FDI and the Composition of Tasks: Evidence from Linked Employer-Employee Data*

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Abstract

Recent theories of offshoring stress that it generates international trade in tasks and as such affects the composition of tasks performed at home. We use detailed information about the employees at German multinationals to analyze how the firms' foreign activities affect the demand for different types of tasks. We estimate the effect on the relative demand for white-collar workers, for workers with high educational attainment and for workers carrying out non-routine tasks and tasks involving personal interaction. Our results suggest that a foreign expansion is associated with an increased relative demand for all these categories. However, the estimated effects are generally small and we find no evidence that the effect on the composition of tasks is stronger than the effect on skill upgrading measured in terms of educational attainment or by the distinction between white-collar and blue-collar workers.

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1 Introduction

There is considerable agreement among economists that globalization is likely to affect the composition of labor demand in the industrialized countries. After all, the opening up to trade by China, India and the countries in Central and Eastern Europe should result in Stolper-Samuelson effects according to standard trade theory. However, so far the empirical evidence of such effects are surprisingly weak. There is little evidence that various aspects of globalization lead to a reallocation of factors towards skill-intensive sectors of the economy (e.g. Berman, Bound and Griliches (1994)) or even to an increase in the relative price of skill-intensive products (e.g. Lawrence and Slaughter (1993), Sachs and Shatz (1994), and Desjounqueres, Machin and Van Reenen (1999)). Studies trying to relate various aspects of globalization to skilled-biased technological change find relatively modest and sometimes even negligible effects (e.g Feenstra and Hanson (1996), Slaughter (2000), Head and Ries (2002)).[1]

Recently, it has been suggested that what is important for whether jobs are offshored or not is not so much the level of skills required for the job but the nature of the tasks carried out (e.g. Grossman and Rossi-Hansberg (2006)). Tasks that are easily codifiable and that do not require extensive personal interaction can potentially be carried out at a distance from the rest of the activities. Whereas such tasks may be correlated with skills, they do not necessarily have to be so. For instance, computer programming typically requires education at the post-secondary level, but can in many cases easily be moved offshore. Maintenance work, on the other hand, may not require any particular education, but cannot easily be moved offshore since it requires proximity to the facilities maintained.

A possible reason for finding small effects of globalization on the relative demand for skills is thus that skills do not capture the most important aspect of the type of job affected. All studies so far have focused on the skill composition of labor demand, either by classifying occupations according to their skill requirement or by measuring the educational attainment of employees. Shifting the perspective from skills to tasks, it has been suggested that what makes a job easily moved abroad is the extent to which it involves routine tasks that can be well described by deductive rules (Levy and Murnane (2004)), to what extent it involves tasks that require codifiable rather than tacit information (Leamer and Storper (2001)) and to what extent if

[1]Feenstra and Hanson (1996) find that offshoring of intermediate input production has contributed significantly to an increase in the relative wage of non-production workers, but that this effect still is dominated by technological change driven by investment in high-tech capital.

involves tasks that do not require physical contact and geographic proximity (Blinder (2006)).

In this paper we use detailed information about the employees at German multinationals to investigate how foreign direct investment (FDI) affect the structure of skills and tasks among the workers at the parent firms. We address the issue of whether weak effects on the skill structure of the parent firms hide stronger effects on the structure of tasks carried out. Our data set is based on linked information on employers and employees with added on information about the employers' foreign direct investment (FDI). It contains a sample of German firms with operations abroad and covers the period 1998-2002. We use a survey of the nature of the work carried out by German workers to create a mapping from tasks to occupations.[2] We then use a cost function approach to estimate the effect of production transfers within multinationals on the demand for workers carrying out non-routine versus routine tasks and on the demand for workers carrying out interactive versus non-interactive tasks (meaning tasks differing in the extent to which they require personal interaction with the parent firm's employees and/or customers). We compare the results with the estimated effects on the relative demand for white-collar workers and on the relative demand for workers with post-secondary education.

Overall, our results do not lend strong support to the view that offshoring has a strong impact on the composition of tasks carried out. We do find evidence of offshoring within German multinationals being associated with a shift in labor demand towards white-collar workers, highly educated workers, workers carrying out non-routine tasks and workers carrying out tasks that require personal interaction. However, the estimated effect is quantitatively small for all four categories, and particularly so for the task categories. In fact, our estimates of the relationship between the firms' foreign operations and relative demand for different worker categories are the highest for highly educated workers.

The paper is organized as follows. In the next section we review the previous literature and discuss the results on offshoring and labor demand. This is followed by a description of the data and method used to estimate the effect of production transfer within multinationals on the composition of labor demand. We then present and discuss our results and, finally, offer some concluding remarks.

[2]The survey used is the Qualification and Career Survey carried out by the German Federal Institute for Vocational Training (Bundesinstitut für Berufsbildung, BIBB) and the Research Institute of the Federal Employment Service (Institut für Arbeitsmarkt- und Berufsforschung, IAB).

2 Offshoring and labor demand

The effect of globalization on wages in the industrialized countries – where globalization is taken to be driven by reductions in the costs associated with trade and cross-border investment – has been analyzed mainly in terms of the effect on the demand for skills. The underlying idea is that reduced costs for trading with developing countries should give rise to increased specialization in skill and capital intensive activities and, as a result, an increased relative demand for skills (both because it increases directly and because capital tends to be complementary to skills). Several papers have investigated empirically whether various aspects of globalization have had this effect (e.g. Feenstra and Hanson (1996), Feenstra and Hanson (1999), Slaughter (2000), Head and Ries (2002), Hansson (2001)). Focusing on studies assessing the effect of FDI, we find that most of them report small or negligible effects. Slaughter (2000), who used industry data for the US, found that the industry's share of production taking place abroad had little effect on the relative demand for non-production workers.[3] Head and Ries (2002) carried out a similar analysis at the firm level based on information on Japanese manufacturing firms and found evidence of skill upgrading in the parent firm. However, their results indicate that less than 10 percent of the actual skill upgrading in Japanese manufacturing firms can be explained by increased employment abroad. [4]

The fact that overall the effects seem rather small has led many observers to conclude that globalization does not seem to be a main source of an apparent increase in the relative demand for skills.

