and knowledge requirements; interaction and context, comprising also information and communication technologies, and workplace characteristics (see Table 1). These factors will be outlined in more detail in the following. The table also summarizes the expectations concerning the directions of impact of the respective job characteristics on the outsourcing potentials and the international tradability of these jobs, which will be further substantiated in the next paragraphs.[6]

[6] We thereby differentiate between unambiguously positive/negative predictions (++/--) and less distinct predictions, which are based on mixed or weak empirical evidence or theoretical considerations (+/-). It is also important to see that, while for some characteristics we expect them to have the same direction of influence on both dimensions of offshoring, this is not always the case.

Table 1: Overview of Theoretical Predictions of Determinants of Offshoring Jobs

Job Characteristics	Outsourcing Potential	International Tradability
a) Measures of Complexity / Knowledge Requirements		
Codifiability and Routines	++	+
Complexity	--	-
b) Measures of Interaction and Context		
Interactivity	?	--
Locational ties, cultural linkages	?	--
Complementary tasks	--	--
Significance of ICT	+	++
c) Types of Work and Working Conditions		
Physical working conditions (e.g. disadvantageous postures)	?	+
Mental working conditions (e.g. pressure to perform)	?	-

Note: ++/-- indicate unambiguously positive/negative predictions; +/- indicate possible positive/negative predictions of a certain job characteristic on outsourcing potential or international tradability

a) Measures of Complexity / Knowledge Requirements

In the context of the theory of the firm and the transaction cost approach (cf. Antras 2003; Barba-Navaretti and Venables, 2004; Coase, 1937; Ethier, 1986; Grossman and Hart, 1986; Hart and Moore, 1990), the basic principle is that both the outsourcing potential and the (national and international) tradability of goods or services increase with their standardization or codifiability (and decrease with their complexity and with the requirements to specific types or allocations of knowledge), as codifiable products or activities can be more easily covered by contracts than complex and customized goods (cf. also Leamer and Storper, 2001). The term codifiability thereby refers directly to the question of whether it is possible to describe a certain activity in a way so that it can be performed by another company, either located in the home country or abroad. Thus, our hypothesis is that outsourcing potential is positively correlated with codifiability.

Costinot et al. (2011) empirically confirm that non-standardized activities are traded inside the firm, whereas standardized tasks can also be purchased from independent providers, i.e. from the market. This paper is one of the few examples discriminating between general outsourceability (which, in the view of the authors, mainly depends on potentials for standardization) and international tradability (referring to international trade barriers). The main determinant of whether a certain job can be performed by a different company is the existence of a market for the respective task performed by the job. Hence, it is initially irrelevant for the outsourcing potential whether this activity is tradable internationally.

Quite similar, routines and complexity in what workers are doing are an important predictor of the outsourcing potential and the tradability of these activities. Costinot et al. (2011) assume that complex (non-routine) tasks may cause problems that cannot be resolved ex ante. As adaptation costs occurring ex post are lower when an activity is provided internally, multinational firms choose vertical integration for complex non-routine tasks. Their empirical examination on the sectoral level

confirms this hypothesis by showing high correlations between shares of complex tasks and intra-firm trade. In a similar manner, Oldenski (2009) finds high (negative) correlations between relocation and the complexity of tasks. Departing from the *Dictionary of Occupational Titles* (DOT),[7] Autor et al. (2003) confirm theoretically and empirically that 'routine tasks' (i.e. limited and well-defined sets of cognitive and manual activities) can more easily be substituted by "computer capital", whereas 'non-routine tasks' (i.e. "problem-solving and complex communication activities"), are rather being complemented or supported than substituted by computer capital (see also below).

Based on the above considerations, we assume that routines have a positive impact on both the outsourcing potential and the international tradability of jobs. Complexity, on the other hand, is supposed to have a contrary effect.

b) Measures of Interaction and Context

High demands for interaction and context, e.g. face-to-face communication with customers, locational ties or requirements to cultural proximity (e.g. skills in languages or law) are believed to reduce international tradability. Using data from the U.S., Bardhan and Kroll (2003) identify several characteristics that are common to internationally tradeable jobs: These jobs do not require personal contact, they have high information requirements, working processes are linked to the internet, or jobs are characterized by large differences in wages across countries, low (market) entry costs and jobs with a low social networking requirement. In line with these findings, van Welsum and Reif (2005) find evidence that, for a sample of OECD countries, outsourceability crucially depends on social contact, codifiability and the use of computers.

On the basis of subjective judgment, Blinder (2009) orders different occupations according to their risk of being offshored. He assigns the *O*Net* jobs to four different categories depending on their offshorability. It is interesting (and may be an outcome of the subjective methodologies used in the studies) that he draws the conclusion that "the more offshorable occupations are not low-end jobs, whether measured by wages or by education" (cf. also Blinder, 2006 and Baldwin, 2006).

Whereas the above approaches are based on the characteristics of single tasks, other scholars emphasize that jobs must be conceived as bundles of tasks (Autor and Handel, 2009). Some combinations of tasks frequently appear together – they are complementary to each other and as such might be more efficiently performed by one worker than by two or more. These 'task portfolios' might limit the division of labor and increase the unbundling costs from outsourcing a specific job (cf. Görlich, 2010; Lanz et al., 2011).[8] Görlich (2010, p. 18f) shows "that the number of potentially offshorable jobs is significantly reduced when complementarities are accounted for".

Jensen and Kletzer (2010) base their index of offshorability on so-called 'occupational requirements': They assume that, for instance, activities involving intensely modern information and communication

[7] The DOT has been followed by the *Occupational Information Network* (O*NET, cf. www.onetonline.org) since the late 1990s, which is now used by most U.S. studies. In Europe and Germany, the *International Standard Classification of Occupations* (ISCO, most recent version from 2008, cf. http://www.ilo.org/public/english/bureau/stat/isco/index.htm) is more common.

[8] Moreover, the existing task classifications are only rather raw approximations to reality and boundaries between tasks are quite differentiated and dynamic in fact.

techniques (ICT)[9] are characterized by high offshoring potentials (see also Autor et al, 2003 as well as Bardhan and Kroll, 2003). These techniques are, to a certain degree, standardized, or at least codifiable, and the distance between supplier and customer is only of minor importance.

Generally spoken, increasing needs to interact personally are supposed to be a barrier to international tradability, whereas the impact on outsourcing potentials is not that clear-cut. If, for instance, interaction requires high levels of trust, outsourcing is less probable; however, trust must not always be confined to intra-firm cooperation. Locational ties and cultural linkages might similarly hinder international tradability of an economic activity, but might have no influence on organizational dislocation on the national level, as, for instance, the cultural background of firms or people does not differ in many respects in the home country. With regard to complementary tasks, the less tradable and the less "outsourceable" activity within a task bundle is expected to determine the outsourcing potentials and the tradability of the whole job. Therefore, high levels of complementarities lower the probability of a task to be internationally tradable or to have outsourcing potentials.

c) Types of Work and Working Conditions

Last but not least, the type of work performed by an individual worker (e.g. blue-collar or white-collar work) and the working conditions linked to a specific job (e.g. its properties with regards to employee's health) might have an impact on the tradability and the outsourcing potentials of that job. Even though, in this context, the effects of outsourcing potential and tradability on the working conditions in the target companies or countries are rather well-researched (see, e.g. Brown et al., 2004), characteristics of work and working conditions as determinants of offshoring have, to our knowledge, not been addressed explicitly so far.

Adverse physical working conditions like, for instance, frequent exposures to noise, heat or humidity or work in disadvantageous positions are often linked to a low quality of jobs. Thus, if possible (i.e. if other factors like locational ties or interactivity do not stand against), firms might try to shift such activities to other firms, most probably to foreign countries where the general level of the quality of working conditions is lower. In this context, country-specific regulatory frameworks, for example with regard to safety at work, might promote such tendencies of relocation. With regard to organizational relocation (outsourcing potential), however, the effect is unclear.

Unfavorable mental working conditions, like, for example, high pressures to perform or the need to execute several activities at the same time, can have similar effects. It also seems probable, however, that they have a countervailing impact. The execution of pressure to perform, for example, requires high levels of control which can supposedly be better realized when performed in close spatial or organizational proximity.

[9] ICT is an umbrella term that includes any sort of communication device or application (http://searchcio-midmarket.techtarget.com/definition/ICT, 10.04.2012)

3 Data and Measurement

3.1 The Data

Our research is based on several cross-sections of the German Qualification and Career Survey of Employees (BIBB Survey).[10] The purpose of this representative employee survey is to describe employees and their jobs in a wide range of perspectives, e.g. to demonstrate trends and features of a changing work environment and to enable its empirical quantification. Up until now, the data include five cross-sections based on telephone interviews, from which we use the waves 1991/92, 1998/99 and 2005/06, each covering 20,000 to 30,000 individuals.[11]

The different cross-sections of the survey contain a variety of information on individual employees, and their jobs. They range from basic information such as education, to current and past employment, mobility, and working conditions, which are especially valuable for our research question. With regards to tasks, the data contain several variables describing in detail the assignment, the content and the attributes of the tasks an employee performs at the workplace. With respect to job characteristics, which are believed to be of relevance for the outsourcing potential and international tradability of jobs, there is plenty of information in the data, which will be described in more detail below.

