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Daniel Baumgarten

International Outsourcing, the Nature of Tasks, and Occupational Stability

Empirical Evidence for Germany

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Daniel Baumgarten*

International Outsourcing, the Nature of Tasks, and Occupational Stability – Empirical Evidence for Germany

Abstract

Using a large administrative data set of individual employment histories in Germany, this paper studies how international outsourcing affects the individual risk of leaving the occupation. Moreover, a rich data set on tasks performed in occupations is used to better characterize the sources of worker vulnerability. While international service outsourcing is associated with an increase in overall stability, the impact of international material outsourcing is slightly negative. These effects, however, are not uniform but depend on the nature of tasks performed in the occupation. Higher intensities of non-routine and interactive tasks are associated with a more beneficial (or less adverse) impact of international outsourcing on occupational stability.

JEL Classification: F16, J23, J24, J63

Keywords: Occupational stability, international outsourcing, duration analysis

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1 Introduction

Labour market adjustment needs caused by increased opportunities for global production sharing are a major concern in industrialized countries (e.g. OECD, 2007). Advances in information and communication technology and the lowering of transportation costs have led to the tradeability of formerly untradeable (intermediate) goods and services, making it feasible to break down the production process into increasingly many separate stages without the need of geographic concentration. A boom in international outsourcing activities undertaken by firms in industrialized countries, which take advantage of international labour cost differences and specialization patterns, has been the consequence.[1,2] While there is a broad consensus on the existence of long-term efficiency gains due to this changed division of labour, the necessary reallocation of resources may be associated with short-term costs that have to be taken into account when estimating the benefits of free trade (cf. Davidson and Matusz, 2004).

Although these adjustment costs may take on different forms, previous research has aimed to capture them by estimating the effect of international outsourcing on the incidence of unemployment or of leaving the current employer, thereby also addressing the question of whether workers have become more vulnerable and employment relationships less stable.[3] This paper follows this stream of the literature but focuses on the risk of leaving the current *occupation*, not employment or the employer, which can be motivated on several grounds.

First, the recent phase of the international fragmentation of production processes can be best understood within the conceptual framework of trade in tasks as opposed to trade in (finished) goods (Grossman and Rossi-Hansberg, 2008). According to the related literature it is the nature of tasks performed on the job that determines the degree of vulnerability towards foreign competition. Characteristics that have been put forward as being relevant in this context are the prevalence of routine tasks (Levy and Murnane, 2004, closely following Autor et al., 2003), the importance of codifiable rather than tacit information (Leamer and Storper, 2001) as well as the degree of geographic proximity and the amount of physical contact required (Blinder, 2006). These characteristics go beyond the traditional high-skill/low-skill dichotomy and are more attached to the occupation than to the industry, the firm or the level of educational attainment. For example, high-skilled software programmers are probably more affected by foreign competition than

[1] Hummels et al. (2001) provide evidence on the development of international material outsourcing over time whereas Amiti and Wei (2005a) document the more recent rise in international service outsourcing.

[2] With the term international outsourcing I refer to the relocation of activities abroad that previously have been performed in the home country, irrespective of whether this occurs through foreign direct investment or through contractual arrangements at arm's length. The term offshoring is often used as a synonym.

[3] Recent examples include Geishecker (2008), Munch (2008), Bachmann and Braun (2008) and OECD (2007). A detailed literature review is given in the next section.

less-skilled taxi drivers or nurses.

Second, leaving the occupation is associated with costs since it involves a loss of specific human capital. Kambourov and Manovskii (2009) show that the returns to occupational tenure can be substantial and outweigh those to firm and industry tenure.[4] Thus, the authors challenge the concepts of firm-specific (see Farber, 1999 for a survey) and industry-specific (Neal, 1995; Parent, 2000) human capital. In a very related vein, Gathmann and Schönberg (2007) develop the concept of task-specific human capital and state that the extent to which skills can be transferred between occupations depends on the similarity of tasks performed in them.[5] Frictional non-employment, which may follow after the termination of an employment relationship in a particular occupation, is another source of adjustment costs.

Third, in spite of some data limitations to be discussed in Section 3, including occupational changes makes it possible to also consider adjustments within firms, adding an additional and potentially important feature to the analysis.[6]

The empirical analysis focuses on Germany, which is an interesting case to address since it is not only the largest country in the European Union but also very open to international trade. It generally features among the highest export levels of the world. Moreover, the nearby countries in central and eastern Europe with their highly skilled but in general still lower-paid workforce provide ample opportunities for intensive production sharing. A hazard model in discrete time (grouped into yearly intervals) is used to determine if and how international outsourcing affects the individual risk of leaving the current occupation and how the impact varies with the intensity of non-routine and interactive tasks of the occupation. For this purpose data on individual employment histories is combined with industry-level indicators for both international material and international service outsourcing as well as information on the nature of tasks predominantly performed in occupations.

The main result obtained in this paper is that the impact of both international material outsourcing (in the manufacturing sector) and international service outsourcing (in the service sector) on occupational stability varies with the intensity of non-routine and interactive tasks of the occupation, with higher degrees of non-routineness and interactivity being associated with a less negative or more positive effect on stability. While international service outsourcing is associated with an increase in overall stability, the impact of material outsourcing is slightly negative.

[4]In their study on the US Kambourov and Manovskii (2009) estimate that ceteris paribus five years of occupational tenure are associated with an increase in wages in the range of 12 to 20 percent.

[5]According to Gathmann and Schönberg (2007) task-specific human capital accounts for 25 to 40 percent of overall wage growth over a ten year period in Germany.

[6]Zimmermann (1998) provides a detailed picture of the different forms of job mobility in Germany. He uses survey data from the German Socioeconomic Panel and finds that changes of occupation occur more frequently than changes of the workplace. Moreover, within-firm changes are more important than changes outside the firm.

The paper is structured as follows. The next section discusses the related literature. The third section describes the data used for the analysis and the fourth section contains a description of the empirical strategy. The fifth section presents the estimation results, the sixth section contains some extensions and robustness checks, and the last section summarizes the main findings and concludes.

2 Related literature

Starting with Feenstra and Hanson (1996, 1999), the early empirical literature on the labour market effects of international outsourcing focused on aggregate labour demand and wages for different skill groups. The analysis of short-term dynamics, however, has been initiated only recently. This paper is most closely related to a limited but growing number of studies that estimate the effect of international outsourcing on worker flows at the micro level. Micro-level studies that relate individual transition probabilities to industry-aggregated measures of outsourcing suffer less from endogeneity and aggregation bias than studies in the line of Kletzer (2000), who analyzes displacement rates at the industry level in response to increasing foreign competition. In particular, the labour market behaviour of an individual worker can be expected not to influence industry aggregates.

Egger et al. (2007) focus on the sectoral reallocation of workers. Using a random sample of Austrian male workers, they find that international outsourcing and trade negatively affect the probability of both staying in and moving into the manufacturing sector, which particularly holds for that part of manufacturing that has a revealed comparative disadvantage. Although they use data at the micro level, the only (time-varying) individual characteristic they are able to control for is age. Therefore, they do not provide evidence on how their results depend on other potentially important worker characteristics. Geishecker (2008) uses data from the German Socioeconomic Panel and finds that international outsourcing significantly reduces individual employment security in the manufacturing sector. He furthermore tests whether this effect varies with the skill level of the individual but cannot reject the hypothesis of a uniform impact. Munch (2008) with data for Denmark and Bachmann and Braun (2008) with data for Germany extend the approach of Geishecker (2008) by distinguishing between competing exit states. Munch (2008) finds that international outsourcing reduces the job-to-job hazard for all skill groups. However, the job-to-unemployment hazard increases for low- and medium-skilled workers while it remains unaffected for high-skilled workers. The quantitative impact is very limited, however. Bachmann and Braun (2008) arrive at the conclusion that in the manufacturing sector only the probability of a transition to non-participation increases with outsourcing intensity. This effect is strongest for medium-skilled workers. In contrast, the authors even find strong and stability-increasing effects of outsourcing in the service sector, particularly for high-skilled workers. The authors hint at positive productivity effects as a potential explanation for this at first sight surprising result.

Taken together, the evidence on skill-dependent effects of international outsourcing on employment stability – with skill usually being defined according to the level of educational attainment – is rather mixed, thus further encouraging the analysis of other relevant job or worker characteristics. Authors such as Leamer and Storper (2001), Levy and Murnane (2004) as well as Blinder (2006) have pointed to the nature of performed tasks on the job as a more important determinant of worker vulnerability. Grossman and Rossi-Hansberg (2008) formalize this notion in their theoretical framework of trade in tasks. However, their model focuses on the impact of falling offshoring costs on equilibrium wages and does not make predictions on short-term labour market dynamics. In fact, the results of the model are based on the assumption of flexible wages, which may be questionable in the short run.