A recent theoretical literature is however shifting the perspective on globalization from its effects on the demand for different levels of skills to its effects on the demand for different tasks. Grossman and Rossi-Hansberg (2006) develop a model where offshoring involves a transfer of tasks rather than the production of certain goods or services abroad. They emphasize that the ease with which tasks can be offshored is not necessarily related to the skill

[3]Slaughter (2000) uses industry level data to identify the link between MNE transfer and within-industry shifts in US labor demand. He assumes that in each industry k capital is a quasi-fixed factor and that the industry minimizes the cost of skilled and unskilled labor according to a translog cost function. He classifies skills by occupations. Non-production workers are classified as more-skilled whereas production workers are classified as less-skilled In each industry cost minimization leads to an equation explaining the level change over some time period in that industry's skilled-labor share of the total wage bill.

[4]Head and Ries (2002) extend the Slaughter study to the firm level and employ a 25-year panel data set for about 1000 Japanese manufacturing firms to investigate the effects of increases in foreign employment on the skill intensity of the domestic workforce. They use the nonproduction worker share of the wage bill and the firm-level average wage as proxies for skill intensity.

content of the task. In their model skilled and unskilled workers carry out tasks that vary regarding the ease with which they can be traded. A reduction in the cost of offshoring tasks will lead to an increase in the amount of tasks offshored, but at the same time it will reduce costs for offshoring firms, increasing productivity and ultimately benefiting the factor used intensively in the sector experiencing a decrease in offshoring costs (which may very well be unskilled labor). The effect on labor demand thus depends on whether you focus on particular tasks or if you focus on a particular skill group.

A number of recent studies have investigated the effect of technological change on the demand for different types of skills utilizing information on occupational tasks. This literature focuses on the scope for substitution between IT and the tasks performed on the job. Autor, Levy and Murnane (2003) develop a framework for analyzing changes in the task composition of occupations. They classify activities performed on the job in five skill categories: *nonroutine analytical* tasks, *nonroutine interactive* tasks, *routine cognitive* tasks, *routine manual* tasks and *nonroutine manual* tasks. Routine tasks are expressible in rules such that they are easily programmable and therefore easily carried out by computers or robots. Nonroutine tasks are not easily programmable but computers are taken to be complementary to both analytical and interactive nonroutine tasks.

We follow Autor et al. (2003) and Spitz-Oener (2006) in that we also link occupations to the extent of routine versus non-routine tasks performed. Moreover, we link occupations to the importance of personal interaction for the tasks carried out. The latter aspect is more closely related to the relative importance of physical contact and geographic proximity. By doing so, we create a data set that allows us to address the question whether a foreign expansion of employment within firms is associated with a change in the composition of tasks carried out in the parent firm.

3 Data

Our estimations make use of a unique and rich linked employer-employee data set from four confidential micro-data sources, assembled at Deutsche Bundesbank in Frankfurt. The basic units of analysis in this study are domestic plants, belonging to multinational enterprises headquartered in Germany. Information on individual workers allows us, however, to compute wage bills of many different worker groups of interest.

The first component of our linked employer-employee data set, worker and job information, comes from quarterly social-security records of the German Federal Labor Agency (Bundesagentur für Arbeit BA). The observations are the universe of workers registered by the social insurance system over the years 1998-2001, representing around 80% of the formally employed German workforce.[5] The records contain worker and job characteristics such as age, education level, occupation and wages. Wages in the German social security data are censored above but there is no censoring from below. The wage upper bound is the contribution assessment ceiling for old-age insurance, which is annually adjusted for nominal wage changes.[6] Workers with an annual income below 3,865 EUR (in 2001) are not subject to social security contributions, but are part of our data and estimation sample and we control for their inclusion (minor employment). We construct establishment-level information by aggregation from the individual-level information.

Second, information on outward FDI comes from the MIDI database (MIcro database Direct Investment, formerly DIREK), collected by Deutsche Bundesbank (BuBa); see Lipponer (2003) for a documentation. The MIDI data on outward FDI cover the foreign affiliates of German MNEs above ownership shares of 10 percent.[7] For the purposes of the present analysis, we extract information on affiliate employment and the FDI-reporting parent firm's ownership share in the foreign affiliate.

Third, in order to link the two data sources on domestic and foreign activities, we use the commercial corporate structure database MARKUS (from Verband der Vereine Creditreform) which allows us to identify all domestic parents and affiliates of FDI-reporting firms. Multinational enterprises are also multi-firm enterprises in the home economy so that outward FDI affects workers beyond the FDI-reporting firm's workforce. Moreover, many German enterprises bundle the domestic management of their foreign affiliates into legally separate firms (mostly limited liability *GmbHs*) for tax and liability reasons. Those bundling firms then report FDI to MIDI as required by German law. The economic impact of the reporting firm's FDI, however, goes beyond the firm's formal legal boundary in that jobs throughout the corporate group can be affected. We consider all firms within a corporate group (an enterprise) as *potential* FDI firms if at least one firm in the group

[5]Coverage includes full- and part-time workers of private enterprises, apprentices, and other trainees, as well as temporarily suspended employment relationships. Civil servants, student workers, and self-employed individuals are excluded and make up the remaining 20% of the formal-sector labor force. Establishments within the same municipality may report under one single establishment identifier. Though our data derive from the pristine BA source, the description by **?** for the scientific-use version of these BA data largely applies to our records.

[6]The ceiling is binding only for a very small fraction of workers.

[7]In 1999 and 2000, reporting is mandatory for all foreign affiliates with an asset total of at least EUR 10 million and at least a ten-percent ownership share of the German parent, or an asset total of at least EUR 1 million and at least a 50-percent ownership.

reports outward FDI activities.[8].

From the resulting matched sample we exclude firms that have zero foreign employment during the entire period that our data cover, which is the 1998-2001 period. Furthermore, we exclude firms with foreign employment greater than 100 times the domestic employment.[9] We then create a balanced panel of plants over the four years. In the end, we are left with 490 firms and 1,266 plants, yielding a total of 5,064 observations in our regressions.