The BIBB Survey is based on telephone interviews with individual employees.[12] The definition of variables regarding individual characteristics, occupations and tasks is mostly consistent across the panel waves. Some partial inconsistency over time, however, makes the comparability of the data somewhat complicated and requires special consideration (cf. Becker and Mündler, 2012; Görlich, 2010). For the subsequent analyses, we therefore use data from the latest three available samples of the BIBB Survey, namely from 1991/92, 1998/99, and 2005/06.[13] Moreover, we restrict our sample to workers aged 15 to 65 years and drop public servants, retirees, unemployed and self-employed individuals, as well as marginal employees, from the sample. These groups are of minor relevance for the analysis of offshoring potential.

The BIBB Survey contains information on most of the job characteristics which have been identified in the literature as relevant determinants of the international tradability and the outsourcing potential of jobs (see Section 2.2). Some characteristics, however, are not available in every wave; thus, for some characteristics we have relied on methodologies established elsewhere, namely the computation of an index on locational ties based on occupations by Blinder (2006), and Schrader and Laaser (2009).

[10] The surveys are carried out by the German Federal Institute for Vocational Training (BIBB), the Research Institute of the Federal Employment Service (IAB), the Federal Institute for Occupational Safety and Health (BAuA) and the Federal Ministry of Education and Research.

[11] A sixth wave of the survey has been finished in spring 2012, but the data will be available only in 2014. For detailed information on the survey, see www.bibb.de.

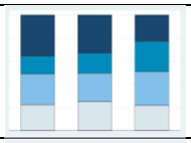
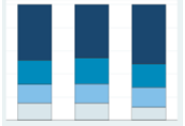
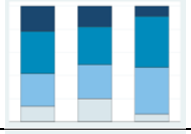
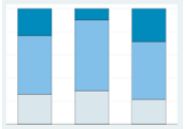
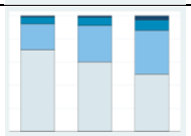
[12] In 1991/92, the survey also contains a small subsample of unemployed individuals and other groups of workers, mainly from the context of the former German Democratic Republic, which is not relevant to the subject of our paper and which we thus exclude from our sample.

[13] Furthermore, it can be argued that trade in tasks is a relatively new (in terms of decades) phenomenon; that the German unification has changed the work environment in Germany; and that we want to use the most recent data available without losing too much information due to inconsistencies.

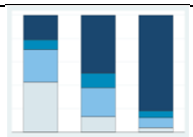
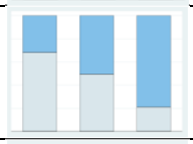
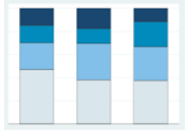
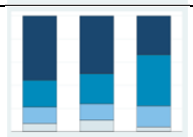
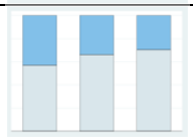
3.2 Identifying and Constructing of Characteristics Determining International Tradability and Outsourcing Potential

The first step of our empirical analyses is to operationalize the characteristics that potentially determine the outsourcing potential and the international tradability of jobs (see Table 1). A large number of the variables in question can be directly extracted from the data, although in most cases we have to smooth inconsistencies over time and in some cases we take several single variables to create an indicator that reflects one characteristic. For example, in the case of physical working conditions or undesirability, we use information on several negative properties of a workplace, such as the existence of smoke, noise, danger etc. and sum them up to one variable capturing the overall undesirability of a workplace, defined as the relative frequency of all negative properties. In other cases, there are various options which can be used to define a characteristic via the variables available and therefore alternative measures are included in the data. Finally, for some characteristics the data do not contain information in every wave, such that we do not include them in the comprehensive analysis in this paper.[14]

Table 2: Operationalization of Job Characteristics

Characteristic	Underlying question / information in survey	Development*, 1991 1998 2006
Codifiability (COD)	Every step of the execution of tasks / activities is stipulated in detail (never, seldom, often, always).	
Routines (ROU)	The operation cycles of work are exactly and constantly repeating (never, seldom, often, always).	
New Scopes (NEW)	Daily work involves addressing new and / or unforeseen problems and challenges or testing new procedures or processes (never, seldom, often, always).	
Interactivity (INT)	Daily work involves direct contact with clients or patients; daily work involves convincing others; daily works involves negotiating agreements (number of items marked).	
Locational Ties (LOC)	Defined on the basis of 3-digit professions according to Blinder (2006) and Schrader and Laaser (2009), respectively.	
Cultural Linkage I: Languages (LAN)	Daily work requires skills in one or more foreign languages (never, seldom, often, always).	
Cultural Linkage II: Law (LAW)	Daily work requires specific knowledge of law and justice (yes or no).	

[14] They could be implemented in analyses that focus on more specific job characteristics. There is a trade-off between the number of characteristics used and the number of waves in which these characteristics can be measured consistently.

Complementary Tasks (COM)	To what amount does the employee perform tasks that are complementary to each other, i.e. often performed together (Görlich 2010).	
Information and Communication Technologies (ICT)	Daily work involves working with computers (yes or no).	
Physical Working Conditions / Undesirability (UND)	Daily work is demanding or painful in physical respect, e.g. hazardous workplace, work in painful positions, undesirable noise, temperature or hygiene (relative frequency of occurring items).	
Pressure to Perform (PRE)	Daily work is characterized by tight deadlines or by high pressure to perform (never, seldom, often, always).	
Blue Collar Workers (BLUE)	Respondent is blue-collar worker (yes or no).	

** Bars for 1991, 1998 and 2006 (left to right), respectively. Darker areas denote higher intensities / larger values of the variables.[15] Source: BIBB Survey 1991, 1998, 2006; own calculations.*

Table 2 contains a detailed description of the information underlying the variables used as a basis for the generation of the characteristics used in our empirical analysis. In the second row we explain the items in the BIBB Survey in more detail alongside the computational procedure we have used to measure characteristics. In the third row we present descriptive statistics regarding the realizations of our variables and their development over time. Darker areas denote higher intensities/larger values of the variables, while the three bars represent the waves 1991, 1998, and 2006, respectively. In many cases, standardization of the variables across the waves has been performed.[16]

With regards to the realizations of the variables and their development over time, a clear picture emerges. Variables that are potentially positively linked to outsourcing potential and international tradability exhibit a decline over time and vice versa. This can be seen in the declining share of codifiable jobs or workplaces. The same is valid for blue-collar workers. Hence, those jobs seem to disappear over time or there are less such tasks to be performed in jobs. This can happen as a consequence of offshoring activities or skill-biased technological change. In contrast, it can be observed that the use of ICT increases significantly, as does the need to learn foreign languages, which is most probably a direct consequence of an increase in internationalization of work environment. Some other variables, however, exhibit only slight changes. Also, some variables feature a trend towards the middle. For example, concerning the degree to which workplaces require

[15] For flag variables (LAW, ICT, BLUE) "yes" is light blue and "no" is white. For categorical variables (COD, ROU, NEW, LAN, PRE) "always" is dark blue, "often" is blue, and "seldom" is light blue and "never" is white. Regarding interactivity (INT), blue indicates at least two items marked, light blue indicates one item marked and white indicates no item marked. The indicator for locational ties (LOC) follows the Schrader and Laaser (2009: 28) classification: dark blue occupations are easily offshorable, blue occupations are offshorable, light blue occupations are hardly offshorable, and white occupations are not offshorable at all. The complementary tasks measure (COM) classifies jobs according to the share of complementary tasks performed: Dark blue stands for more than 80 % of tasks, blue for more than 50 %, and light blue for more than 10 % white for less than 10 % of tasks. The indicator of physical working conditions (UND) measures the relative frequency of the above mentioned items occurring: dark blue: almost all occur; blue: the majority occurs; light blue: some occur; white: none occur.