On the empirical side, there are a few studies that relate occupations and tasks to international outsourcing, but they do so within a classical labour demand estimation framework. Information on employment prospects of individual workers is lost in this context. Crinò (2008) estimates demand elasticities for different US white-collar occupations and finds that, within skill groups, international service outsourcing penalizes tradeable occupations and benefits complex non-tradeable occupations. In a related paper Becker et al. (2007) analyze how the onshore workforce composition of German multinational enterprises responds to a change in their offshore employment levels, thus proxying foreign direct investment expansions. They obtain as a result that an increase in offshore employment leads to a relative increase in the number of high-skilled workers and to a relative shift towards more non-routine and interactive tasks with the former effect being more pronounced.

A recent study that looks, among other things, at the occupational dimension of international outsourcing from an individual-level perspective and thus chooses an approach that is more comparable to the one used in this paper, is by Liu and Trefler (2008) on the US. They find that the probability of changing the occupation is positively (negatively) related to the import (export) of services from (to) low-wage countries. This effect is economically small, however.

This study contributes to the literature in the following ways. First, to the best of my knowledge it is the first one to relate individual occupational stability to international outsourcing for a European country. Moreover, compared to the study on the US by Liu and Trefler (2008) the longitudinal information contained in the individual employment histories is more extended. Second, it maps task categories into occupations, thus allowing for a more detailed identification of characteristics that have an influence on the vulnerability of occupations. Third, it distinguishes between international material and international service outsourcing, thus expanding on Bachmann and Braun (2008) who consider (narrow) outsourcing in the manufacturing and in the service sector, respectively.

3 Data

3.1 Individual employment histories

The principal data set used in the empirical analysis is the IAB Employment Sample.[7] It is a 2-percent random sample of administrative social security records, which is provided by the Institute for Employment Research (IAB) and the German Federal Employment Agency.[8] The population is the universe of employees in Germany who were employed in a job covered by social security at least once in the time period 1975–2004 (for employees in western Germany) or 1992–2004 (for employees in eastern Germany). This includes roughly 80 percent of all employees. Civil servants and the self-employed are not included. The social security records are based on notifications issued at the beginning and end of each employment and unemployment spell. Moreover, employers send an updating report on behalf of their employees at the beginning of each calendar year.

The information provided for the employment spells includes – apart from the exact starting and end dates of a particular employment relationship as well as other individual and workplace characteristics – the occupation of the individual, following the classification of the German Federal Employment Agency (Bundesantalt für Arbeit, 1988). With respect to whether an occupational spell has ended, the notification scheme has the consequence that intra-establishment occupation changes can only be observed at an annual basis while changes of the occupation that occur together with an establishment change and transitions into non-employment are in principle available on a daily basis. To arrive at a consistent time scale, I focus on yearly time intervals throughout the analysis.

Due to the administrative nature of the data its reliability and quality can be regarded as being very high. Other advantages are the large sample size and the absence of problems common to many survey-based panel data sets such as panel attrition or recall bias. One advantage applicable particularly to the present study is the fact that the occupational coding is identical to the one used in the German Qualification and Career Survey, where the task data is drawn from. This makes it possible to map task contents into occupations.

3.2 Data on the nature of tasks

Data on task contents of occupations is drawn from the 1998/99 wave of the German Qualification and Career Survey, which was jointly carried out by the Federal Institute for Vocational Education and Training (BIBB) and the IAB and covers about 30,000 individuals between 16 and 65 years.[9] The distinct advantage of this survey, previously used for

[7]See Bender et al. (2000) as well as Drews (2007) for a detailed description of the data.

[8]The weakly anonymised data was first accessed during a stay at the Research Data Centre (FDZ) of the German Federal Employment Agency at the IAB and subsequently via controlled remote data processing.

[9]The study is also available for cross-sections of the years 1979, 1985/86 and 1991/92. The most recent wave has been chosen because the sample year corresponds to the starting year of the empirical

example by DiNardo and Pischke (1997) and Spitz-Oener (2006), is that respondents do not only state their occupation but also give a detailed account of the tasks they perform on the job and the associated work tools used. Becker et al. (2007) propose a technique to map task contents into occupations. Specifically, they derive measures of non-routineness and interactivity for each occupation, thus operationalizing the task categories suggested by Levy and Murnane (2004) and Blinder (2006). As a starting point, they make use of a list of 81 surveyed tools. For each of the items they classify the associated task (i) as routine or non-routine and (ii) as interactive or non-interactive. A higher number of non-routine (interactive) tasks – averaged over two-digit occupations[10] – implies a higher intensity of the corresponding task category. I largely follow their proposition and construct three occupation-specific task measures: the degree of non-routineness, the degree of interactivity[11], and the interaction (measured as the product) between the two. The reasoning for the latter measure is that occupations which score poorly in both dimensions may be the most vulnerable ones. All of the measures are continuous and (after a normalization) lie in the range of 0 to 1, with 1 denoting maximum intensity. Details on the variable construction are relegated to the Appendix. Moreover, note that as part of the sensitivity analysis I also check if results are robust to the application of alternative task-to-occupation mappings.

3.3 International outsourcing indicators

Largely following the literature and based on the proposition of Feenstra and Hanson (1996, 1999), I measure international outsourcing intensity at the industry level as the share of imported intermediate inputs in total production, thus proxying that part of value added that could have been created in the home country but has in fact been created abroad. Making use of input-output tables supplied by the German Federal Statistical Office, which explicitly distinguish between domestic and foreign inputs at the industry level, I construct two measures. The first one captures international material outsourcing. As the concept of material outsourcing is not very meaningful for the service sector – at least not as a potential substitute for domestic labour – I calculate it for the manufacturing industries only. The chosen measure restricts attention to inputs imported by the domestic (two-digit) industry j from the same industry abroad:

$$MOS_{jt} = \frac{Imported\,Intermediates_{\,jjt}}{Y_{jt}}. \tag{1}$$

analysis.

[10] A few occupations had to be grouped to have a sufficient number of observations per occupation.

[11] Note that I depart from Becker et al. (2007) with respect to the measure of interactivity. In particular, in addition to the tools list I also make use of a separate questionnaire on 13 job descriptions since I find that the former alone is not able to capture in a fully satisfactory way the highly interpersonal nature of some classical service-oriented occupations. See Appendix A for the details.

In the terminology of Feenstra and Hanson (1999) this corresponds to the narrow concept of international outsourcing. Compared to a broader measure, which includes intermediate inputs imported from any other (manufacturing) industry k abroad, it better captures the idea of a make-or-buy decision and hence, is the preferred one.

International service outsourcing is approximated through the share of imports from commercial service industries abroad in industry output:

$$SOS_{jt} = \frac{\sum_{l \in CS} Imported\, Intermediates_{\,ljt}}{Y_{jt}}, \tag{2}$$

where I closely follow Amiti and Wei (2005a,b, 2006) as far as the industries included in the numerator of the measure are concerned.[12] Output (Y_{jt}) is measured as the industry's production value.

Industry variables are at the NACE Rev.1.1 two-digit level (WZ2003). Comparable input-output tables are available for the time period 1995 to 2004. Figure 1 displays the development of the proposed measures over time and differentiated by the sector of economic activity. It becomes apparent that outsourcing activities have slowed down a bit at the beginning of the new century. Indeed, material outsourcing in the manufacturing sector peaks in the year 2000 whereas international service outsourcing reaches its maximum in 2001 (service sector) and 2002 (manufacturing sector), respectively. This also confirms that material and service outsourcing follow different time paths and consequently, can be identified separately in the empirical analysis. Furthermore, the sector-level figures mask considerable heterogeneity in the development over time across two-digit industries – which is the relevant level of aggregation in the subsequent analysis.

Unfortunately, the NACE classification is available in the individual employment data only from 1999 onwards. This shortens the time period available for the empirical analysis.

4 Empirical strategy

It is common for studies on individual job separations to control for state or duration dependence. The longer a match persists the more match-specific human capital is accumulated and the less likely a dissolution occurs. The discussion on occupation-specific human capital (cf. Kambourov and Manovskii, 2009) suggests that the same argument can be put forward to occupational matches. Hence, a duration model, which explicitly controls for the time spent in the occupation, is a natural choice.

I construct occupational spells from the individual employment histories as the consecutive time working in a given two-digit occupational category. Focusing on the two-

[12] In particular, these comprise: Post and telecommunications (NACE Rev.1.1 code 64); banking and financial intermediation services (65); insurance services (66); activities related to financial intermediation and insurance (67); renting of machinery and equipment (71); computer and related activities (72); research and development (73); other business activities (74).

rather than the three-digit level reduces potential problems of measurement error. I define an occupational spell as having ended if at least one of the following conditions is met: a) There is a change in the two-digit occupational category of the individual; b) the individual experiences a spell of unemployment; or c) the social security records display an interruption of more than 60 days in the employment history of the individual. The latter case is interpreted as an intervening spell of non-participation. All three instances indicate that an employment relationship in this particular occupation is not stable.

As mentioned in Section 3.1, intra-establishment occupation changes are only measured at a yearly basis. Hence, even though all other transitions are measured at daily frequency, I choose a specification in discrete time, grouped into yearly intervals. In accordance with the notification scheme for the social security records, the 1st of January of each year is taken as the date of reference, i.e., I analyze whether occupational spells running at the beginning of the year end in failure by the end of the year.[13] Grouping the time variable in this way further has the advantage of being consistent with the main variables of interest, that is the outsourcing indicators, which are available at an annual basis only.