Fourth, in order to investigate how FDI affects the task structure at the parent firm we create two different measures of the nature of the tasks carried out by workers holding a particular occupation: (i) the degree of non-routine tasks performed, and (ii) the degree of tasks requiring personal interaction performed. The basis for judging whether the tasks are mostly non-routine and interactive is the answers given by workers holding different occupations to questions regarding the nature of the work in the Qualification and Career Survey for 1998/1999.[10] This survey is carried out by the German Federal Institute for Vocational Training (Bundesinstitut für Berufsbildung, BIBB) and the Research Institute of the Federal Employment Service (Institut für Arbeitsmarkt- und Berufsforschung, IAB) and includes questions about tools, instruments and other types of equipment used by the employee, about the use of computers and about the extent to which the work is related to computer programming, repairing and supervision.

We code the answers to 81 different questions about the nature of the work into an indicator whether a yes implies non-routine tasks and into an indicator whether a yes implies tasks which require personal interaction with other workers in the firm and/or with the firm's customers. To check robustness, we create one set of indicators where we make a conservative assessment and one set of indicators where we are more liberal in linking a yes to non-routine and interactive tasks.[11]

We then use information about the average response to these questions by employees holding different occupations to link occupations to different types of tasks. In doing so, we first establish what is the maximum number of

[8]The three data sources do not share common firm identifiers. We use a string-matching procedure to identify clearly identical firms and their establishments (see Appendix A for a detailed description)

[9]As noted above, in some cases the management of foreign activities seems to take place in separate firms which we have not been able to link to any other firms. That the ratio of foreign to domestic employment may be very large is also observed in the sample of Japanese firms used by Head and Ries (2002)

[10]The BIBB/IAB data have been used in various contexts, for instance by Acemoglu and Pischke (1998) in their study on firm-provided training.

[11]In Appendix C, we provide a detailed list of the items classified as non-routine respectively interactive.

non-routine tasks and interactive tasks, respectively, performed by any occupation (based on response to the questions in the survey). We then measure a particular occupation's degree of non-routine and interactive tasks, respectively, as the ratio between the number of such tasks performed (according to the average response in the survey) and that maximum number. For example, let us say that the maximum number of non-routine tasks carried out according to the response in the survey are 20. To measure the tasks carried out by a secretary, we look at the average number of non-routine tasks carried out by respondents holding jobs as secretaries. Let us say that this number is 5. We then assign secretaries the value 0.25 when we measure the extent to which they carry out non-routine tasks. In terms of the cost of employers for different tasks, we assign 25 percent of the wage cost of a secretary to non-routine tasks and 75 percent to routine tasks.

In order to check whether our results are sensitive to the way we have chosen to map occupations to tasks, we also use the mapping created by Spitz-Oener (2006) in her work on IT and labor demand. Her mapping is in this context more restrictive in that it is based on a smaller (and different) set of questions in the survey.[12]

4 Descriptive evidence

Figures XX-XX show average cost shares for skills and tasks 1998-2001 for our sample of multinationals as well as for a sample of firms that do not belong to any company groups with foreign investments. We distinguish between the manufacturing sector and the service sector, excluding commerce. We focus on four different distinctions between workers: (i) whether they have post-secondary education, (ii) whether they are white-collar workers, (iii) whether they carry out non-routine tasks, and (iv) whether they carry out tasks that require personal interaction with workers in the parent firm and/or parent firm customers.

In the service sector, there is a clear upward trend in the cost shares of both our skill measures (white-collar workers and workers with post-secondary education) as well as both our measures of non-offshorable tasks (non-routine and interactive tasks) for the multinationals, but not for the non-multinationals (although there is an increase in the cost share of workers with post-secondary education). In the manufacturing sector, there is also an increase in these cost shares for the multinationals over the full period 1998-2001, but this is mainly due to a marked increase between 1998 and 1999. After 1999 there have been modest decreases. As in the service sector, there

[12] Again, details are provided in Appendix C.

is no clear increase in these cost shares for the non-multinationals, except for regarding the cost share of workers with upper secondary education.

Generally speaking, the increase in cost shares is the largest for the education-based measure, while the changes in the composition of tasks are relatively small. There is an especially large increase in the cost share of workers with upper-secondary education between 2000 and 2001 in the service sector, mainly stemming from the business services sector.

[INCLUDE FIGURES]

Overall, there is thus a tendency for skill-upgrading as well as a change in the composition of tasks within our sample of firms during the four-year time period for which we have data. As in most industrialized countries, the supply of highly educated workers has increased in Germany, so the large increase in the cost-share of highly educated workers may at least partly be a reflection of supply effects.

Cost shares may increase because the proportion of different types of workers change and/or because relative wages change. An increase in the relative wage of skilled workers in the face of an increasing relative supply would suggest an even larger increase in relative demand. To get a sense of to what extent the increases in cost shares are driven by increases in proportions and in relative wages we decompose the changes in the cost shares. Let θ_i be the cost share of worker/task i. A change in θ_i over time can be decomposed in the following way:

$$\theta_{it} - \theta_{it-1} = \Gamma(\frac{w_{it} - w_{it-1}}{w_{it-1}} - \frac{w_{-it} - w_{-it-1}}{w_{-it-1}} + \frac{L_{it} - L_{it-1}}{L_{it-1}} - \frac{L_{-it} - L_{-it-1}}{L_{-it-1}}) \quad (1)$$

where

$$\Gamma \equiv \frac{\theta_{it-1} w_{-it-1} L_{-it-1}}{w_{-it} L_{-it} + w_{it} L_{it}} \frac{L_{it}}{L_{it-1}} \quad (2)$$

and w_{it} is the price and L_{it} the number of workers/tasks i at time t, while the subscript $-i$ is used to denote workers/tasks not included in category i.