[16] Detailed information and Stata Programs are available upon request.

new scope or are characterized by a high pressure to perform, it can be said that far less jobs are nowadays characterized by a very high or very low degree of new scopes or pressure to perform.[17]

Table 3: Correlation between Characteristics

	COD	ROU	NEW	INT	LOC	LAN	LAW	COM	ICT	UND	PRE	BLUE
COD	1											
ROU	0.4681*	1										
NEW	-0.1156*	-0.2152*	1									
INT	-0.2034*	-0.1858*	0.2957*	1								
LOC	0.0150*	0.0506*	-0.1254*	0.1091*	1							
LAN	-0.0739*	-0.1003*	0.1620*	0.1950*	-0.0721*	1						
LAW	-0.0917*	-0.1000*	0.1808*	0.2276*	-0.0096	0.0659*	1					
COM	-0.1983*	-0.1744*	0.2899*	0.3178*	-0.1338*	0.2231*	0.2292*	1				
ICT	-0.1575*	-0.1353*	0.2393*	0.2625*	-0.3055*	0.2647*	0.1719*	0.5214*	1			
UND	0.1827*	0.1281*	-0.0269*	-0.2827*	0.1885*	-0.1543*	-0.0823*	-0.1120*	-0.3318*	1		
PRE	0.1251*	0.0058	0.3114*	0.1327*	-0.1359*	0.0571*	0.1242*	0.1348*	0.1218*	0.0846*	1	
BLUE	0.2487*	0.1866*	-0.1885*	-0.4897*	0.0623*	-0.2375*	-0.1890*	-0.3632*	-0.4445*	0.5351*	-0.0378*	1

*Note: * indicate significant correlation at the one percent level. Shaded areas indicate correlation coeff. of > 0.3*
Source: BIBB Survey 1991, 1998, 2006; own calculations.

Of course, as discussed in detail before, it can be argued that a number of variables identified in the literature to determine the offshoring potential of a job are very similar or measure similar job characteristics. Therefore, it is important to define a set of many possible variables to use in the empirical analysis. There is, of course, a trade-off between a decreasing level of additional variation from the characteristics and an increasing level of multicorrelation. This feature is, apart from data restrictions, central to our decision on the number of characteristics to include. We therefore use a set of variables from which we think that each item identifies a distinct dimension of international tradability or outsourcing potential. However, doubts always remain as to whether certain variables could be missing. We feel assured that the level of correlation between the chosen characteristics is sufficiently small. A correlation matrix is therefore shown in Table 3.

The table reveals that there is of course some correlation between nearly all of our characteristics, displayed by the significance of the correlation coefficients. However, as we use a very large dataset, this is less expressive than the size of the coefficients per se. We use a threshold of a correlation coefficient of more than 0.3 to define strong correlation between two variables, which is a rather conservative value. From the cells in Table 3, it can be seen that for most of the variables this threshold is not reached. However, there are two exceptions, one being ICT and one being our indicator for blue-collar workers. More specifically, we can only measure both variables as dummies, such that the size of correlation coefficients is more difficult to interpret.[18] Second, it could be the case that both variables potentially have a direct influence on offshoring beyond the influence they

[17] The averages of both variables, however, rise.

[18] A correlation between two indicator variables returns the phy coefficient and rather represents a difference in means test. The phi coefficient has a maximum value that is determined by the distribution of the two variables and thus not necessarily ranges from -1 to +1. See Davenport El-Sanhury (1991) for a thorough discussion.

have via workplace characteristics.[19] We further control for variation between our characteristics in the empirical analysis carried out in Section 5.

3.3 Aggregation of the Data and Further Control Variables

Apart from the outlined job and workplace characteristics, the BIBB Survey contains further valuable information we use for our analysis. First, there are different variables allowing us to generate aggregates of the two indicators of offshoring, e.g. occupation, sector affiliation etc. (see Section 5); second, we can use individual and household information to test our hypotheses within the data in the context of a Mincerian wage regression as a first pass to their quality (see Section 6).

At first, we compute two indicators at the individual level. To further use the information on job offshorability in other datasets, we have aggregated our indicators on different levels. First, and probably most interestingly, we have information on the job classification of each employee, at the Kldb1988 4–digit level.[20] This very detailed information can be merged with labor market data from the Federal Employment Agency[21]. Second, we have information on the industry classification of each employee and can therefore aggregate our indicators at the industry level (approximately NACE 2-digit level). Furthermore, we can also use information on the location of the employee's workplace (German State), or the task groups individual workers perform.

4 Method and Implementation

4.1 Overview: Objectives of the Analysis

The main objective of our paper is to supply individual (and later also task-, occupation-, and industry-specific) indicators of outsourcing potential and international tradability. These indicators will be obtained empirically from the data described above in a transparent and objective, i.e. data-driven way. The aim is to use them in further research by merging them with other datasets, as well as to use them in an analysis of the effects of outsourcing potential and international tradability on wages within the BIBB Survey.

In order to compute the indicators, we make use of the rich information contained in our data referring to individuals, their job, job-related tasks as well as the characteristics of these jobs. As outlined in Section 2, various job characteristics that might have an impact on the outsourcing potential and on the international tradability have been identified in the literature. While we have decided to use the set of characteristics shown in Table 2, further analyses can focus on other variables as well. Our two indicators have the following form:

$$outsourcing\ potential_i = weight_{1j} \cdot job\ characteristic_{ij}$$

$$international\ tradeability_i = weight_{2j} \cdot job\ characteristic_{ij},$$

[19] See, for example, the literature on SBTC, e.g. Spitz-Oener, 2006.

[20] The KldB 88 ("Klassifizierung der Berufe") is a classification of professions quite common in German datasets and literature. Contrary to the International Standard Classification of Occupations (ISCO), it is based on the actual type of professional activity, and not on skill levels.

[21] For example the LIAB dataset from the IAB (www.fdz.iab.de).

where we compute each indicator for every individual i based on her individual- and job-specific characteristics j defined as in Table 2. The realizations of each of the twelve workplace characteristics will be summed up to form the two indicators.

The main question of this procedure is how to weight each characteristic in each indicator. So far, the literature has been based on the use of simple, subjective weights that mainly focus on one or very few characteristics. We could simply use the hypotheses derived from the literature on the influence of specific characteristics on offshorability displayed in Table 1, and assign each characteristic the same (standardized) weight (or subjective weights if we think that some characteristics are more important than others). While this procedure would supply theoretically-confirmed indicators, it would not test the underlying theory on the data available. Hence, instead, we use a multivariate method, namely principal component analysis (PCA). Using this approach, we first test whether the data fits the underlying theories on the determinants of offshoring potential, and second obtain variance-maximizing weights that have been computed in a maximally transparent, i.e. non-arbitrary, and objective, i.e. data-driven, way. We present the method of PCA below and explain how we condense the available information into two indicators, one representing outsourcing potential and the other international tradability in Section 4.3.

4.2 Principal component analysis (PCA)

Principal component analysis is a multivariate method that allows for the reduction of potentially multicollinear information, in our case possibly correlated job characteristics. Simultaneously, PCA reduces the number of dimensions, while at the same time regains maximally explained variance. By decomposing the covariance matrix of a number of variables, PCA gains the leading Eigenvectors as a series of uncorrelated linear combinations of the characteristics. This method can be seen as a statistical technique for data reduction. It helps to reduce the number of variables in an analysis by producing a series of uncorrelated linear combinations of the variables, in our case the two indicators of offshoring potential that contain a maximal share of the variance.[22] The objective of PCA is to find unit-length linear combinations of the variables with the greatest variance. The first principal component has maximal overall variance. The second principal component has maximal variance among all unit length linear combinations that are uncorrelated to the first principal component and so forth. All principal components combined contain the same information as the original variables. PCA is a linear transformation of the data. It does not assume that the data satisfy a specific statistical model. The principal components generated have several useful properties. They are uncorrelated (orthogonal) among each other. The leading principal components have maximal generalized variance among all linear combinations. It is also possible to interpret PCA as a fixed effects factor analysis with homoscedastic residuals:

$$y_{ij} = a_i' b_j + e_{ij}, i = 1, \dots, n \; j = 1{,}2$$

where y_{ij} are the elements of the matrix y, a_i (scores) and b_j (loadings) are f-vectors of parameters, and e_{ij} are independent homoscedastic residuals. In our case the scores i represent the job characteristics. The loadings b_j represent the weights assigned to each indicator j, with $j = 1{,}2$ representing either outsourcing potential or international tradability. The order of indicators will

[22] For more detailed information, see Rabe-Hesketh and Everitt (2007, Chap. 14).

depend on which loadings best represent the hypotheses derived from the literature on how the job characteristics should influence outsourcing potential or international tradability. It follows that E(Y) is a matrix of rank f, with f typically substantially less than n or p. Thus we may think of PCA as a regression model with a restricted number of unknown independent variables. We may also say that the expected values of the rows (or columns) of Y are in some unknown f-dimensional space. For more information on these properties and for other characterizations of PCA, see Jackson (2003) and Jolliffe (2002). We use the PCA to estimate the weights of the job characteristics as loadings on the first two components, i.e. the two indicators of outsourcing potential and international tradability, respectively.

Two further points have to be discussed. First, it is an open question of whether or not to rotate the components after the PCA. When relying on a fixed or desired number of components (in our case the two indicators), the application of an orthogonal varimax rotation could lead to an easier interpretation of the components. However, some of the desired optimality properties of the PCA components are lost (cf. Kaiser, 1958). This would mean that the first rotated component does not maximize the explained variance of the data and that the second component no longer maximizes the variance orthogonal to the first components. However, the rotation would maintain the property that the number of rotated components in sum maximizes the explained variance. Furthermore, the rotated components are still uncorrelated and the loadings of the characteristics are allocated differently on the two components in such a way that they have a clearer, i.e. more distinct interpretation from one another. Since there is no conclusion on whether or not to rotate the components in the econometric literature, we have performed both estimates, with no qualitative difference between the two methods.