The empirical analysis is based on a stock sample and covers the time period from 1999 to 2003. The choice of the starting year is driven by the availability of the NACE industry classification in the individual employment data whereas the year 2004 had to be excluded because I allow for a transition period of up to 60 days to determine whether a spell has ended in failure. Furthermore, I restrict the analysis to full-time workers. Hence, I discard apprentices, trainees, marginal and part-time workers as well as individuals who are currently on leave due to military service, child-bearing, etc.[14] In addition, I do not consider spells in agricultural and mining occupations. If an individual has more than one occupation at the same time, I only use information on the highest-paying one. Furthermore, spells with missing information in any of the covariates are dropped.[15]

The data is organized in person-year form as suggested by Allison (1982) and Jenkins (1995). The hazard of leaving the occupation is defined as the exit probability in the time

[13] This strategy leads to an underrepresentation of short occupational spells since it excludes the ones that start after the 1st of January and end before the year is over. A considerable share of them, however, corresponds to specific worker groups with a lot of short-term appointments such as seasonal workers, artists, etc. It is therefore unlikely that the duration of these (very) short spells is primarily driven by international factors.

[14] To be precise, I drop the entire spell if more than 25 percent of the corresponding person-year observations are not in full-time employment. This way I aim to avoid an excessive loss of observations in cases in which just a very short intervening period is spent in the same occupation but in part-time employment. However, changing this threshold, e.g. dropping the entire spell if at least one of the corresponding person-year observations is not in full-time employment, does not affect the regression results in a significant way.

[15] In this respect the level of education/training constitutes the only exception as here a 'missing education' dummy is explicitly included. This is due to its relevance for the research question and the peculiarity of the data (cf. footnote 16).

interval $[t-1,\, t)$ conditional upon survival up to $t-1$:

$$\lambda_i(X_{it}, \alpha_{it}) = Pr(t-1 \leq T < t | T \geq t-1, X_{it}, \alpha_{it}), \tag{3}$$

where T is the random duration variable, X_{it} a vector of individual characteristics and α_{it} a set of interval dummy variables that capture duration dependence in a flexible way. The unconditional probability of leaving the occupation in time interval $[t-1,\, t)$ then is

$$Pr(t-1 \leq T < t | X_{it} \ldots X_{i1}, \alpha_{it} \ldots \alpha_{i1}) = \lambda_i(X_{it}, \alpha_{it}) \times \prod_{j=1}^{t-1}(1 - \lambda_i(X_{ij}, \alpha_{ij})). \tag{4}$$

I choose a complementary log-log representation of the hazard rate:

$$\lambda_i(X_{it}, \alpha_{it}) = 1 - \exp\left(-\exp\left(\beta' X_{it} + \alpha_{it}\right)\right), \tag{5}$$

which is appropriate if one assumes a proportional hazards model for the underlying data process in continuous time. Multiple occupational spells are allowed. Let K denote the total number of spells by each individual and let d_{ik} be a censoring indicator, which takes the value of 1 if the k-th occupational spell of individual i is completed and 0 otherwise. The likelihood function to be maximized then is

$$L = \prod_{i=1}^{n}\prod_{k=1}^{K}\left(\frac{1 - \exp\left(-\exp\left(\alpha_{it} + \beta' X_{it}\right)\right)}{\exp\left(-\exp\left(\alpha_{it} + \beta' X_{it}\right)\right)}\right)^{d_{ik}} \times \prod_{j=1}^{t}\exp\left(-\exp\left(\alpha_{ij} + \beta' X_{ij}\right)\right). \tag{6}$$

The regressor vector X_{it} includes individual and establishment characteristics (age, gender, nationality, the level of education/training[16] and establishment size) as well as the occupation-specific task measures and the industry-aggregated outsourcing indicators as described in Section 3. To control for other time-varying industry characteristics (e.g. export orientation and technological change) and in accordance with the cited empirical literature, a measure of net exports ($exports_{j(i)t} - imports_{j(i)t}$), industry output ($Y_{j(i)t}$) and the capital-output ratio ($K_{j(i)t}/Y_{j(i)t}$) add to the list of explanatory variables. In addition, the model also contains a full set of time, industry and region dummies and the regional unemployment rate as supplied by the German Federal Employment Agency in order to capture permanent differences between industries as well as general and regional economic conditions. The presence of industry fixed effects ensures that it is indeed the variation of international outsourcing intensity (and the other time-varying industry

[16] I define three educational categories. 1) Low: no vocational training, no high-school; 2) Medium: high-school and/or vocational training; 3) High: university or technical college. Note that the information given in the social security records on the education sometimes suffers from a poor quality, which manifests itself in missing values or inconsistencies across consecutive spells of the same individual. Therefore I use an imputation procedure proposed by Fitzenberger et al. (2006), which helps to overcome this problem. Nevertheless, for some individuals the educational information remains missing so that they have to be grouped into a separate category.

variables) over time that drives the regression results, not their differences in the cross-section. The chosen intervals for the set of duration dummies, α_{it}, are $(0;1]$ years, $(1;2]$ years, $(2;3]$ years, $(3;4]$ years, $(4;5]$ years, $(5;7]$ years, and $(7;\infty)$ years. This choice is much in line with Geishecker (2008) and Bachmann and Braun (2008) and ensures full flexibility at the beginning of an occupational spell when most of the movements can be expected to take place. Table 1 displays summary statistics of the variables included in the empirical analysis.

The chosen empirical strategy does not come without caveats. First, one consequence of stock sampling is the problem of left truncation or delayed entry. Many ongoing occupational spells already started before 1999. However, as the records contain information on the individual employment histories since 1975 (western Germany) and 1992 (eastern Germany), respectively, and given the chosen specification of the baseline hazard, I am able to tackle this problem with standard techniques by conditioning on the elapsed duration. Note that I opt against the alternative of a flow-sampling scheme because the period of analysis from 1999 to 2003 would then leave me with short occupational spells only. These would be representative of new occupational matches but not at all of the employed population in Germany. Moreover, previous research has shown that the (negative) impact of international outsourcing on employment stability is particularly pronounced for long durations (cf. Geishecker, 2008) so that a lot of relevant information would be lost. Results based on the flow sample, however, are available on request from the author. They are not different from the ones reported here in a qualitative sense.

Second, ignoring unobserved individual heterogeneity when it is important can lead to biased estimation results of the baseline hazard and the response of the hazard rate to changes in the exogenous variables (e.g. Lancaster, 1990). Whereas disentangling true duration dependence from a selection effect is not the aim of the analysis and hence unproblematic, potential biases in the coefficients of the exogenous variables give more cause for concern. This problem, however, has been shown to be important in the presence of a wrong functional form of the baseline hazard and much less so when a flexible specification is chosen (cf. for example Meyer, 1990; Dolton and van der Klaauw, 1995). Moreover, theoretical reasonings (e.g. van den Berg, 2001) and simulation results (cf. Baker and Melino, 2000) indicate that, if present at all, biases tend towards zero so that the estimates should rather be conservative and not exaggerated. Hence, for the largest part of the analysis I do not explicitly control for unobserved heterogeneity, but I do adjust the standard errors allowing for correlations between consecutive spells of the same individual. Note that I subject this approach to a sensitivity check. In particular, I examine if the results change when a normally distributed random effect is allowed for in the regression.[17] However, do-

[17]In principle, due to the presence of repeated spells one could also control for unobserved heterogeneity in a fixed-effects regression framework. However, the sample period is short so that a large – and most likely not random – share of observations (from individuals without repeated spells) would be lost. In general, censoring is widespread and not independent of the length of preceding spells, which renders a

ing so with the stock sample at hand does not take account of the potential self-selection into longer occupational spells based on unobservables, either (also cf. Geishecker, 2008).

Finally, a cautionary remark is in order with regard to statistical inference and significance testing of the model parameters. As Moulton (1986, 1990) shows, including aggregate variables in a regression at the micro level can potentially lead to (downward) biased standard errors due to contemporaneous correlation. This applies to this study, which includes variables at the level of the industry and the region. As Geishecker (2008) observes in his related study, the problem with the remedies most often used in the literature for the case of non-linear models is that they rest on the assumption of a large number of groups relative to the number of observations. This is not the case in the present study so that their applicability is questionable. Hence, following Geishecker (2008), the route taken here is to include a full set of industry and region dummies, which account for any contemporaneous residual correlation that is due to time-constant unobserved group heterogeneity.

As Bachmann and Braun (2008) point out, there are remarkable differences between the manufacturing and the service sector as far as the effect of international outsourcing on employment stability is concerned. Therefore the model in equation (6) is estimated separately for both sectors.[18] As a consequence, I right-censor occupational spells that are continued in a sector that is not under consideration.