By calculating the sum of the first two terms and the sum of the last two terms of (1) we can separate out the change due to a change in relative wages and the change due to a change in the number of workers/tasks. Tables 1 and 2 show the results of such a decomposition for the manufacturing and service sector, respectively. The tables make clear that the increases in the cost shares of skills and non-offshorable tasks are larger in the service sector than in the manufacturing sector. They also reveal that more than half of the overall increase can be attributed to an increase in the proportion of

Table 1: Decomposition of changes in the cost shares of workers/skills 1998-2001 for the manufacturing sector

	Total change	relative wages	percentage contribution	proportion workers/tasks	percentage contribution
Post-sec. edu.	0.031	0.012	38.9	0.019	61.1
White-coll.	0.034	0.013	36.8	0.022	63.2
Non-rout. (cons.)	0.010	0.004	42.2	0.006	57.8
Interact. (cons.)	0.009	0.002	27.5	0.007	72.3

Note: Task measures are based on the conservative classification (but change very little if the liberal classification is used).

Table 2: Decomposition of changes in the cost shares of workers/skills 1998-2001 for the service sector

	Total change	relative wages	percentage contribution	proportion workers/tasks	percentage contribution
Post-sec. edu.	0.118	0.031	26.5	0.087	73.5
White-coll.	0.099	0.035	35.4	0.064	65.6
Non-rout. (cons.)	0.044	0.017	38.6	0.027	61.4
Interact. (cons.)	0.014	0.006	41.1	0.007	58.9

Note: Commerce is not included. Task measures are based on the conservative classification (but change very little if the liberal classification is used).

workers/skills. Still, the contribution of a change in the relative prices of workers/skills is substantial; between 26.5 and 42.2 percent depending on measure and sector.

The contribution of a change in relative wages to the increase in the cost share of workers with post-secondary education is 38.9 percent in the manufacturing sector and 26.5 percent in the service sector. This is evidence of increased demand for highly educated workers in Germany during this time period, in particular in the manufacturing sector.

5 Econometric analysis

In our econometric analysis we estimate the contribution of FDI to shifts in the demand for these types of workers. In order to distinguish between FDI that is mainly driven by market-seeking motives (horizontal FDI) and FDI that is mainly driven by cost-reducing motives (vertical FDI) we distinguish between FDI located in other high-income countries and FDI located in low-income countries (cf. Hansson (2001)).[13] We expect that, in line with previous studies, vertical FDI tends to shift labor demand away from low-skilled workers, whereas horizontal FDI may go the other way (which is the case for Japanese multinationals when skills are measures by the white-collar, blue-collar distinction, see Head and Ries (2002)). Regarding the effect on the composition of tasks, we expect that FDI tends to shift labor demand away from tasks that easy to offshore, i.e. routine and non-interactive tasks. However, we have no priors as to whether this effect is likely to be stronger or weaker depending on the destination of FDI.

We use a translog cost function approach to derive the following estimating equation:

$$\theta_{ijkt} = \alpha_j + \beta_1 log(\frac{w_i}{w_{-i}})_t + \beta_2 log(\frac{K}{Y})_{jt} + \beta_3 log(Y)_{jt} + \gamma FDI_{kt} + \delta TD + e_{jt} \quad (3)$$

where j indexes plants, k indexes firms; t indexes time; θ_{ijkt} is the percentage share of factor input i in total variable costs; w_{it} is the price of factor input i; w_{-it} is the price of a composite of the other variable factors; $(K/Y)_{jt}$ is the capital-output ratio; Y_{jt} is real value added; TD is a full set of time dummy variables; and e_{jt} is an additive error term. The wage regressor accounts for variation in θ_{ijkt} due to firms substituting away from more-expensive factors. We treat capital as a quasi-fixed factor. The capital regressor accounts for variation in θ_{ijkt} due to capital investment and the output regressor controls for the scale of output at plant level. Capital is measured by the amount of the firm's reported value of fixed assets in constant prices (Dec/31/1998 Euros) that we can allocate to the plant when using employment weights. Output is measured by the amount of the firm's reported turnover in constant prices that can be allocated to the plant by using the same procedure.

The variable capturing the transfer of activities within multinationals is FDI_{kt} (in specifications distinguishing between FDI into high-income and low-income countries we use two variables; $HFDI_{kt}$ and $VFDI_{kt}$). FDI_{kt} is a measure of the firm's operations abroad. Note that it varies over firms rather than plants. We thus assume that the relative demand for skills and tasks at all plants belonging to a company group is affected in the same way by the company's foreign activities.

We follow Head and Ries (2002) in measuring the exposure to the firm's foreign activities as the share of foreign activities in total activities.[14] We construct firm-specific measures of foreign activities in the following way:

[13] An alternative specification is to interact the measure of FDI with the per capita income level of the host country, see Head and Ries (2002).

[14] An alternative would be to use the ratio between activities abroad and activities at

$$FDI_{kt} = \frac{\sum_c x_{ckt}}{\sum_c x_{ckt} + \sum_{j \in k} x_{jkt}} \quad (4)$$

where C is the set of all countries outside Germany and x_{jkt} is a measure of the activity of plant j belonging to firm k in Germany.

The perhaps most natural variable to use in order to capture the extent of the firm's foreign activities is employment, since it measures directly the extent to which the firm's employment has been offshored. However, because productivity differs across countries and labor intensity across activities, this measure may overestimate the domestic workers' exposure to being substituted by workers in low-income countries. A measure that would not systematically overestimate exposure to low-income countries is sales. However, sales may be affected by tax differentials (through transfer pricing) and will be a poorer measure of affiliate activities, since it includes re-sale of final products imported from other parts of the firm. We will use employment as our main measure of foreign activities, but check robustness by using sales as well.

We are interested in finding out whether we can reject the hypotheses that $\gamma = 0$, which would imply that there is no relationship between the firm's share of activities abroad and its demand for skills or tasks at home. Provided that we can reject this hypothesis, we are also interested in comparing the size of the estimated relationship for our different measures of skills and tasks. The time dummies control for changes in the skill or task composition that is common to all firms. We use a fixed-effect specification to control for any plant-specific technology differences that are common over time.