Second, PCA per se is sometimes described as an arbitrary method, especially concerning the selection of variables, in our case job characteristics. There is probably no single, 'best' PCA-specification. Instead, we have decided to cross-check our result via a 'meta-analysis', where we take the median coefficient loadings from a large number of different specifications, which each drops up to four of the twelve variables.[23] This allows us to analyze the robustness of our indicators regarding the selection of variables used in a series of PCA-specifications.

4.3 Identification of Offshorability Indicators

In general, the results of a PCA depend on the selection of variables included in the model. Note that, as described in the sections above, we can potentially use either a larger or a smaller number of characteristics, facing a trade-off between estimated consistency and additional explained variation. Therefore, making a decision for one unique specification is difficult. A simple way to overcome that difficulty could be to choose a model including all available variables; however, the number of potential variables to be included could possibly be very large. Moreover, the quality of variables in a given specification of a PCA also depends on the choice of the total set of variables and results can easily change with the inclusion or exclusion of single variables. Table 4 presents the results from a PCA on the whole sample with the twelve characteristics described in Section 3.2.

[23] This results in $\binom{12}{8}$ different specifications. All of which we can, of course, not show.

Table 4: PCA Estimates

Characteristic	Component 1	Component 2	*KMO*	*SMC*
Codifiability	**-0.24**	**0.42**	*0.67*	*0.26*
Routines	**-0.23**	**0.27**	*0.66*	*0.24*
New Scopes	**0.26**	**0.35**	*0.76*	*0.22*
Interactivity	**0.35**	-0.06	*0.77*	*0.33*
Locational Ties	-0.13	**-0.25**	*0.53*	*0.18*
Languages	**0.24**	0.07	*0.89*	*0.10*
Law	**0.21**	0.14	*0.87*	*0.09*
Complementary Tasks	**0.37**	0.18	*0.75*	*0.36*
ICT	**0.39**	0.13	*0.76*	*0.41*
Undesirability	**-0.30**	**0.30**	*0.66*	*0.36*
Pressure to Perform	0.11	**0.58**	*0.60*	*0.15*
Blue Collar Workers	**-0.41**	0.19	*0.76*	*0.46*
Overall			*0.73*	

Note: Loadings larger than 0.2 are marked bold. Kaiser-Meyer-Olkin measure (KMO) and squared multiple correlations of variables (SMC) in columns 4 and 5.
Source: BIBB Survey 1991, 1998, 2006; own calculations.

The PCA performed shows that the first two components, which we want to interpret as the two indicators, explain a large portion of the variance, with eigenvalues of 3.1 and 1.4, respectively. Further components have smaller eigenvalues. Our results in columns 2 and 3 of Table 4 show high robust loadings for the majority of characteristics on the first two components of the PCA. The literature regards loadings that are larger than 0.2 as meaningful. Therefore, we have marked them bold. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) in column 4 shows that it is sufficiently high for most of the characteristics and the overall estimation. In the last column, the squared multiple correlations of variables with all other variables (SMC) shows that most of the variables do not correlate with all the other variables to a large degree, except the variables for ICT and blue-collar workers. This has already been addressed in Section 3.2.

When interpreting the two components, we rely on the hypotheses from the literature set out in Section 2. We have concluded, for example, that codifiability and routines should have a large positive impact on outsourcing potential, whereas they should have a small positive impact on international tradability. The same holds for the other variables, respectively. When comparing the loadings of the components with the hypotheses from the literature, we conclude that component 2 encompasses a large number of high loadings from variables influencing the outsourcing potential. For this reason, we have to interpret it accordingly. For component 1, the case is that a large number of loadings correlate with the hypotheses regarding international tradability, albeit in an inverse way. An example: Knowledge in law and languages should be negatively correlated with international tradability. However, both variables load positively on the first component. The same holds for other variables. Hence, we interpret component 1 as a negative measure of international tradability or, respectively, as a measure of barriers to international tradability.

Therefore, we use the negative value of the loadings of component 1 in the indicator on international tradability and the (positive) loadings of component 2 in the indicator on outsourcing potential as weights needed to calculate the two indicators regarding offshore potential:

$$outsourcing\ potential_i \quad = \quad 0.42 \cdot Routine_i + 0.13 \cdot ICT_i + 0.18 \cdot Complements_i \ + \cdots$$

$$international\ tradeability_i = -0.23 \cdot Routine_i - 0.39 \cdot ICT_i - 0.37 \cdot Complements_i \ + \cdots$$

Very similar qualitative results are obtained when using the varimax rotation, when performing the meta-analysis and using the median loadings of all the specifications, and when estimating the PCA on every wave separately.[24]

To give an overview on how these indicators can now be used in further analyses, we present empirical results for the aggregation of these indicators on several levels in the next section, while performing a direct application on individual earnings in the BIBB data in Section 6.

5 Empirical Results

In this section, we present the results from the aggregation of indicators we have gained from the first two components of the PCA. As already stated, we have labeled them 'outsourcing potential' and 'international tradability', and have then aggregated them to the level of occupations, tasks, and sectors of economic activity. For the aggregation, we use the mean loadings of the components.[25]

Regarding occupations, Table 5 displays the mean loadings of the components arranged with reference to the scheme outlined in Figure 1 above (Section 2.1).[26] It reveals that a majority of occupations may be classified as offshorable (sector D) – they display above average loading for both indices of international tradability and outsourcing potentials. This applies, for instance, to many industries within the manufacturing sectors, particularly those with lower skill requirements. Most service sectors, on the other hand, are based in segments A and C, i.e. they are more prone to integration– be it in the home country or abroad, via FDI.

[24] Results of these robustness checks may be obtained from the authors upon request.

[25] An aggregation based on median loadings is also possible - it yields quite similar results.

[26] Classification is based on median of components (0.112 for Outsourcing Potential, -0,112 for International Tradeability)

Table 5: Outsourcing Potential and International Tradability by Occupational Groups

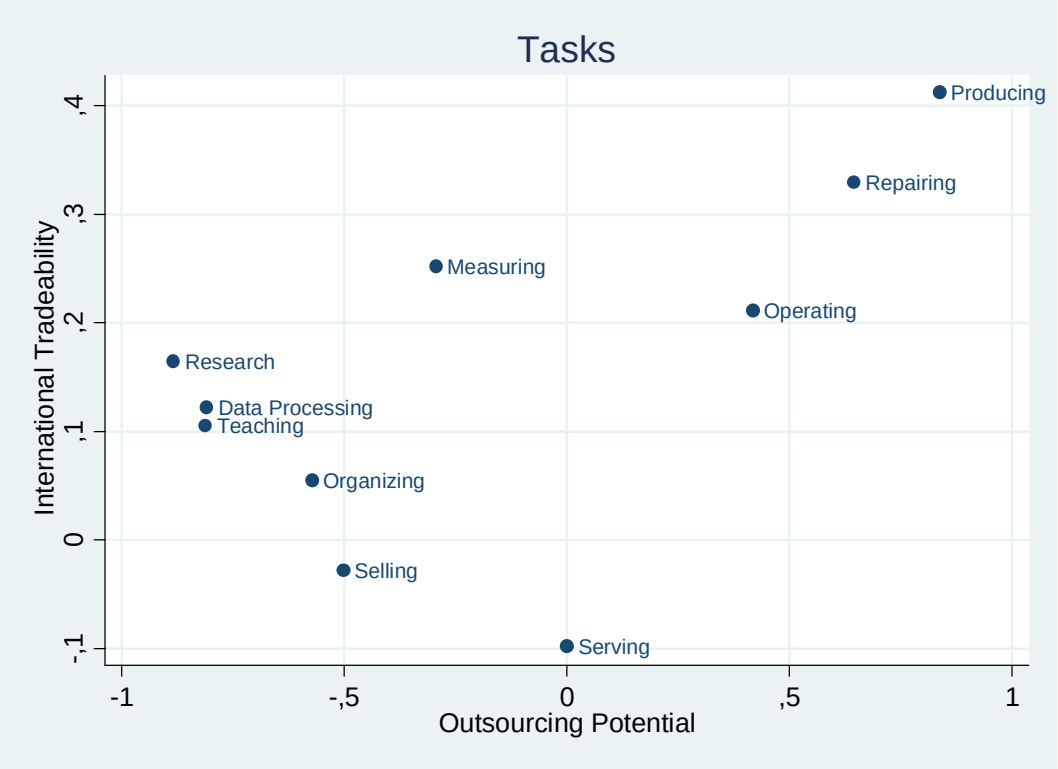
Occupational Group	Outsourcing potential	International Tradability	Matrix Quadrant (see Fig.1)
Other service occupations	-0,701	-1,081	A
Security	-0,015	-1,273	A
Health services	-0,098	-1,090	A
Service merchants and related	-0,773	-0,207	A
Caring professions, education, social and natural scientists	-0,154	-0,496	A
Machine operators and related	0,260	-1,969	B
Transport	0,157	-1,555	B
Engineers, chemists, physicists, mathematicians	0,379	-0,875	B
Commodity traders	-0,305	0,051	C
Writers, artistic occupations	-0,763	0,512	C
Other professions	-0,797	1,390	C
Technicians, technical specialists	-0,478	1,109	C
Organization and administration, office occupations	0,108	1,294	C
Textile and clothing	0,033	1,654	C
Metal production and processing	0,485	0,757	D
Ceramics and glass	0,785	1,046	D
Wood Processing and production	0,605	1,279	D
Civil engineering	0,620	1,421	D
Wood and plastic procession	0,563	1,501	D
Assemblers	0,289	1,789	D
Craftsmen	0,419	1,739	D
Nutrition	0,601	1,623	D
Product testers, shipping finishers	0,473	1,926	D
Electronics	0,437	2,002	D
Leather production, leather and hide processing	0,469	2,103	D
Stone processing and material production	0,915	1,707	D
Metal construction, mechanical engineering etc.	0,750	1,890	D
Mining and mineral production	0,716	2,021	D
Agriculture, forestry and horticulture	0,879	1,941	D
Chemicals and plastics	0,292	2,545	D
Paper production and processing, printing	0,939	1,900	D
Workers without a particular task description	0,394	2,536	D