I run separate regressions for each of the three task measures. In the baseline specifications the outsourcing indicator(s) and the task measures enter as separate regressors whereas the extended specification allows for interaction effects between the two.

5 Estimation results

Table 2 displays results for the non-interacted baseline specification. As the models with the three different task measures yield almost identical estimates, attention is restricted to the one that includes the combined non-routineness/interactivity measure.

Since the focus of this paper is on the effect of international outsourcing, I will only highlight some of the other estimates. They are in line with previous studies on both employment stability and occupational mobility, whose interplay determines the duration of occupational matches (e.g. Farber, 1999; Kambourov and Manovskii, 2008).

In particular, the risk of experiencing a failure decreases with tenure in occupation and age – with the exception of the age category 60–65, where retirement decisions become increasingly important. The occupational hazard rate is higher for lower-educated workers and foreigners, reflecting their greater difficulty in acquiring occupation-specific human

fixed-effects treatment inappropriate (cf. van den Berg, 2001).

[18]The manufacturing sector comprises the NACE codes 15–37. In the service sector I restrict attention to private (for-profit) services, that is the NACE codes 50–74.

capital. Interestingly, women and high-educated individuals are more likely to end their occupational spell in the manufacturing sector but less likely to do so in the service sector, which points at differences in the respective career paths. As far as the task measures are concerned, it becomes apparent that spells in occupations characterized by higher degrees of non-routine and interactive tasks are less likely to end. Turning to the other industry-level variables, the only noteworthy effect stems from the capital-output ratio. The latter has a strong stability-reducing impact in manufacturing, possibly capturing the effect of technological change. Finally, occupational stability increases with establishment size with the exception of the largest category (>= 1000 employees), where it starts to decrease again, particularly in the service sector. Important internal labour markets may explain this result.

International outsourcing in the manufacturing sector

The three basic specifications without interaction terms reveal that the risk of leaving the occupation significantly increases with international material outsourcing and significantly decreases with international service outsourcing (Table 2, middle column). Hence, the latter does not act in a disrupting but in a stabilizing way. This finding is consistent with the view that in the manufacturing sector service outsourcing indeed acts in a manner similar to technological progress and has a productivity-enhancing effect (Grossman and Rossi-Hansberg, 2008). As a consequence, the value of occupational matches also increases and less of them are destroyed. This positive effect seems to more than offset the relocation of certain tasks abroad. The effect is also quantitatively important, with a one-percentage-point increase in outsourcing intensity leading to a reduction in the hazard rate of around 17 percent.[19] However, one has to keep in mind that the level of service outsourcing in the manufacturing sector still is quite low. Between 1999 and 2003 the overall increase was about 0.22 percentage points, so that the cumulated stability-increasing effect over the sample period amounts to about 4 percent on average. On the other hand material outsourcing, which is more substitutional to the work accomplished in the manufacturing sector at home, reduces occupational stability. The economic significance, however, is almost negligible with a one-percentage-point increase in outsourcing intensity being associated with a rise in the hazard rate of merely 0.6 percent, which is much lower than the marginal effect of about 6 percent that Geishecker (2008) found in his study on employment security. Apart from the different definition of the dependent variable – he focused on work-to-non-employment transitions – the inspected time frame certainly plays a role here as a lot of the adjustments have probably already been undertaken before the end of the 1990s.

[19] In the proportional hazards model the marginal effect of the explanatory variables on the hazard rate is $\left(e^{\beta} - 1\right) * 100\%$.

Including interaction terms between the outsourcing indicators and the task measures shows that the stability-reducing impact of material outsourcing decreases with the degrees of non-routineness and interactivity (as well as the interaction between the two) of one's occupation (Table 3). The coefficient of the interaction term is negative and highly significant in all specifications. In contrast, the impact of service outsourcing does not depend in a significant way on the task intensities. It is true that in the non-linear model at hand the coefficient of the interaction term is not necessarily informative about the interaction effect as Ai and Norton (2003) show. Calculating the interaction effect together with the corresponding standard errors in the correct way, however, confirms the first (naive) assessment.[20] The interaction effect of material outsourcing is negative and significant for all the observations in the estimation sample whereas the interaction effect of service outsourcing is insignificant, again for (almost) the entire sample. To get an impression of the economic significance of the results, we can compare the total effect of international outsourcing for different quantiles of the task measures. For instance, whereas the cumulative effect of material outsourcing on the occupational hazard rate over the sample period is 1.41 percent for the 5^{th} percentile of the non-routineness/interactivity distribution, it amounts to -0.25 percent for the 95^{th} percentile (Table 4).[21] Hence, the spread of the effect is sizeable compared to the mean effect but overall still very moderate in economic terms. Table 4 also reveals – to some extent surprisingly – that the regression with the combined task measure does not lead to a more pronounced spread of the effect than either of the two separate measures, i.e. the intensity of non-routine or the intensity of interactive tasks.

International outsourcing in the service sector

Even though the import of services in the service sector can be expected to play a similar role to the import of goods in the manufacturing sector, that is being more of a substitute than a complement for the work performed in the home country, the three basic specifications all yield a negative and significant effect on the risk of leaving the occupation (Table 2, right column). This result is in line with Bachmann and Braun (2008) although the analyzed outcome variables and the service outsourcing indicators used differ slightly. Turning to the quantitative importance, the hazard of leaving the

[20] Applying to the complementary log-log case the formula for two continuous variables given by Ai and Norton (2003), I calculate the interaction effect as (omitting the subscripts of the variables for convenience):

$$\frac{\partial^2 \lambda}{\partial OUT \partial TASK} = \beta_{OUT\times TASK} * \exp\left(-\exp\left(\alpha+\beta' X\right)+\alpha+\beta' X\right) + \left(\beta_{OUT}+\beta_{OUT\times TASK} * TASK\right) * \\ \left(\beta_{TASK}+\beta_{OUT\times TASK} * OUT\right) * \exp\left(-\exp\left(\alpha+\beta' X\right)+\alpha+\beta' X\right) * \left(1-\exp\left(\alpha+\beta' X\right)\right).$$

[21] These values have been calculated as $\left(\exp\left(\left(\beta_{OUT}+\beta_{OUT\times TASK} * TASK_{0.05/0.95}\right) * \Delta OUT\right)-1\right) *$ 100%.

occupation in the service sector decreases by about 2.5 percent on average if outsourcing intensity rises by one percentage point. Note that service outsourcing intensity in the sector as a whole increased by 0.19 percentage points between 1999 and 2001 and decreased again by 0.15 percentage points in the years thereafter (cf. Figure 1) so that the effect is small in economic terms.[22] The picture is more diverse, however, when the effect is allowed to vary with the intensity of non-routine and interactive tasks of the occupation (Table 3). As with material outsourcing in the manufacturing sector, the coefficient of the interaction term is negative and significant – and so is the non-linear interaction effect. A closer inspection reveals that the spread of the effect is indeed non-negligible. Whereas a one-percentage-point increase in service outsourcing leads to a rise in the hazard rate by 1.41 percent for the 5^{th} percentile of the non-routineness/interactivity distribution, it reduces the hazard rate by 6.75 percent for the 95^{th} percentile (Table 4). However, again we have to relate these figures to the still fairly low outsourcing levels (and changes) in the sector. Nevertheless, the results are consistent with the hypothesis that international service outsourcing leads to a specialization towards non-routine and interactive tasks in the service sector. Only employment relationships in occupations that use these tasks intensively become more stable, which may again be attributable to productivity enhancements and increased profitability of domestic firms.

6 Extensions and robustness checks

6.1 Alternative task measures

In a first step I check how sensitive the results are with respect to the employed task-to-occupation mapping.[23] For this purpose I construct alternative measures of non-routineness (*Task: non-routine ALT1*) and interactivity (*Task: interactive ALT1*), making use of the separate questionnaire on 13 job descriptions (instead of the 81 workplace-related tools), which is also available in the German Qualification and Career Survey 1998/1999. These job descriptions are again classified into non-routine and/or interactive tasks (cf. Table A2) and corresponding task intensities are calculated following the procedure proposed by Becker et al. (2007) as described in Section 3.2 and Appendix A.[24] In addition, I also apply the measure of interactivity resulting from the original Becker et al.

[22] However, the growth of service outsourcing in the service sector was quite rapid in the pre-sample period 1995 to 1999 when it increased by almost 0.5 percentage points. Under the assumption that the effect of service outsourcing was identical back then, the regression results predict an average stability-increasing effect of about 1.2 percent for this time span.

[23] In addition, I have also run regressions with discretized task measures. That is, instead of inserting the continuous measure I have included dummy variables for occupations characterized by low and high intensities (with 'medium' being the left-out category) as well as the corresponding interactions with the outsourcing indicators. Results (available on request) remain qualitatively the same.

[24] Spitz-Oener (2006) and more recently Borghans et al. (2008) and Antonczyk et al. (2009) use (variants of) the same set of questions to construct similar task measures.