There are a number of well-known potential endogeneity problems in estimating an equation such as (3). The presence of the term $log(\frac{w_i}{w_{-i}})_{kt}$ introduces endogeneity problems for two reasons; because wages and employment are jointly determined and because wages appear in the dependent share variable. One way this has been dealt with in the previous literature is to simply omit $log(\frac{w_i}{w_{-i}})_{kt}$ with the motivation that relative-wage variation across plants might reflect skill-mix differences rather than exogenous wage differences and theory predicts no wage variation across plants assuming perfect mobility. This procedure, however, may lead to omitted variable bias, and would be inappropriate if we believe that labor is less than perfectly

home, as in Slaughter (2000). This measure would have the advantage of being independent of the size of the firm's operations in another region than the one captured by the measure (e.g. the ratio between affiliate employment in low-income countries and parent employment in Germany is independent of the firm's affiliate employment in high-income countries). However, it is also sensitive to outliers. Moreover, the Head-Ries measure has a natural interpretation since it is a share and thus lie within the 0 to 1 range.

mobile, which we would do when dealing with a relatively rigid labor market such as the German one. In our estimations, we will include a wage measure that is based on the wages paid for the different types of workers/tasks in other firms within the same sector as the one observed. We thus try to purge our wage measure from endogeneity stemming for joint determination of wages and employment by using observations on the wages paid by other firms operating in the same sector rather than the actual wages paid by the observed firm.

In the estimations, we cluster standard errors by firms. We estimate a number of different specifications in order to check whether the results are robust. We run specifications where observations are weighted by the plants share of the total wage bill and we include additional controls, such as the R&D intensity and the import penetration of the industry. We also try different measures of the cost shares of non-routine and interactive tasks.

6 Results

The estimated relationship between offshore employment and the relative demand for skills and tasks may of course vary across sectors. In the following we will present results for the whole sample, but for some specifications also separately for the following three different sectors: manufacturing, services excluding commerce, and commerce. In commerce, FDI is likely to be almost exclusively in distribution and therefore of the horizontal type; domestic sales units are being replicated abroad. We would not expect such FDI to have a strong impact on the composition of either workers or skills in the domestic plants.

Table 3 shows the results for a regression of the share of white-collar workers using a similar specification to that used by Head and Ries (2002). The first column shows the results for the whole sample, while columns 2-4 show results for the three different sectors. The results are based on regressions where observations have been weighted by the plant's wage bill. They are quite similar to the ones reported by Head and Ries (2002); the estimated coefficients of the capital-output ratio and of output are negative and the estimated coefficient of offshore employment in manufacturing is positive. However, whereas the coefficient of offshore employment estimated by Head and Ries (2002) is large and significant, our estimate is quite small and not significantly different from zero. Only for the whole sample, we get an estimate that is significant at the 10 percent level.

The results from similar regressions for the education-based measure of skills and the two task measures are presented in Table 4. In this table the

Table 3: Replicating Head and Ries (2002)

	All sectors	Manuf.	Services	Commerce
	(1)	(2)	(3)	(4)
Log (assets / value-added)	-4.273	-5.707	-.359	-.191
	(2.380)*	(2.855)**	(1.366)	(.802)
Log value-added	-17.389	-20.872	-1.691	-2.645
	(8.794)**	(9.721)**	(2.652)	(1.670)
Offshore empl.	4.571	4.353	5.920	.023
	(2.404)*	(2.913)	(4.707)	(1.339)
Year 1999	5.214	5.928	3.355	.514
	(2.245)**	(2.435)**	(1.293)***	(.221)**
Year 2000	4.248	4.901	3.855	1.175
	(.889)***	(1.076)***	(1.108)***	(.550)**
Year 2001	4.771	5.364	4.072	1.295
	(1.084)***	(1.223)***	(1.207)***	(.343)***
Obs.	5064	1871	2114	1026
R^2	.956	.945	.977	.967

Source: Linked MIDI and BA data, 1998 – 2001.

results are based on the whole sample of firms. The estimated coefficients of offshore employment is positive and significant at the 1-percent level in all three columns. That is, offshore employment is associated with an increase in the cost share of highly educated workers and with an increase in the cost shares of non-routine and interactive tasks. However, the estimated coefficients are relatively small, especially for the task-based measures (4.6 for post-secondary education, 1.7 and 1.2 for non-routine and interactive tasks, respectively). The smaller estimates for the task-based measures do not necessarily imply that offshore employment is estimated to contribute less to a change in task composition than to educational upgrading. As was evident from the descriptive statistics presented, the overall change in the task composition has been smaller than the educational upgrading. In order to draw any conclusions about the relative importance of offshore employment to the change in the composition of skills and tasks we need to relate the estimated coefficients to the actual changes, which will do shortly.

Table 5 shows the results for specifications where we distinguish between offshore employment in high-income and low-income countries and where

Table 4: A comparison of different outcomes

	Higher education	Non-routine tasks	Interactive tasks
	(1)	(2)	(3)
Log (assets / value-added)	-1.457	-.997	-.523
	(1.140)	(.676)	(.330)
Log value-added	-6.050	-4.303	-2.024
	(4.193)	(2.538)*	(1.235)
Offshore empl.	4.642	1.738	1.171
	(1.573)***	(.689)**	(.431)***
Year 1999	2.841	1.421	.899
	(1.110)**	(.709)**	(.433)**
Year 2000	2.618	.994	.709
	(.487)***	(.337)***	(.289)**
Year 2001	3.271	1.194	.811
	(.622)***	(.430)***	(.344)**

Source: Linked MIDI and BA data, 1998 – 2001.
All sectors are combined.

we add additional controls. Including additional controls does not affect the estimated coefficients of overall offshore employment. Distinguishing between offshoring to high-income and low-income countries reveal that for the education-based measure and for non-routine tasks, the positive relationship with offshoring stems from activities located in other high-income countries. It is only in the case of interactive tasks that we get a positive estimate of offshoring to low-income countries.

Table 6 shows the results from similar regressions as in Table 4, only with different measures of the cost shares of non-offshorable tasks. For each of the two non-offshorable tasks we use two alternatives: (i) a measure based on a more liberal classification of tasks into non-routine and interactive, and (ii) a measure based on the classification used by (Spitz-Oener, 2006). In all instances, the estimated coefficients are positive and significant at the 10 percent level. The magnitudes of the estimates do not change very much. The more liberal measure of interactive tasks yields a lower estimate that the conservative one (.4 compared to 1.2 in Table 4), but otherwise the estimates are very similar to the ones in Table 4.