Note: A: domestic integration; B: domestic outsourcing; C: FDI; D: offshoring.
Source: BIBB Survey 1991, 1998, 2006; own calculations.

Regarding tasks, Figure 2 shows – in line with the results on occupations in Table 5 – that manual and production tasks are located towards sector D (offshoring), whereas service tasks tend to cluster in sector A (in-house production). Within service oriented tasks, international tradability differs significantly: Whereas activities based on personal interaction, like serving or selling, are

characterized by low values of international tradability, other service activities of a rather impersonal nature, like measuring or data processing, indicate high levels of international tradability, which is compliant with the theoretical expectations. The rather unbalanced picture emerging in Figure 2 might also be due to the fact that the vast majority of workers in the survey are not confined to one single task, but declared to perform several tasks. The applied weighting procedure thus leads to component means different from zero.

Figure 2: Outsourcing Potential and International Tradability by Task Groups



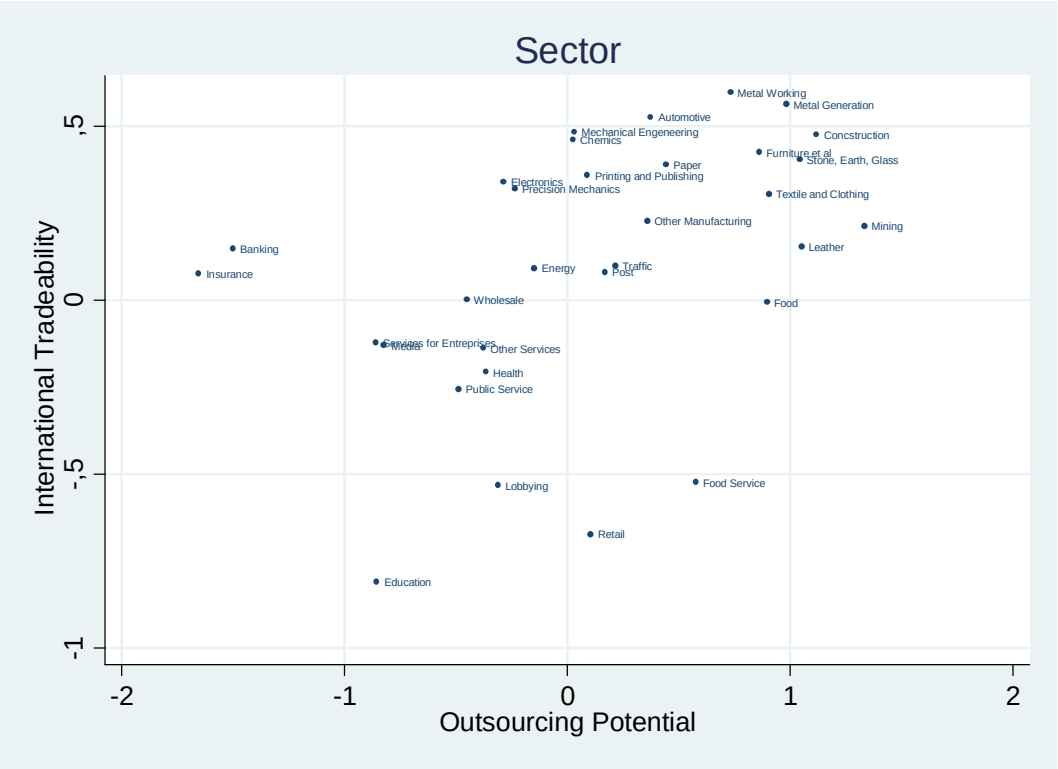
Source: BIBB Survey 1991, 1998, 2006; own calculations.

Figure 3 displays aggregate results on the basis of sectors of economic activity. The pattern matches the observations above in such a way that service activities are clustered in the lower left segment of the scatterplot (segment A with regard to Figure 1), whereas most manufacturing activities are located in its upper right quadrant (segment D).[27] Financial and insurance services, for example, tend to be performed abroad. It has to be taken into account, however, that these results are based on pooled data ranging from the early 1990s until 2006. Moreover, variations in the computation of these indicators might be possible. A large number of these variations have been tested and the results, with regards to the sorting of sectors, tasks or occupations into offshorability, are qualitatively very similar.[28]

[27] Besides substantial reasons, one factor for these congruent patterns regarding sectors, occupations and tasks might be the fact that all classifications in the data are based on personal judgments of the survey respondents.

[28] In the Appendix, we provide information on the robustness checks mentioned in Section 4. Both Figure A3 and Figure A4 present the offshoring potentials by sector, similar to Figure 3. In Figure A3, we use the varimax rotation. This leads to a reallocation of sectors more orthogonally to the traditional one-dimensional categorization of offshoring potentials. The qualitative classifications of sectors into offshorable and tradeable remains largely the same, however.

Figure 3: Outsourcing Potential and International Tradability by Sector



Source: BIBB Survey 1991, 1998, 2006; own calculations.

From the table and figures above, it can be seen that the traditional, one-dimensional view of offshoring potential does not seem to be consistent with the introduction of two distinct indicators for offshorability. Instead of aligning from lower left to upper right, a significant degree of variation seems to exist for a large number of sectors, occupations, or tasks. About 80% of sectors are characterized by both low or by both high outsourcing potential and international tradability. There is significant variation from the diagonal line from A to D. Hence, our indicators seem to allow for identifying and controlling for this type of variation between the two dimensions of offshorability.

In Figure A2 we present the results from the 'meta-analysis', where we have used the medians of the component loadings from a vast number of specifications, which each drop up to four characteristics. Here, the results are also more in contrast to the literature so far, that does not distinguish between outsourcing potential and international tradability when analyzing offshoring potential. The results pictured in Figure 3 can, therefore be seen as a more conservative estimate.

6 An Application with respect to Employee Income

In this section we perform an application of the two indicators of offshorability based on the BIBB Survey. This dataset features information on individual wages as well as individual, household, and firm characteristics. It is therefore possible to estimate a simple Mincer (1974) wage equation and to include the two measures of outsourcing potential and international tradability in the following (log) linear model:

$$y_{it} = \alpha_{it} + \beta_1 \, outsourcing_{it} + \beta_2 \, trade_{it} + \gamma \boldsymbol{X}_{it} + \varepsilon_{it} \, ,$$

where y_{it} either embodies nine brackets of monthly gross income, ranging in a 500 Euro scale from <500 to >4000 Euros per month, or the log monthly gross income of individual i at time t.[29] We estimate the coefficients β_1 and β_2 using ordinary least squares and interpret them as the effects of an increase of one standard deviation in the two indicators on either the (linear) probability of reaching a higher income bracket or on a percentage change in income.

As we know from the theoretical literature on the labor market effects of offshoring, the impact of offshoring on wages can be ambiguous (see, for example, Grossman and Rossi-Hansberg, 2008). However, as we have disentangled offshoring along the two dimensions of outsourcing potential and international tradability, we might draw additional conclusions regarding the question which effect dominates empirically. From the empirical literature, we would expect a (weak) negative correlation between the outsourcing potential of the job an employee performs as well as between the international tradability of this job and an employee's income (see, for example, Antonczyk et al. 2009).