(2007) mapping, without the introduced modification (*Task: interactive ALT2*). Regression results allowing for interactions between international outsourcing and the alternative task measures are displayed in Table 5, the associated marginal and cumulated effects in Table 6. The results are in general very supportive of the aforementioned findings, with two differences standing out. For one instance, the coefficient of the interaction term between international service outsourcing and the interactivity measure *ALT1* is *positive* and weakly significant in the manufacturing sector, thus suggesting that the stability-increasing effect of service outsourcing *decreases* with the intensity of interactive tasks. This is at odds with prior expectations but may be explained by the fact that in the manufacturing sector low scores in the interactivity measure frequently correspond to primarily production-oriented occupations. These should not be substitutional to the import of services, anyway. Moreover, this result is not confirmed when using the interactivity measure *ALT2* and does not change in any way the main conclusion that the overall effect of service outsourcing on the occupational hazard rate is still significantly negative for the entire sample. Second, the spread of the overall effect of international service outsourcing in the service sector (in quantitative terms) depends considerably on the task measure used. The direction of the effect – higher intensities of non-routine and interactive tasks being associated with a more stability-increasing effect of service outsourcing – remains unaffected, though.

Since the (main) results are not driven by the choice of the task-to-occupation mapping, I return to the task measures used in the main analysis for the following robustness checks and extensions. For the sake of space I restrict attention to the specification based on the interaction between the degrees of non-routineness and interactivity.

6.2 Nature of tasks versus educational attainment

As has been argued in the introduction, the intensity of non-routine and interactive tasks of the occupation is not necessarily informative about the skill level of the individual. However, several occupations that are characterized by a high degree of both non-routineness and interactivity, such as physicians, managers and engineers, are typically filled by high-educated workers so that empirically it is an open question whether the task measures indeed capture important aspects that are not accounted for by the skill level and vice versa. For a first inspection of this issue I estimate the pairwise correlation coefficients between the three task measures and each of the four educational categories. Results are tabulated in Table 7. The following points stand out. First, the most pronounced (and positive) associations can be observed for the high-education dummy. Second, the high-education dummy correlates more strongly with the measure of non-routineness than with the one of interactivity. Third, in general correlations are lower (in absolute terms) in the service sector than in manufacturing. Against this background, I apply the same strategy as in the previous subsection and estimate two additional specifications: one where the effect of international outsourcing is allowed to vary only with the skill level of the individual and another one where the outsourcing indicators are interacted with the educational dummies as well as the degree of non-routineness/interactivity.

Interestingly, for the manufacturing sector I fail to reject the null hypothesis of a uniform impact across educational levels in both specifications as both the Wald test on joint significance as well as the p-values of the individual coefficients – with the exception of the interaction between service outsourcing and the low-education dummy – indicate (Table 8). Furthermore, in the second specification the coefficient of the interaction term of material outsourcing with the task measure remains strongly significant. In contrast, in the service sector the effect does vary with education. The overall effect of outsourcing is significantly stability-increasing for individuals with medium and high education and stability-reducing for individuals with low education. Still, in the second specification the coefficient of the interaction term between service outsourcing and the task measure remains strongly significant. I conclude that although there is a positive correlation between the skill level of an individual and the intensity of non-routine and interactive tasks performed in the occupation, the latter has an additional effect that should not be omitted.

6.3 Redefinition of a failure

Despite the loss of specific human capital, occupational changes might also characterize voluntary (stepping-stone) mobility in the line of Jovanovic and Nyarko (1997). Hence, to ensure that I indeed capture worker vulnerability, I redefine a failure to only include transitions into non-employment whereas direct transitions to a new occupation are right-censored. Reporting results for the outsoucing variables only, the previous findings are largely confirmed (Table 9). Both the stability-reducing effect of material outsourcing and the stability-increasing effect of service outsourcing are even more pronounced. Interestingly, in the manufacturing sector the correlation between service outsourcing and the occupation-to-non-employment hazard is more negative for *lower* degrees of non-routineness/interactivity. However, recall the related discussion in Section 6.1.

6.4 Unobserved heterogeneity

Even though I control for duration dependence in a flexible way and for much of observed individual heterogeneity, there might be unobservables influencing the results. Hence, as a robustness check I include an individual random effect, which is assumed to follow a normal distribution and to be uncorrelated with the explanatory variables. The results for the simple and the interacted model are displayed in Table 10. As can be seen, coefficients remain virtually unchanged. For the manufacturing sector the likelihood ratio test even rejects the null hypothesis of the presence of unobservable effects at the 5-percent level of significance.

7 Summary and concluding remarks

Combining data on individual employment histories with industry-aggregated measures of international outsourcing and information on the tasks performed in occupations, this study has investigated the impact of international outsourcing on occupational stability in Germany and how it depends on the task contents of occupations. The concept of 'trade in tasks' (Grossman and Rossi-Hansberg, 2008) suggests that the latter are important determinants of vulnerability in a world of ever more fragmented production processes. Moreover, recent evidence by Kambourov and Manovskii (2009) indicates that leaving the occupation is costly for individuals as it involves the loss of specific human capital.

In the manufacturing sector an increase in international material outsourcing is associated with a decline in occupational stability. The strength of the effect rises for lower intensities of non-routine and interactive tasks of the occupation although the quantitative importance is very limited. In contrast, international service outsourcing is associated with a statistically as well as economically significant *increase* in occupational stability that is independent of the task contents of the occupation. This result is consistent with the notion that service outsourcing leads to an increase in productivity that more than compensates for the relocation of certain tasks abroad. In the service sector this result is less clear-cut. Whereas the overall effect of international service outsourcing is stability-increasing, workers employed in occupations characterized by low degrees of non-routineness and interactivity may suffer from greater instability.

The results for both sectors are robust to several different specifications. Most importantly, the effect found for the intensity of non-routine and interactive tasks is not accounted for by the level of educational attainment.

The result that, overall, international service outsourcing is not associated with negative effects for the domestic labour market is in line with Amiti and Wei (2005b) and Hijzen et al. (2007). Whereas the former find positive effects on industry-level productivity and no negative effects on industry-level employment in the US, the latter analyze firm-level employment and worker turnover in the UK – without finding negative effects, either. However, one also has to bear in mind that the importance of international service outsourcing is still rather limited in Germany. Hence, the results do not rule out adverse effects for a larger group of workers in the future although the pace of international outsourcing has slowed down a bit lately.

Furthermore, while this study has added new insights to the discussion on the labour market effects of international outsourcing, it certainly does not capture all relevant adjustment channels. First, it has only focused on occupational stability of employed workers. Adjustments in the form of lower or higher job creation in certain occupations – with direct consequences for unemployed workers – have not been considered. Second, unfortunately adjustments within two-digit occupations cannot be identified, either. Spitz-Oener (2006) documents considerable changes in task usage within occupations for the time period 1979 to 1999. It is likely that this trend has continued and that it can at least partly be attributed to the increased international fragmentation of production processes. From a policy perspective, this study highlights once more the importance of being able to adapt to changing conditions and requirements in the workplace. Measures directed at increasing the transferability of accumulated human capital from one employment relationship to the next, e.g. through further education or further training on the job, are probably best suited to minimize adjustments costs while reaping the benefits of globalization.

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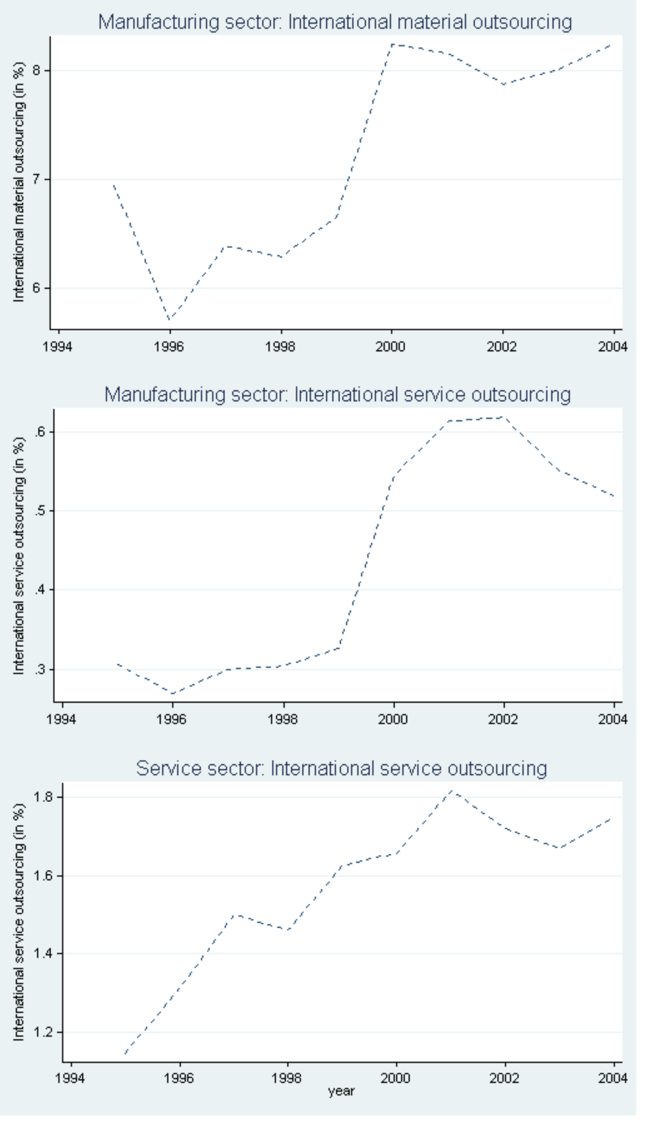
Figures and Tables

Figure 1: Development of international outsourcing intensity over time



Notes: Author's calculations. Intensities calculated according to the formulae given in equations (1) and (2) with data from German input-output tables. Averages over two-digit industries weighted by the respective production values. The manufacturing sector comprises the industries with NACE codes 15–37 and the service sector refers to the industries with NACE codes 50–74.