Table 5: Richer specifications

	Higher education		Non-routine tasks		Interactive tasks	
	(1)	(2)	(3)	(4)	(5)	(6)
Log (assets / value-added)	-1.492 (1.141)	-1.460 (1.120)	-1.014 (.678)	-.995 (.666)	-.523 (.330)	-.519 (.326)
Log value-added	-6.051 (4.192)	-6.125 (4.178)	-4.303 (2.538)*	-4.348 (2.538)*	-2.024 (1.235)	-2.039 (1.242)
Offshore empl.		4.815 (1.588)***		1.788 (.694)***		1.178 (.434)***
Offshore empl. in HW countries	5.682 (2.080)***		2.262 (1.069)**		1.159 (.562)**	
Offshore empl. in LW countries	3.635 (2.372)		1.230 (1.070)		1.184 (.593)**	
RnD share in production		yes		yes		yes
Import penetration share in absorption		yes		yes		yes
Year 1999	2.850 (1.111)**	2.876 (1.133)**	1.426 (.710)**	1.436 (.713)**	.899 (.434)**	.900 (.425)**
Year 2000	2.616 (.487)***	2.627 (.541)***	.993 (.338)***	1.030 (.355)***	.709 (.288)**	.743 (.290)**
Year 2001	3.274 (.620)***	3.196 (.656)***	1.195 (.430)***	1.203 (.445)***	.811 (.344)**	.854 (.360)**

Source: Linked MIDI and BA data, 1998 – 2001.
All sectors are combined.

Tables 7 – 9 present calculations based on the estimated coefficients that serve to quantify the results. The estimated coefficients are multiplied by the average change in the offshore employment measure to get the predicted change in the cost share due to the firms' foreign activities. We then calculate the percentage share of this predicted change in the actual share to arrive at a measure of the predicted contribution of offshore employment to the observed changes in cost shares of skills/tasks.

As is evident from these tables, in quantitative terms, our measure of offshore employment does not seem to be very important in explaining shifts in labor demand. At most, it seems to contribute around 4 percent to explaining the actual change in the cost shares of skills, measured by either the white-collar/blue-collar distinction or by educational attainment. The contribution to explaining the changes in the cost shares of non-offshorable tasks seems even smaller, around 1 percent. The exception is regarding the change in the cost share of interactive tasks in the service sector, where offshore employment is calculated to contribute 4.5 percent of the total change.

Since we are estimating the relationship between the cost shares and the firms' own foreign employment, one might argue that we are only capturing

Table 6: Robustness checks

	Non-routine tasks altern. 1	Interactive tasks altern. 1	Non-routine tasks altern. 2	Interactive tasks altern. 2
	(1)	(2)	(3)	(4)
Log (assets / value-added)	-1.222	-.221	-1.218	-1.328
	(.814)	(.173)	(.646)*	(.736)*
Log value-added	-5.345	-.981	-5.034	-5.396
	(3.049)*	(.659)	(2.402)**	(2.727)**
Offshore empl.	2.062	.436	1.250	1.321
	(.837)**	(.244)*	(.674)*	(.725)*
Year 1999	1.686	.505	1.499	1.533
	(.851)**	(.248)**	(.738)**	(.742)**
Year 2000	1.219	.396	1.322	1.221
	(.406)***	(.176)**	(.425)***	(.336)***
Year 2001	1.492	.470	1.541	1.400
	(.511)***	(.215)**	(.486)***	(.401)***

Source: Linked MIDI and BA data, 1998 – 2001.
Non-routine tasks, alternative 1, classifies more tasks as being non-routine. Interactive tasks, alternative 1, classifies more tasks as being interactive. Non-routine tasks, alternative 2, uses a different set of questions in the BIBB/IAB data to define non-routine tasks, similar to Spitz-Oener (2006). Interactive tasks, alternative 2, uses a different set of questions in the BIBB/IAB data to define interactive tasks, similar to Spitz-Oener (2006). See main text for details.

a part of the overall effect of offshoring. For instance, we do not capture the effect of the firms' decision to use independent foreign suppliers of intermediate inputs. For the manufacturing sector, we can however use the estimated coefficient of industry-wide import penetration to get a sense of how results change by including broader measures of foreign competition. By adding the predicted change in the cost share based on the estimated coefficient of import penetration to the predicted change based on the estimated coefficient of offshore employment, we get an estimate of the overall contribution of offshoring to the actual change in the composition of labor demand. The largest contribution we get for the cost share of highly educated workers and white-collar workers; 14.4 and 13.5 percent, respectively. These estimates come close to the lower of the ones reported by Feenstra and Hanson (1999) based on industry data for the US using a somewhat different methodology. The contribution of offshoring to changes in the cost shares of non-routine and interactive tasks, however, seems considerably lower; 8.5 percent and 1.7 percent, respectively.

Table 7: Quantifying the relationship between offshore employment and the composition of skills/tasks, all sectors

	Estimated coeff.	Pred. change due to offsh.	Contrib. to change (%)
Post-sec. edu.	4.64	0.126	4.2
White-coll.	4.57	0.124	4.6
Non-rout. (cons.)	1.74	0.047	1.2
Interact. (cons.)	1.17	0.032	1.0

Note: The predicted change due to offshoring is based on the change in the weighted measure of offshore employment 1998-2001, which is 0.027.

Table 8: Quantifying the relationship between offshore employment and the composition of skills/tasks, manufacturing

	Estimated coeff.	Pred. change due to offsh.	Contrib. to change (%)
Post-sec. edu.	5.29	0.241	3.1
White-coll.	4.35	0.198	3.4
Non-rout. (cons.)	1.63	0.074	1.0
Interact. (cons.)	1.08	0.049	0.9

Note: The predicted change due to offshoring is based on the change in the weighted measure of offshore employment 1998-2001, which is 0.046.

Table 9: Quantifying the relationship between offshore employment and the composition of skills/tasks, services

	Estimated coeff.	Pred. change due to offsh.	Contrib. to change (%)
Post-sec. edu.	6.12	0.123	1.1
White-coll.	5.92	0.119	1.2
Non-rout. (cons.)	3.03	0.061	1.4
Interact. (cons.)	3.05	0.061	4.5

Note: The predicted change due to offshoring is based on the change in the weighted measure of offshore employment 1998-2001, which is 0.020.