An important benefit from directly using the BIBB Survey data is that the variables of interest do not represent aggregate indicators, but individual attributes. Hence, we do not lose information or variation, as it would be the case when aggregating the offshoring indicators in advance. However, there is also a downside to this approach: As the available information on wages and firm level characteristics is based on statements of workers, and as it appears in rather crude classifications, it might be somewhat unreliable. Moreover, we cannot control for unobserved heterogeneity because of the cross-sectional character of the data.

Several control variables are included. On the individual level, we control for the sex and the age of workers as well as for the type of schooling and for additional qualification, such as vocational training or university education. We also have information on tenure and experience as well as on foreign origin/citizenship. Furthermore, several variables on the worker's household are available: its size, the existence of children, and information about whether the worker's partner is employed or not. Contrary to this, information on the employer is relatively sparse and contains only the industry classification and a firm size class, both of which we include as dummy variables. We also control for the region (Bundesland) and the year. As already mentioned, two variables for ICT use and status as blue-collar worker enter the wage equation directly, in addition to the indirect effect via the offshoring indicators.[30]

[29] While the latter is the definitely preferable variable, it is only available for the wave 2006.

[30] Both variables have been shown to have an own distinct influence on individual income. See, for example, the literature on skill-biased technological change or on compensating wage differentials.

Table 5: Outsourcing Potential, International Tradability, and Employee Income

Variable	Income Class		ln Monthly Gross Wage	
	(1)	(2)	(3)	(4)
Outsourcing Potential	0.3477***	0.0064	0.1100***	0.0020
	(0.0060)	(0.0050)	(0.0061)	(0.0044)
International Tradeability	-0.4790***	-0.2805***	-0.1644***	-0.0827***
	(0.0046)	(0.0065)	(0.0041)	(0.0048)
Control Variables	No	Yes	No	Yes
N. of Obs.	49194	49194	11412	11412
F-Stat	6996.49	1621.42	858.91	348.67
R squared	0.22	0.64	0.15	0.64
AIC	195136.17	157639.86	21161.15	11519.92

*Note: Standard deviation in parentheses: p<0.10, ** p<0.05, *** p<0.01. See Table A4 for the exact control variables; Source: BIBB/IAB/BAuA Worker Survey 1991, 1998, 2006 (Income Class); 2006 (ln Monthly Gross Wage); Own Calculations.*

Table 5 displays the results of interest, while Table A2 in the Appendix displays the full regression table. Specifications 1 and 2 show the results for income brackets as a dependent variable, while specifications 3 and 4 do so for the log income. In specifications 1 and 3 we can see both the direct and the indirect effects of the two indicators on the dependent variable, while we control for the indirect effects using the control variables mentioned above in specifications 2 and 4. First, we find that both indicators are significantly correlated with the income bracket of the log wage of an employee. However, we find that the outsourcing potential of an individual's job is positively correlated with the outcome variable if we do not control for covariates. Once we do so, the effect vanishes.

International tradability is negatively correlated with the outcome. This holds independently of our choice of dependent variables and whether or not we add control variables. The effects for the log income are smaller than for income brackets, and the control variables explain about half of the raw difference in income. The effect of the international tradability of a job is economically significant as well: A worker performing a job that is one standard deviation more internationally tradable has a 28% lower probability of being in a higher wage bracket, and is correlated with an 8.2% lower wage.

The control variables employed are statistically significant and have the theoretically expected sign. The indicators of computer use and status as blue-collar workers are often significant as well. The use of a computer at work increases the wage by 7.7%, while blue-collar workers earn 4.6% less. Regression diagnostics suggest that we can explain a large part of the variation in the dependent variable, which especially holds when including only the two offshoring indicators. We have to note that because the BIBB Survey is a repeated cross-section, we cannot control for unobserved heterogeneity and therefore refrain from interpreting our results as causal. The share of explained variance, however, is quite high, as the R squared indicates. We can also say that, in addition to the usually employed determinants of individual wages, our indicators of outsourcing potential and international tradability add further explanatory power to this type of estimation.

7 Conclusions

In this paper we measure and analyze the outsourcing potential and the international tradability of jobs, their relevance across occupations, task groups, and economic sectors, as well as their impact on individual income using German micro-level data.

So far, the empirical evidence on trade in tasks has focused on grouping certain tasks according to their offshoring potential. While the literature has precisely modeled the effects of falling offshoring costs and rising intra-firm division of labor, there has been, until now, a substantial degree of imprecision in analyzing offshoring as a one-dimensional decision (cf. Hogrefe, 2011). Contrary to this, the decision to outsource a certain activity, i.e. buying intermediates on the market instead of producing them inside the firm might be driven by factors other than the decision of whether or not to perform these activities abroad or domestically.

For instance, while transaction costs may influence the outsourcing decision, they might not affect international tradability. Contrary to this, transportation costs, cultural factors or trade barriers are not likely to affect outsourcing while being important determinants of international trade. The contribution of this paper is therefore (a) to compute two indicators of job offshorability that differentiate between the effects of outsourcing potential and international tradability while using a series of determinants of offshoring potential of certain activities besides routine and interactivity and (b) to test the theoretical hypotheses regarding the consequences of offshorability on individual income using these two indicators.

To address these questions, we use recent waves (1991, 1998, 2006) of the German Qualifications and Career Survey (BIBB Survey), a representative, individual-level dataset containing rich information on the work environment of individual workers, including tasks, job characteristics, professions, wages, and demographic variables. Instead of analyzing groups of tasks (Spitz-Oener, 2006), we use direct information on job properties, which can be linked to outsourcing potential as well as to the international tradability of a job. In addition to the determinants covered in most of the literature so far (routines, interactivity and ICT use), we include a larger number of job characteristics. We apply principal component analysis, a mathematical procedure that uses an orthogonal transformation to reduce the set of possibly correlated determinants into a smaller set of linearly uncorrelated components. This happens in such a way that these sets explain the largest possible variance in the data. We end up with two indicators along the two dimensions of offshoring. By aggregating these indicators to the occupation, task, or industry level, we observe that most activities or sectors are characterized by either high or low outsourcing potential and international tradability, but that there is a sufficient degree of variation between both dimensions that can and needs to be exploited in further research.

Finally, we estimate a Mincer wage equation augmented by the two measures including several control variables both on the individual as well as on the firm level. We find that the inclusion of these variables significantly adds to explain the variation in employee income. While the outsourcing potential of a job does not always seem to be correlated with lower wages, its international tradability does. The effect is economically significant.

Our research contributes to the literature on trade in tasks and sheds further light on the economic consequences of offshoring or the ability to offshore jobs. When distinguishing between outsourcing potential and international tradability, we can assess that the effect of offshoring potential on wages

in Germany is driven to a larger extent by international tradability and to a lower extent by the outsourcing potential of a job. Furthermore, by including various properties of tasks performed by employees, we are able to open the black box behind the offshoring potential of different jobs.

Regarding further work, our analysis enables us to link the components gained from the task information in the BIBB Survey to further data, for instance via classifications of occupations or industries available in both datasets. This gives new possibilities to further analyze, for example, why offshoring of tasks does not explain recent changes in the German wage structure (cf. Antonczyk et al., 2009), or how offshoring affects other variables such as the employee structure of a firm or the bargaining power of trade unions.

8 References

Antonczyk, D. / Fitzenberger, B. / Leuschner, U. (2009): Can a Task-Based Approach Explain the Recent Changes in the German Wage Structure, in: *Journal of Economics and Statistics (Jahrbücher für Ökonomie und Statistik), 229 (2+3), 214-238.*

Antras, P. (2003) Firms, contracts, and trade structure, in*: Quartely Journal of Economics* 118 (4), 1375-1418.

Antras, P. / Helpman, E. (2004) Global Sourcing, in: *Journal of Political Economy* 112 (3), 552-580.

Autor, D.H. / Levy, F. / Murnane, R.J. (2003): The Skill Content of Recent Technological Change: An Empirical Exploration, in: *Quarterly Journal of Economics*, 118 (4), 1279-1333.

Autor, D.H. / M. Handel (2009): Putting Tasks to the Test: Human Capital, Job Tasks and Wages. NBER Working Paper No. 15116.

Baldwin, R. (2006): Globalisation: The Great Unbundling(s), Graduate Institute of International Studies, Geneva, Economic Council of Finland, Helsinki.

Barba-Navaretti, G. / Venables, A. (2004): *Multinational Firms in the World Economy*, Princeton University Press.

Bardhan, A.D. / Kroll, C.A. (2003): The New Wave of Outsourcing, Research Report, Fisher Center for Real Estate and Urban Economics, University of California, Berkeley.

Becker, S. / Ekholm, K. / Mündler, M. (2009): Offshoring and the Onshore Composition of Tasks and Skills, CEPR Discussion Paper No. 7391.

Becker, S. / Mündler, M. (2012): Trade in Tasks: A Preliminary Exploration with German Data, EFIGE Working Paper No. 45.