Table 1: Summary statistics

		Manufacturing		Services	
		mean	std. dev.	mean	std. dev.
Individual characteristics (source: IABS)					
End of occupational spell: yes		0.121	(0.327)	0.181	(0.385)
Occupational tenure: (0; 1] years	Occ. tenure: (0;1]	0.117	(0.321)	0.189	(0.391)
Occupational tenure: (1; 2] years	Occ. tenure: (1;2]	0.087	(0.282)	0.114	(0.318)
Occupational tenure: (2; 3] years	Occ. tenure: (2;3]	0.070	(0.255)	0.085	(0.279)
Occupational tenure: (3; 4] years	Occ. tenure: (3;4]	0.061	(0.239)	0.067	(0.251)
Occupational tenure: (4; 5] years	Occ. tenure: (4;5]	0.053	(0.224)	0.055	(0.227)
Occupational tenure: (5; 7] years	Occ. tenure: (5;7]	0.089	(0.285)	0.091	(0.288)
Age: 25–29	Age: 25–29	0.084	(0.278)	0.111	(0.314)
Age: 30–34	Age: 30–34	0.150	(0.357)	0.173	(0.379)
Age: 35–39	Age: 35–39	0.183	(0.387)	0.179	(0.384)
Age: 40–44	Age: 40–44	0.168	(0.374)	0.154	(0.361)
Age: 45–49	Age: 45–49	0.143	(0.350)	0.130	(0.336)
Age: 50–54	Age: 50–54	0.119	(0.323)	0.105	(0.306)
Age: 55–59	Age: 55–59	0.069	(0.254)	0.059	(0.235)
Age: 60–65	Age: 60–65	0.037	(0.188)	0.030	(0.170)
Gender: Female	Female	0.216	(0.411)	0.366	(0.482)
Education: Missing	Ed.: missing	0.013	(0.113)	0.026	(0.158)
Education: Low	Ed.: low	0.150	(0.357)	0.083	(0.276)
Education: High	Ed.: high	0.107	(0.309)	0.128	(0.335)
Nationality: Foreign	Foreign	0.099	(0.298)	0.068	(0.251)
Establishment characteristics (IABS)					
Establishment size: 20–99	ES: 20–99	0.210	(0.408)	0.303	(0.459)
Establishment size: 100–499	ES: 100–499	0.315	(0.464)	0.234	(0.424)
Establishment size: 500–999	ES: 500-999	0.115	(0.319)	0.063	(0.244)
Establishment size: >=1000	ES: >=1000	0.253	(0.435)	0.090	(0.287)
Task measures (Q&C Survey)					
Task Index: Non-routineness	Task: non-routine	0.404	(0.215)	0.399	(0.210)
Task Index: Interactivity	Task: interactive	0.403	(0.157)	0.493	(0.129)
Task Index: Non-routineness/interactivity	Task: non-routine/interactive	0.185	(0.151)	0.206	(0.136)
Industry characteristics (Statistical Office)					
Material Outsourcing (in %)	MOS	6.834	(5.123)		
Service Outsourcing (in %)	SOS	0.436	(0.469)	1.670	(2.080)
Net exports (in billion euros)	NEXP	16.769	(24.199)	0.437	(2.591)
Output (in billion euros)	Y	97.198	(62.631)	139.940	(75.899)
Capital-output ratio	K/Y	0.803	(0.232)	1.522	(2.694)
Regional characteristics (Empl. Agency)					
Regional unemployment rate	Unemployment	9.810	(3.913)	10.769	(4.409)
Observations (person × year)		579334		635537	

IABS: IAB Employment Sample
Q&C Survey: German Qualification and Career Survey 1998/99
Statistical Office: German Federal Statistical Office
Empl. Agency: German Federal Employment Agency

Table 2: Hazard rate model: Baseline results

Dependent variable: End of occupational spell (0/1)	Manufacturing		Services	
Occ. tenure: (0; 1]	1.383***	(0.011)	1.564***	(0.009)
Occ. tenure: (1; 2]	0.903***	(0.013)	1.019***	(0.011)
Occ. tenure: (2; 3]	0.518***	(0.016)	0.704***	(0.013)
Occ. tenure: (3; 4]	0.464***	(0.017)	0.581***	(0.014)
Occ. tenure: (4; 5]	0.336***	(0.019)	0.424***	(0.016)
Occ. tenure: (5; 7]	0.207***	(0.016)	0.263***	(0.014)
Age: 25–29	−0.230***	(0.017)	−0.173***	(0.012)
Age: 30–34	−0.326***	(0.016)	−0.188***	(0.012)
Age: 35–39	−0.403***	(0.016)	−0.254***	(0.012)
Age: 40–44	−0.504***	(0.017)	−0.342***	(0.013)
Age: 45–49	−0.519***	(0.018)	−0.377***	(0.014)
Age: 50–54	−0.525***	(0.019)	−0.353***	(0.015)
Age: 55–59	−0.151***	(0.021)	−0.109***	(0.017)
Age: 60–65	1.193***	(0.019)	0.973***	(0.018)
Female	0.132***	(0.009)	−0.057***	(0.007)
Ed.: missing	0.002	(0.031)	0.031	(0.017)
Ed.: low	0.090***	(0.011)	0.216***	(0.010)
Ed.: high	0.035*	(0.016)	−0.116***	(0.011)
Foreign	0.091***	(0.013)	0.159***	(0.011)
ES: 20–99	−0.307***	(0.012)	−0.154***	(0.008)
ES: 100–499	−0.520***	(0.012)	−0.264***	(0.009)
ES: 500–999	−0.644***	(0.017)	−0.426***	(0.016)
ES: >=1000	−0.434***	(0.015)	0.204***	(0.013)
Task: non-routine/interactive	−0.736***	(0.034)	−1.047***	(0.028)
MOS	0.006*	(0.003)		
SOS	−0.193***	(0.038)	−0.025**	(0.009)
NEXP	0.004	(0.003)	−0.003	(0.003)
Y	0.003	(0.002)	0.002*	(0.001)
K/Y	0.927***	(0.121)	−0.052	(0.038)
Unemployment	0.000	(0.012)	−0.031***	(0.008)
Constant	−2.856***	(0.370)	−1.618***	(0.109)
log pseudo-likelihood	−194355.18		−263067.48	
Observations (person × year)	579334		635537	

*p<0.05, **p<0.01, *** p<0.001
Standard errors (in parentheses) are clustered at the level of the individual.
All regressions include industry dummies, year dummies and region dummies. Reference category: Occ. tenure: >7 years; Age: < 25; Gender: Male; Ed.: medium; ES: 0–19.

Table 3: International outsourcing and the nature of tasks: Interactions

Dependent variable: End of occupational spell (0/1)	Manufacturing			Services		
MOS	0.011***	0.022***	0.011***			
	(0.003)	(0.003)	(0.003)			
MOS × Task: non-routine	−0.012**					
	(0.004)					
MOS × Task: interactive		−0.040***				
		(0.005)				
MOS × Task: non-routine/interactive			−0.023***			
			(0.006)			
SOS	−0.173***	−0.179***	−0.190***	0.056***	0.072***	0.023*
	(0.044)	(0.048)	(0.041)	(0.010)	(0.011)	(0.011)
SOS × Task: non-routine	−0.045			−0.174***		
	(0.049)			(0.011)		
SOS × Task: interactive		−0.030			−0.205***	
		(0.072)			(0.015)	
SOS × Task: non-routine/interactive			−0.007			−0.210***
			(0.072)			(0.016)
log pseudo-likelihood	−194251.72	−194491.37	−194344.9	−262849.4	−263246.46	−262970.06
Observations (person × year)	579334	579334	579334	635537	635537	635537

*p<0.05, **p<0.01, *** p<0.001
Standard errors (in parentheses) are clustered at the level of the individual.
In addition, regressions include the explanatory variables listed in Table 2.