7 Concluding Remarks

This paper is the first to examine the extent to which offshoring affects the composition of tasks carried out in the offshoring firms. We have utilized detailed information on the employees of a sample of German multinationals to create measures of composition of tasks as well as of skills and to estimate their relationship with the firms' foreign activities. We find a positive relationship between the firms' foreign activities and their cost shares of white-collar workers and workers with post-secondary education as well as of non-routine and interactive tasks.

In quantitative terms, however, this relationship does not seem very important. We are only able to attribute a few percent of the observed changes in the composition of skills and tasks to the firms' offshoring. Moreover, we find no evidence of offshoring being more strongly associated with a change in the composition of tasks than in the change in the composition in skills. In fact, the strongest relationship appears to be between offshoring and educational upgrading.

A potential weakness of the analysis in this study is the short time-period for which we have data; only a four-year period between 1998 and 2001. It is reassuring, however, that our estimated relationship between offshoring and the cost share of skills – measured either by the white-collar/blue-collar distinction or by educational attainment – is qualitatively and quantitatively similar to what has been found in previous studies. This makes us relatively confident in our conclusion that the German multinationals' foreign activities are only weakly related to a change in the composition of tasks in the parent firms.

Appendix

A Linked employer-employee data

Our goal is to link jobs to their FDI exposure throughout German corporate groups. This requires a two-step procedure. First, we identify all MIDI firms that are in the commercial company structure database MARKUS. Departing from the MIDI firms in MARKUS, we move both down and up in the corporate hierarchy of MARKUS to select the affiliates and ultimate parents of the MIDI firms. Second, we string-match all domestic establishments in the BA worker database to the so-selected MARKUS firms for identification of all establishments related to *FDI firms*. We also string-match the domestic establishments to MIDI itself for identification of all those FDI reporting firms that are not part of a corporate group (but stand-alone firms).

We link the data based on names and addresses. By law, German establishment names must include the firm name (but may by augmented with qualifiers). Before we start the string-matching routine, we remove clearly unrelated qualifiers (such as manager names or municipalities) from establishment names, and non-significance bearing components from establishment and firm names (such as the legal form) in order to compute a link-quality index on the basis of highly identifying name components. Our string-matching is implemented as a Perl script and computes link-quality indices as the percentage of words that coincide between any pair of names. We take a conservative approach to avoid erroneous links. We keep two clearly separate subsets of the original data: First, establishments that are perfect links to MARKUS or MIDI, i.e. establishment names that agree with firm names in every single letter. Second, establishments that are perfect non-links, i.e. establishment names that have no single word in common with any FDI-related MARKUS or MIDI firm. We drop all establishments with a link-quality index between zero and one from our sample, i.e. establishments whose name partially corresponds to an FDI firm name but not perfectly so. Those establishments cannot be told to be either foreign-expansion or control establishments without risk of misclassification.[15] The procedure leaves us with a distinct foreign-expansion group of FDI establishments and a control group of non-FDI establishments.

The BA establishment name file is from November 2002 and contains names of establishments that are no longer active so that we include exit-

[15] The string-matching routine runs for several weeks, checking 3.8 million establishments against 65,000 *FDI firms*. It is infeasible to manually treat possible links with imperfect link-quality rates.

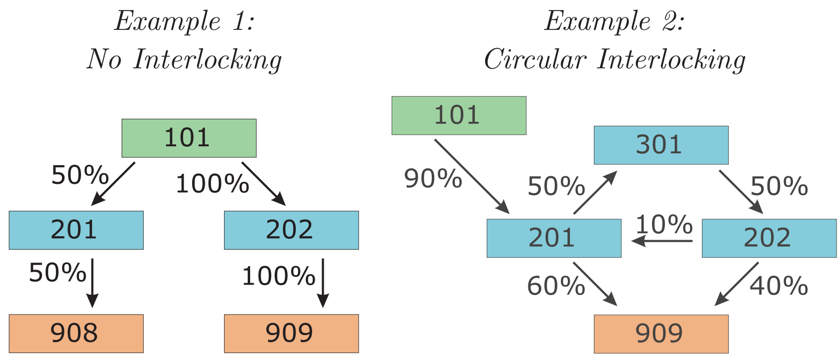

Figure 1: **Examples of Corporate Groups**

ing and entering establishments. To capture exits after 1999 is particularly important for us, because one margin of separation is establishment closure. Firm names in the MARKUS database are from three vintages of data, November 2000, November 2001 and November 2002. This is to make sure that in case of name changes in one of the years 2000 through 2002, we do not miss out on string-matches.

Our procedure is designed to remove laterally related firms (sisters, aunts, or nieces) from the sample so that they neither enter the foreign-expansion nor the control group. Take Example 1 of Figure 1 and consider firm 201 to be the FDI-conducting (and FDI-reporting) firm in the depicted corporate group. The first step of our procedure identifies firm 201 in MARKUS and its affiliate and parent 908 and 101 but does not identify firms 202 (a sister to 201) and 909 (a niece to 201). If any name component of establishments in firms 202 or 909 coincides with those of 101, 201 or 908 (but the establishment name is not an identical match to 101, 201 or 908), the establishments in firms 202 and 909 are discarded and neither enter the foreign-expansion nor the control group. If no single name component of establishments in firms 202 or 909 is the same as that of 101, 201 or 908, the establishment may enter our control group. If one considers sisters, aunts, and nieces with no single identical name component to be equally affected by FDI of firm 201 as those with common names or direct relations, their inclusion in the control group would make the control group more similar to the foreign-expansion group than it should be. If anything, however, the reduced difference would work against our worker separation estimates. Moreover, interlocking (of which Example 2 of Figure 1 is a special case) limits the number of only laterally related firms.