Blinder, A.S. (2006): Offshoring: The Next Industrial Revolution?, in: *Foreign Affairs* 85 (2).

Blinder, A.S. (2009): How Many US Jobs Might be Offshorable?, in: *World Economics*, 10 (2), 41-78.

Brown, D.K. / Deardorff, A. / Stern, R. (2004): The Effects of Multinational Production on Wages and Working Conditions in Developing Countries, in: Baldwin, R.E. / Winters, A.L. (Eds.) *Challenges to Globalization: Analyzing the Economics*, University of Chicago Press, 279-329.

Coase, R. (1937): The Nature of the Firm, in: *Economica*, 4 (16), 386-405.

Costinot, A. / Oldenski, L. / Rauch, J. (2011): Adaption and the Boundary of Multinational Firms, in: *Review of Economics and Statistics* 93 (1), 298-308.

Crinò, R. (2009): Offshoring, Multinationals and Labour Market: A Review of the Empirical Literature, in: *Journal of Economic Surveys*, 23 (2), 197-249.

Davenport, E., / El-Sanhury, N. (1991): Phi/Phimax: Review and Synthesis. *Educational and Psychological Measurement 51*, 821–828.

Ethier, W.J. (1986): The Multinational Firm, in: *Quarterly Journal of Economics*, 101 (1), 805-833.

Federico, S. (2012): Headquarter Intensity and the Choice Between Outsourcing Versus Integration at Home or Abroad, in: *Industrial and Corporate Change,* 21, 1337-1358.

Giuri, P. / Torrisi, S. / Zinovyeva, N. (2008) ICT, skills, and organizational change: evidence from Italian manufacturing firms, in: *Industrial and Corporate Change*, 17, 29-64

Görlich, D. (2010): Complementary Tasks and the Limits to the Division of Labour, Working Paper No. 1670, Kiel Institute for the World Economy.

Grossman, G.M. / Hart, O. (1986) The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration, in: *Journal of Political Economy* 94 (4), 691-719.

Grossman, G.M. / Helpman, E. / Szeidl, A. (2005): Complementarities Between Outsourcing and Foreign Sourcing, in: *American Economic Review*, 95, 19-24.

Grossman, G.M. / Rossi-Hansberg, E. (2006): *The Rise of Offshoring: It's not Wine for Cloth Anymore*, Princeton University Press.

Grossman, G.M. / Rossi-Hansberg, E. (2008): Trading Tasks: A Simple Theory of Offshoring, in: *American Economic Review*, 98 (5), 1978-1997.

Hart, O. / Moore, J. (1990) Property Rights and the Nature of the Firm, in: *Journal of Political Economy* 98 (6), 1119-1158.

Hogrefe, J. (2011): Offshoring and Relative Labor Demand from a Task Perspective, *mimeo*.

Jackson, J.E. (2003): *A User's Guide to Principal Components*. New York: Wiley.

Jensen, J.B. / Kletzer, L.G (2010): Measuring Tradable Services and the Task Content of Offshorable Services Jobs, in: Abraham, K. / Harper, M. / Spletzer, J. (eds.): *Labor in the New Economy*, University of Chicago Press, 309-335.

Jolliffe, I.T. (2002): *Principal Component Analysis*. 2nd ed. New York: Springer.

Kaiser, H.F. (1958): The Varimax Criterion for Analytic Rotation in Factor Analysis, in: *Psychometrika,* 23, 187-200.

Lanz, R. / Miroudot, S. / Nordås, H. K. (2011): Trade in Tasks. OECD Trade Policy Working Papers 117. Paris: OECD.

Leamer, E. / Storper, M. (2001): The Economic Geography of the Internet Age, NBER Working Paper No. 8450.

Mankiw, N. / Swagel, P. (2006): The Politics and Economics of Offshore Outsourcing, in: *Journal of Monetary Economics*, 53 (5), 1027-1056.

Merino, F. / Rodríguez, D.R. (2007) Business services outsourcing by manufacturing firms. *Industrial and Corporate Change*, 16, 1147-1173.

Mincer, J. (1974): *Schooling, Experience and Earnings*, Columbia University Press: New York.

Oldenski, L. (2009): Export Versus FDI: A Task-Based Framework for Comparing Manufacturing and Services, *mimeo*.

Oldenski, L. (2012): The Task Composition of Offshoring by U.S. Multinationals, *mimeo*.

Rabe-Hesketh, S. / Everitt, B.S. (2007): *A Handbook of Statistical Analyses Using Stata*. 4th ed. Boca Raton, FL: Chapman & Hall/CRC.

Spitz-Oener, A. (2006): Technical Change, Job Tasks, and Rising Educational Demands: Looking outside the Wage Structure, in: *Journal of Labor Economics*, 24 (2), 235-270.

Schrader, K. / Laaser, C. (2009): Globalisierung in der Wirtschaftskrise: Wie sicher sind die Jobs in Deutschland?, Kieler Diskussionsbeiträge No.465, Kiel Institute for the World Economy.

Van Welsum, D. / Reif, X. (2005): Potential Offshoring: Evidence from Selected OECD Countries, in: Brookings Trade Forum, OECD, 1, 164-194.

9 Appendix

Table A1: Overview of Variables used in Section 5 and Section 6

Variable		Observations	Mean	Std. Dev.	Minimum	Maximum
beruf2	Job Classification, Kldb1988 2 Digit	67.250	63,92	21,61	1	99
beruf3	Job Classification, Kldb1988 3 Digit	67.411	641,95	217,12	10	970
beruf4	Job Classification, Kldb1988 4 Digit	67.411	6.426,18	2.166,58	110	9911
berufsabschnitt	Job Classification (33 Groups)	67.250	22,79	8,61	1	33
berufsbereich	Job Classification (broad)	67.250	4,30	0,96	1	6
branche	Industry Classification	66.040	39,26	19,28	1	67
wizwe	Sector	66.307	2,90	1,49	1	5
land	State	67.327	7,55	4,59	1	16
wage	Gross Monthly Income, detailed	13.616	2.461,84	1.836,35	1	50000
einkommen	Gross Monthly Income, grouped	58.998	4,10	1,99	1	9
age	Age	67.411	40,09	10,59	18	65
azeit	Working Time	66.933	37,78	10,41	5	168
experience	Experience	66.943	20,78	11,55	0	53
gebland	National Origind	67.382	0,07	0,25	0	1
hhsize	Household Size	67.411	2,07	1,08	1	9
indikdet	Firm Size Class	65.634	3,11	1,66	1	6
jahr	Year	67.411	1.997,17	5,77	1991	2006
kenntnis	Qualification	63.984	1,87	1,06	1	4
kids	Number of Kids in Household	67.391	0,52	0,50	0	1
partwork	Partner Works	46.870	0,33	0,47	0	1
schule	Education	66.151	1,99	1,04	1	4
sex	Sex	67.411	0,45	0,50	0	1
staat	Foreign Citizenship	67.193	0,04	0,18	0	1
stib	Job Position	66.373	1,64	0,48	1	2
tenure	Tenure	64.686	11,12	9,52	0	50

Source: BIBB Survey 1991, 1998, 2006, own calculations.