Table 4: Task-dependent marginal and cumulated effects of international outsourcing

		Manufacturing				Services			
		p5		p95		p5		p95	
		ME	CumE	ME	CumE	ME	CumE	ME	CumE
MOS	Task: non-routine	1.00**	1.36	0.10	0.14				
	Task: interactive	1.57***	2.14	−0.34	−0.46				
	Task: non-routine/interactive	1.03***	1.41	−0.19	−0.25				
SOS	Task: non-routine	−16.36***	−3.92	−19.08***	−4.63	3.62***	0.15	−7.42***	−0.32
	Task: interactive	−16.81***	−4.04	−17.99***	−4.34	2.78**	0.11	−5.94***	−0.25
	Task: non-routine/interactive	−17.36***	−4.18	−17.67***	−4.26	1.41	0.06	−6.75***	−0.29

*p<0.05, **p<0.01, *** p<0.001
p5: 5^{th} percentile of task measure, p95: 95^{th} percentile of task measure
Marginal effects (ME – in %) are based on the regressions that allow for interactions between international outsourcing and the task measures (cf. Table 3). They have been calculated as $\left(\exp\left(\beta_{OUT} + \beta_{OUT\times TASK} * TASK_{pX}\right) - 1\right) * 100\%$.
P-values are based on standard errors (not displayed here) calculated according to the delta method. Cumulated effects (CumE – also in %) are obtained by multiplying the expression in the interior brackets of the marginal effects formula with the change of international outsourcing intensity between 1999 and 2003 in the manufacturing (service) sector as a whole (cf. Figure 1).

Table 5: International outsourcing and the nature of tasks: Alternative task measures

Dependent variable: End of occupational spell (0/1)	Manufacturing			Services		
MOS	0.015***	0.013***	0.018***			
	(0.003)	(0.003)	(0.003)			
MOS × Task: non-routine ALT1	−0.023***					
	(0.004)					
MOS × Task: interactive ALT1		−0.022***				
		(0.004)				
MOS × Task: interactive ALT2			−0.027***			
			(0.004)			
SOS	−0.214***	−0.225***	−0.166***	0.078***	0.070***	0.023*
	(0.042)	(0.041)	(0.046)	(0.010)	(0.010)	(0.010)
SOS × Task: non-routine ALT1	0.059			−0.191***		
	(0.044)			(0.010)		
SOS × Task: interactive ALT1		0.106*			−0.193***	
		(0.045)			(0.010)	
SOS × Task: interactive ALT2			−0.050			−0.116***
			(0.055)			(0.012)
log pseudo-likelihood	−194395.75	−194430.81	−194528.81	−262992.17	−263123.41	−263548.96
Observations (person × year)	579334	579334	579334	635537	635537	635537

*p<0.05, **p<0.01, *** p<0.001
Standard errors (in parentheses) are clustered at the level of the individual.
In addition, regressions include the explanatory variables listed in Table 2.

Table 6: Task-dependent marginal and cumulated effects of international outsourcing: Alternative task measures

		Manufacturing				Services			
		p5		p95		p5		p95	
		ME	CumE	ME	CumE	ME	CumE	ME	CumE
MOS	Task: non-routine ALT1	1.30***	1.77	−0.26	−0.35				
	Task: Task: interactive ALT1	1.19***	1.63	−0.31	−0.42				
	Task: Task: interactive ALT2	1.43***	1.95	−0.30	−0.41				
SOS	Task: non-routine ALT1	−18.76***	−4.55	−15.43***	−3.68	4.85***	0.20	−8.48***	−0.37
	Task: Task: interactive ALT1	−19.57***	−4.76	−13.72***	−3.25	4.46***	0.18	−8.20***	−0.35
	Task: Task: interactive ALT2	−15.93***	−3.81	−18.56***	−4.49	−0.02	−0.00	−6.56***	−0.28

*p<0.05, **p<0.01, *** p<0.001
p5: 5^{th} percentile of task measure, p95: 95^{th} percentile of task measure
Marginal effects (ME – in %) are based on the regressions that allow for interactions between international outsourcing and the task measures (cf. Table 5). They have been calculated as $\left(\exp\left(\beta_{OUT} + \beta_{OUT\times TASK} * TASK_{pX}\right) - 1\right) * 100\%$.
P-values are based on standard errors (not displayed here) calculated according to the delta method. Cumulated effects (CumE – also in %) are obtained by multiplying the expression in the interior brackets of the marginal effects formula with the change of international outsourcing intensity between 1999 and 2003 in the manufacturing (service) sector as a whole (cf. Figure 1).

Table 7: Pairwise correlation coefficients between the task measures and the education dummies

	Manufacturing			Services		
	NR	INTER	NR/INTER	NR	INTER	NR/INTER
Ed.: missing	−0.051***	−0.041***	−0.048***	−0.061***	−0.040***	−0.058***
Ed.: low	−0.241***	−0.299***	−0.261***	−0.230***	−0.211***	−0.224***
Ed.: medium (base)	−0.136***	−0.003*	−0.150***	−0.167***	0.016***	−0.176***
Ed.: high	0.494***	0.364***	0.535***	0.431***	0.173***	0.436***

*p<0.05, **p<0.01, *** p<0.001
The table displays the point-biserial correlation coefficients (mathematically equivalent to the traditional Pearson product moment correlation coefficient) between the education dummy variables and the intensities of non-routine tasks (NR), interactive tasks (INTER) as well as the interaction between the two (NR/INTER).

Table 8: Nature of tasks versus educational attainment

Dependent variable: End of occupational spell (0/1)	Manufacturing		Services	
MOS	0.006*	0.012***		
	(0.003)	(0.003)		
MOS × Ed.: missing	−0.007	−0.008		
	(0.006)	(0.006)		
MOS × Ed.: low	0.001	−0.001		
	(0.002)	(0.002)		
MOS × Ed.: high	−0.001	0.004		
	(0.003)	(0.003)		
MOS × Task: non-routine/interactive		−0.028***		
		(0.006)		
SOS	−0.199***	−0.209***	−0.032***	0.010
	(0.039)	(0.042)	(0.009)	(0.010)
SOS × Ed.: missing	0.097	0.097	0.044***	0.040***
	(0.085)	(0.085)	(0.009)	(0.009)
SOS × Ed.: low	0.052*	0.054*	0.062***	0.051***
	(0.026)	(0.027)	(0.006)	(0.006)
SOS × Ed.: high	−0.019	−0.030	0.001	0.017**
	(0.030)	(0.033)	(0.005)	(0.005)
SOS × Task: non-routine/interactive		0.059		−0.195***
		(0.082)		(0.017)
log pseudo-likelihood	−194350.65	−194340.38	−262995.51	−262919.14
Wald test: MOS × Educ. equal (p-value)	0.543	0.275		
Wald test: SOS × Educ. equal (p-value)	0.115	0.102	0.000	0.000
Observations (person × year)	579334	579334	635537	635537

*p<0.05, **p<0.01, *** p<0.001
Standard errors (in parentheses) are clustered at the level of the individual.
In addition, regressions include the explanatory variables listed in Table 2. Reference category: Ed.: medium.

Table 9: Redefinition of a failure: Only transitions into non-employment

Dependent variable: End of occupational spell (0/1)	Manufacturing		Services	
MOS	0.011**	0.017***		
	(0.004)	(0.004)		
MOS × Task: non-routine/interactive		−0.028***		
		(0.007)		
SOS	−0.219***	−0.263***	−0.044***	−0.005
	(0.048)	(0.052)	(0.011)	(0.012)
SOS × Task: non-routine/interactive		0.226*		−0.176***
		(0.092)		(0.020)
log pseudo-likelihood	−134307.76	−134298.97	−198697.85	−198655.63
Observations (person × year)	553160	553160	597282	597282

*p<0.05, **p<0.01, *** p<0.001
Standard errors (in parentheses) are clustered at the level of the individual.
In addition, regressions include the explanatory variables listed in Table 2. The number of observations is lower than in the other regressions since spells ending with direct occupation-to-occupation transition are right-censored at the beginning of the interval in which the transition is made.

Table 10: Random effects estimation results

Dependent variable: End of occupational spell (0/1)	Manufacturing		Services	
MOS	0.006*	0.011***		
	(0.003)	(0.003)		
MOS × Task: non-routine/interactive		−0.023***		
		(0.005)		
SOS	−0.194***	−0.191**	−0.025**	0.024*
	(0.039)	(0.041)	(0.009)	(0.009)
SOS × Task: non-routine/interactive		−0.007		−0.212***
		(0.071)		(0.015)
log likelihood	−194354.33	−194344.06	−263057.21	−262960.52
Likelihood ratio test: $\rho = 0$ (p-value)	0.096	0.098	0.000	0.000
Observations (person × year)	579334	579334	635537	635537

*p<0.05, **p<0.01, *** p<0.001
Standard errors in parentheses.
In addition, regressions include the explanatory variables listed in Table 2.

Appendix

A Construction of task measures

Following Becker et al. (2007), the task measures are based on the 1998/99 wave of the German Qualification and Career Survey. To make the sample comparable with the individual employment histories, I restrict attention to workers covered by social security with a working week of at least 20 hours. The measures proposed by Becker et al. (2007) build on a set of 81 yes-no-questions regarding the use of workplace-related tools. As described in more detail below, I modify the main interactivity measure employed in this paper by making (additional) use of two items of a separate list of 13 job descriptions. In detail, the variable construction is as follows:

Non-routineness: I choose exactly the same approach as Becker et al. (2007) and use their scheme to classify each of the 81 questioned workplace-related tools as being sign of a routine or non-routine activity (cf. Table A1 for the categorization) . In a next step the number of tools characterizing a non-routine activity is averaged over two-digit occupations.[25] A continuous task intensity measure lying in the range of 0 to 1 is then obtained by normalizing this average number with respect to the maximum in any occupation.

Interactivity: This measure aims to capture the need of both geographic proximity and interpersonal contact (cf. Blinder, 2006). Again, I take the proposition of Becker et al. (2007) as reference, that is, in analogy to above tasks associated with certain tools are classified as interactive and the number of interactive tasks is averaged over occupations (again cf. Table A1). However, since I find that the tools list alone is not able to capture in a fully satisfactory way the highly interpersonal nature of classical service-oriented occupations such as hairdressers, waiters, teachers, among others, I depart from Becker et al. (2007) and introduce a second component. In particular, I make use of the separate questionnaire on 13 job descriptions and classify two of them, i.e. 'training and teaching others' as well as 'providing for, waiting on and caring for people' as strictly interpersonal tasks (cf. Table A2). This choice is explicitly based on the perceived shortcoming of the tools list. Again, I calculate averages over occupations. There is no straightforward way of merging the two components so that I choose the following approach. I first rescale the two components in such a way that they exhibit the same mean and the same standard deviation. For every occupation, I keep the maximum of the two. Finally, I proceed with the normalization described above. Note that regression results do not change

[25] A few occupations had to be grouped to have a sufficient number of observations per occupation.

in a qualitative way if I merge the two components by taking simple averages or by extracting a common factor via a principal components analysis.

Occupations with the highest and lowest intensities of non-routine and interactive tasks (according to the chosen measures) are displayed in Table A3.

As a robustness check the following alternative task-to-occupation mappings are employed. For one instance and based on Spitz-Oener (2006), Borghans et al. (2008) and Antonczyk et al. (2009), I choose an alternative classification of non-routine and interactive tasks that is entirely based on the separate list of 13 job descriptions (cf. Table A2). The construction of the task measures (*Task: non-routine ALT1* and *Task: interactive ALT1*) is analogous to the one described above. As far as the degree of interactivity is concerned, I choose the measure resulting from the original Becker et al. (2007) mapping as another alternative (*Task: interactive ALT2*). That is, this measure is solely based on the tools list and does not consider additional items from the questionnaire on job descriptions.

Table A1: List of workplace-related tools and classification of non-routine and interactive tasks following Becker et al. (2007)

	Non-routine tasks	Interactive tasks:
Tools or devices		
Simple tools		
Precision-mechanical, special tools	x	
Power tools		
Other devices		
Soldering, welding devices		
Stove, oven, furnace		
Microwave oven		
Machinery or plants		
Hand-controlled machinery		
Automatic machinery		
Computer-controlled machinery		
Process plants		
Automatic filling plants		
Production plants		
Plants for power generation		
Automatic warehouse systems		
Other machinery, plants		
Instruments and diagnostic devices		
Simple measuring instruments		
Electronic measuring instruments		
Computer-controlled diagnosis		
Other measuring instruments, diagnosis		
Computers		
Personal or office computers		
Connection to internal network		
Internet, e-mail		
Portable computers (laptops)		
Scanner, plotter		
CNC machinery		
Other computers, EDP devices		
Office and communication equipment		
Simple writing material		
Typewriter		
Desktop calculator, pocket calculator		
Fixed telephone	x	
Telephone with ISDN connection	x	
Answering machine	x	
Mobile telephone, walkie-talkie, pager	x	
Fax device, telecopier		
Speech dictation device, microphone		x
Overhead projector, beamer, TV	x	x
Camera, video camera	x	x
Means of transport		
Bicycle, motorcycle		x
Automobile, taxi		x
Bus		x
Truck, conventional truck		x
Trucks for hazardous good, special vehicles		x
Railway		x
Ship		x
Aeroplane		x
Simple means of transport		x
Tractor, agricultural machine		
Excavating, road-building machine		x
Lifting-aids on vehicles		x
Forklift, lifting truck		
Lifting platform, goods lift		
Excavator		
Crane in workshops		
Erection crane		
Crane vehicle		
Handling system		
Other vehicles, lifting means		
Other tools and aids		
Therapeutic aids	x	x
Musical instruments	x	x
Weapons	x	x
Surveillance camera, radar device		
Fire extinguisher	x	x
Cash register		x
Scanner cash register, bar-code reader		x
Other devices, implements		
Software use by workers with computers		
Word processing program		
Spreadsheet program		
Graphics program	x	
Database program		
Special, scientific program	x	
Use of other software		
Computer handling by workers with computers		
Program development, systems analysis	x	
Device, plant, system support	x	
User support, training	x	x
Computer use by any worker		
Professional use: personal computer	x	
Machinery handling by workers with machinery		
Operation of program-controlled machinery		
Installation of program-controlled machinery	x	
Programming of program-controlled machinery	x	
Monitoring of program-controlled machinery	x	
Maintenance, repairs	x	x

Source: Becker et al. (2007). Items refer to the list of questioned tools in the German Qualification and Career Survey 1998/99. The authors' strict classification is used. Any non-intended deviations from the original classification are the fault of the author.

Table A2: List of job descriptions and classification of non-routine and (strictly) interactive tasks

	Non-routine tasks	Interactive tasks
Training and teaching others	x	xx
Consulting, informing others	x	x
Measuring, testing, quality controlling		
Surveillance, operating machinery, plants, or processes		
Repairing, renovating	x	
Purchasing, procuring, selling	x	x
Organizing, planning	x	x
Advertising, public relations, marketing, promoting business	x	x
Information acquisition and analysis, investigations	x	
Conducting negotiations	x	x
Development, research	x	
Manufacture or production of merchandize		
Providing for, waiting on, caring for people	x	xx

Author's classification. Items refer to the list of questioned job descriptions in the German Qualification and Career Survey 1998/99. The listed tasks have been used to construct alternative measures of non-routineness and interactivity, applying the procedure described in Section A. In addition, the tasks marked with 'xx' have been characterized as strictly interpersonal and also enter the composite measure of interactivity used in the main analysis. See Section A for further details.

Table A3: Occupations with the highest and lowest intensities of non-routine and interactive tasks

Rank	Non-routineness		Interactivity	
1	Chemist, physicist, mathematician	1.00	Clergyman	1.00
2	Engineer	0.87	Teacher	0.92
3	Physician, pharmacist	0.84	Physician, pharmacist	0.91
4	Scientist	0.77	Social worker	0.86
5	Technician	0.76	Policeman, fireman, security personnel	0.83
64	Unskilled worker	0.12	Spinner, winder, cordmaker; textile manufacturer	0.17
65	Cook	0.11	Assembler	0.17
66	Tailor, textile processing; textile refiner, dyer	0.11	Molder, caster	0.17
67	Cleaning service worker	0.08	Beverage producer, tobacco producer	0.15
68	Unskilled construction worker	0.08	Unskilled worker	0.11

Author's calculation. Task intensities were computed as described in Section A with data from the German Qualification and Career Survey 1998/99. Higher values indicate higher task intensities.

B Industry-level data

The industry-level data used in this study is supplied by the German Federal Statistical Office, either through its input-output tables or through its online collection of time series.[26] The level of aggregation is the two-digit (subsection) level of the NACE Rev.1.1 classification (WZ2003). Apart from indicators for international outsourcing intensity as described in Section 3.3 the included variables are net exports ($exports_{jt} - imports_{jt}$), industry output ($Y_{jt}$) and the capital-output ratio (K_{jt}/Y_{jt}). The output measure used is the industry's production value.

There is no need to deflate expressions in ratios. However, production values as well as imports and exports have been converted into constant prices. In particular, production values have been deflated with the price indices implicit in the volume indices, which are available at the higher-aggregated NACE subsection (not division) level. Imports and

[26] See https://www-genesis.destatis.de/genesis/online.

exports have been converted into constant prices by applying the corresponding price indices for imports and exports of manufactured goods and services, respectively.

(Gross) capital values for the industry “activities related to financial intermediation and insurance (NACE Rev.1.1 code 67)” are not available. I have imputed them with the weighted average of the industries “banking and financial intermediation services (65)” and “insurance services (66)”. Note, however, that treating this information as missing instead and hence, loosing all the observations of this industry, does not change estimation results in a significant way.

A final remark is in order regarding the industry information available in the individual employment data. As already stated in Section 3.3, the NACE classification is available only from 1999 onwards. To be precise, for the years 1999 to 2002 only the NACE Rev.1 industry coding (WZ1993) is given, which in a few cases differs from the NACE Rev.1.1. The recoding from NACE Rev.1 to NACE Rev.1.1 has been done with the official recoding scheme provided by the German Federal Statistical Office (based on the five-digit level). If one Rev.1 code is associated with many Rev.1.1 codes, the industry information has been set to missing.