Table A2: Outsourcing Potential, International Tradability, and Employee Income

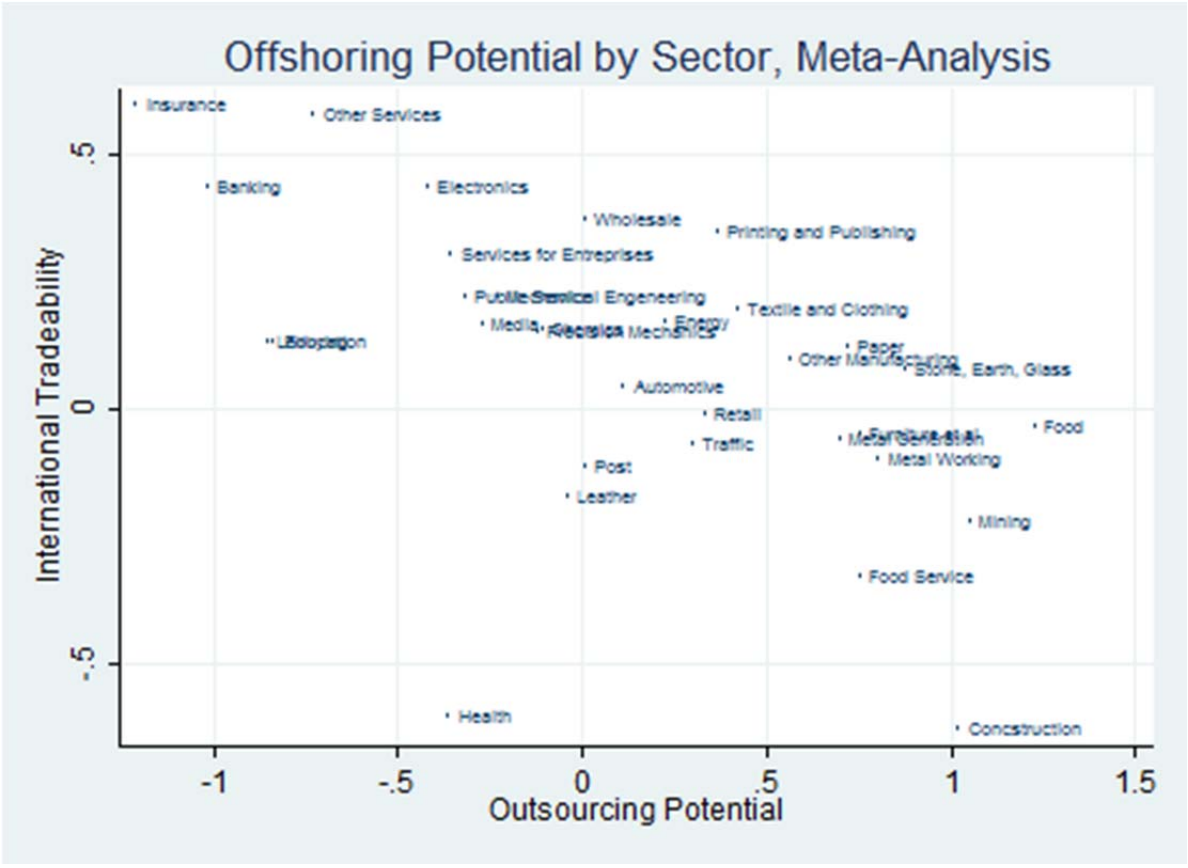
Variable	Income Class		ln Monthly Gross Wage	
	(1)	(2)	(3)	(4)
Outsourcing Potential	0.3477***	0.0064	0.1100***	0.0020
	(0.0060)	(0.0050)	(0.0061)	(0.0044)
International Tradeability	-0.4790***	-0.2805***	-0.1644***	-0.0827***
	(0.0046)	(0.0065)	(0.0041)	(0.0048)
Computer Use		0.0223		0.0770***
		(0.0163)		(0.0140)
Blue-Collar Worker		-0.0401**		-0.0466***
		(0.0191)		(0.0142)
Sex		-0.7631***		-0.2058***
		(0.0151)		(0.0104)
Age		0.0029		0.0245***
		(0.0077)		(0.0060)
Age squared		0.0003***		-0.0002***
		(0.0001)		(0.0001)
Tenure		0.0377***		0.0261***
		(0.0020)		(0.0014)
Tenure squared		-0.0005***		-0.0004***
		(0.0001)		(0.0000)
Experience		0.0377***		0.0028
		(0.0039)		(0.0029)
Experience squared		-0.0011***		-0.0001
		(0.0001)		(0.0001)
Working Time		0.0679***		0.0274***
		(0.0010)		(0.0007)
Hauptschule (reference)				
Realschule		0.0743***		0.0262**
		(0.0142)		(0.0102)
Abitur		0.3523***		0.1139***
		(0.0228)		(0.0141)
Vocational Training (reference)				
School Education		0.0905***		0.0456***
		(0.0192)		(0.0120)
Firm Qualification		0.0026		-0.0156
		(0.0133)		(0.0281)
University		0.5812***		0.1204***
		(0.0297)		(0.0177)
Household size		-0.0171***		0.0041
		(0.0061)		(0.0088)
Kids in HH		-0.0007		0.0658***
		(0.0114)		(0.0131)
Partner is Working		0.1482***		0.0797***
		(0.0170)		(0.0128)
Foreign Citizenship		-0.0473		-0.0102
		(0.0404)		(0.0245)
Constant	4.2156***	0.2723**	7.5374***	5.6527***
	(0.0079)	(0.1326)	(0.0070)	(0.1103)
Dummy Variables	No	Yes	No	Yes
N. of Obs.	49194	49194	11412	11412
F-Stat	6996.49	1621.42	858.91	348.67
R squared	0.22	0.64	0.15	0.64
AIC	195136.17	157639.86	21161.15	11519.92

Note: Standard deviation in parentheses: p<0.10, ** p<0.05, *** p<0.01; Dummy variables contain region (Bundesland), firm size classes, industry classification, job classification and year;
Source: BIBB/IAB/BAuA Worker Survey 1991, 1998, 2006 (income class); 2006 (in monthly gross wage), own calculations.

Figure A3: Outsourcing Potential and International Tradability by Sector, Varimax Rotation

Source: BIBB Survey 1991, 1998, 2006, own calculations.

Figure A4: Outsourcing Potential and International Tradability by Sector, Meta-Analysis



Source: BIBB Survey 1991, 1998, 2006, own calculations.

IAW-Diskussionspapiere

Die IAW-Diskussionspapiere erscheinen seit September 2001. Die vollständige Liste der IAW-Diskussionspapiere von 2001 bis 2010 (Nr. 1-69) finden Sie auf der IAW-Internetseite www.iaw.edu/publikationene/iaw-diskussionspapiere.

IAW-Diskussionspapiere seit 2011:

Nr. 70
Banks in Space: Does Distance Really Affect Cross-Border-Banking? (Februar 2011)
Katja Neugebauer

Nr. 71
An Almost Ideal Wage Database Harmonizing the ILO Database October Inquiry (Februar 2011)
Daniela Harsch / Jörn Kleinert

Nr. 72
Disclosure Risk from Interactions and Saturated Models in Remote Access (Juni 2011)
Gerd Ronning

Nr. 73
Disclosure Risk from Factor Scores (Juli 2011)
Gerd Ronning / Philipp Bleninger

Nr. 74
Endogenous Transport Costs in International Trade (Juli 2011)
Jörn Kleinert / Julia Spies

Nr. 75
International Sourcing, Product Complexity and Intellectual Property (August 2011)
Alireza Naghavia / Julia Spies / Farid Toubal

Nr. 76
Labor Demand During the Crisis: What Happened in Germany? (Oktober 2011)
Olga Bohachova / Bernhard Boockmann / Claudia M. Buch

Nr. 77
Unemployment and Portfolio Choice: Does Persistence Matter? (November 2011)
Franziska M. Bremus / Vladimir Kuzin

Nr. 78
The Role of Employees for Post-Entry Firm Growth (Februar 2012)
Andreas Koch / Jochen Späth / Harald Strotmann

Nr. 79
Nationality Matters: The Geographic Origin of Multinationals and (Februar 2012)
the Productivity of their Foreign Affiliates
Christian Arndt / Julia Spies

Nr. 80
All You Need Is Trade: On the In(ter)dependence of Trade and Asset Holdings in Gravity Equations (März 2012)
Jörn Kleinert / Katja Neugebauer

Nr. 81
The Tradeoff between Redistribution and Effort: Evidence from the Field and from the Lab (März 2012)
Claudia M. Buch / Christoph Engel

Nr. 82
Factor Shares and Income Inequality – Empirical Evidence from Germany 2002-2008 (Mai 2012)
Martin Adler / Kai Daniel Schmid

Nr. 83
Network and Selection in International Migration to Spain (Mai 2012)
Nina Neubecker, Marcel Smolka, Anne Steinbacher

IAW-Diskussionspapiere

Nr. 84
Do Better Capitalized Banks Lend Less? Long-Run Panel Evidence from Germany (Mai 2012)
Claudia M. Buch / Esteban Prieto

Nr. 85 (Juni 2012)
From the Stability Pact to ESM – What next?
Claudia M. Buch

Nr. 86 (Juni 2012)
The Connection between Imported Intermediate Inputs and Exports: Evidence from Chinese Firms
Ling Feng / Zhiyuan Li / Deborah L. Swenson

Nr. 87
EMU and the Renaissance of Sovereign Credit Risk Perception (August 2012)
Kai Daniel Schmid / Michael Schmidt

Nr. 88 (September 2012)
The Impact of Random Help on the Dynamics of Indirect Reciprocity
Charlotte Klempt

Nr. 89
Specific Measures for Older Employees and Late Career Employment (Oktober 2012)
Bernhard Boockmann / Jan Fries / Christian Göbel

Nr. 90
The Determinants of Service Imports: The Role of Cost Pressure and Financial Constraints (Oktober 2012)
Elena Biewen / Daniela Harsch / Julia Spies

Nr. 91
Mindestlohnregelungen im Maler- und Lackiererhandwerk: eine Wirkungsanalyse (Oktober 2012)
Bernhard Boockmann / Michael Neumann / Pia Rattenhuber

Nr. 92
Turning the Switch: An Evaluation of the Minimum Wage in the (Dezember 2012)
German Electrical Trade Using Repeated Natural Experiments
Bernhard Boockmann / Raimund Krumm / Michael Neumann / Pia Rattenhuber

Nr. 93 (Januar 2013)
Outsourcing Potentials and International Tradability of Jobs
Evidence from German Micro-Level Data
Tobias Brändle / Andreas Koch