Table 10: Ownership Inference

Affiliate-parent pair	Iteration (Length of Walk) 1	2	3	5	9	100
201-101	.9	.90	.900	.92250	.92306	.92308
201-202	.1					
201-301		.05		.00125		
202-101			.225	.22500	.23077	.23077
202-201		.25		.00625		
202-301	.5					
301-101		.45	.450	.46125	.46153	.46154
301-201	.5					
301-202		.05		.00125		
909-101		.54	.540	.64350	.64609	.64615
909-201	.6		.100		.00006	
909-202	.4	.06		.00150		
909-301		.20	.030	.00500	.00001	

B Corporate ownership and FDI exposure

We infer the economically relevant ownership share of a domestic firm in any other domestic firm. The relevant ownership share can differ from the recorded share in a firm's equity for two reasons. First, a firm may hold indirect shares in an affiliate via investments in third firms who in turn control a share of the affiliate. We call ownership shares that sum all direct and indirect shares *cumulated* ownership shares. Second, corporate structures may exhibit cross ownership of a firm in itself via affiliates who in turn are parents of the firm itself. We call ownership shares that remove such circular ownership relations *consolidated* ownership shares. This appendix describes the procedure in intuitive terms; graph-theoretic proofs are available from the authors upon request.

Consolidation removes the degree of self-ownership (α) from affiliates, or intermediate firms between parents and affiliates, and rescales the ultimate ownership share of the parent to account for the increased control in partly self-owning affiliates or intermediate firms (with a factor of $1/(1-\alpha)$). Investors know that their share in a firm, which partly owns itself through cross ownership, in fact controls a larger part of the firm's assets and its affiliates' assets than the recorded share would indicate. In this regard, cross ownership is like self-ownership. Just as stock buy-backs increase the value of the stocks because investors' *de facto* equity share rises, so do cross-ownership relations raise the *de facto* level of control of the parents outside the cross-ownership circle.

We are interested in *ultimate* parents that are not owned by other domestic firms, and want to infer their *cumulated and consolidated* ownership in all affiliates. Consider the following example of interlocking (Example 2 in Figure 1). The ultimate parent with firm ID 101 holds 90 percent in firm 201, which is also owned by firm 202 for the remaining 10 percent. However, firm 201 itself holds a 25 percent stake in firm 202—via its holdings of 50 percent of 301, which has a 50 percent stake in 201. Firms 201 and 202 hold 60 percent and 40 percent of firm 909. Our cumulation and consolidation procedure infers the ultimate ownership of 101 in all other firms.

We assemble the corporate ownership data in a three-column matrix:[16] the first column takes the affiliate ID, the second column the parent ID, and the third column the effective ownership share. Table 10 shows this matrix for Example 2 in Figure 1 (the third column with the direct ownership share is labelled 1, representing the single iteration 1).

On the basis of this ownership matrix, our inference procedure walks through the corporate labyrinth for a prescribed number of steps (or iterations). The procedure multiplies the ownership shares along the edges of the walk, and cumulates multiple walks from a given affiliate to a given ultimate parent. Say, we prescribe that the algorithm take all walks of length two between every possible affiliate-parent pair (in business terms: two firm levels up in the group's corporate hierarchy; in mathematical terms: walks from any vertex to another vertex that is two edges away in the directed graph).

We choose the following trick to infer the *cumulated and consolidated* ownership for ultimate parents: We assign every ultimate parent a 100 percent ownership of itself. This causes the procedure to *cumulate and consolidate* the effective ownership share for all affiliates of ultimate parents, at any length of walks. There are seven distinct possibilities in the example to move in two steps through the corporate labyrinth. Table 10 lists these possibilities as iteration 2 (all entries in or below the second row). With our trick, there is now an eighth possibility to move from affiliate 201 to parent 101 in two steps because we have added the 101-101 loop with 100-percent ownership. As a result, our procedure cumulates ownerships of ultimate parents for all walks that are of length two or shorter. The procedure starts to consolidate shares as the length of the walk increases. Iteration 3 in Table 10 shows the cumulated and partially consolidated ownership of ultimate parent 101 in affiliate 201, for all three-step walks, including the first cycle from 201

[16]We assemble cleared ownership data by first removing one-to-one reverse ownerships and self-ownerships in nested legal forms (such as *Gmbh & Co. KG*).

through 202 and 301 back to 201 and then to 101.

In 2000, the maximum length of direct (non-circular) walks from any firm to another firm is 21. So, for all ultimate parents, the *cumulated and consolidated* ownership shares are reported correctly from a sufficiently large number of iterations on. Table 10 shows iteration 100. The ownership share of 101 in 201 has converged to the exact measure ($.9/(1-.1\cdot.5\cdot.5) = .\overline{923076}$) at five-digit precision. Firm 101 controls 92.3 percent of firm 201's assets, among them firm 201's foreign affiliates.

To calculate the FDI exposure at any hierarchy level in the corporate group, we use a single-weighting scheme with ownership shares. The economic rationale behind single-weighting is that ultimate parents are more likely to be the corporate decision units (whereas FDI conducting and reporting firms in the group may be created for tax and liability purposes). We first assign FDI exposure measures (foreign affiliate employment by world region) from domestic affiliates to their ultimate domestic parents. Suppose firm 201 in Example 2 of Figure 1 conducts FDI in the corporate group. We assign 92.3 percent of 201's FDI exposure to firm 101, the ultimate domestic parent. We then assign the same 92.3 percent of 201's FDI exposure to all affiliates of 101 (201 itself, 202, 301, 909). So, jobs throughout the group (including those at 201 itself) are only affected to the degree that the ultimate parents can control foreign-affiliate employment (or turnover). We assign only 92.3 percent of 201's FDI exposure to 201 itself because the ultimate parent only has 92.3 percent of the control over employment at 201.[17]

Because we choose single-weighting in the domestic branches of the MNE, we also single-weight foreign-affiliate employment by the ownership share of the domestic parent in its foreign affiliates. Mirroring the minimal ownership threshold of 10 percent in the MIDI data on foreign affiliates, we also discard the FDI exposure of domestic affiliates with ownership shares of less than 10

[17] An alternative assignment scheme would be double-weighting, first weighting FDI exposure by ownership and then assigning the FDI exposure to jobs throughout the corporate group using ownership weights again. We decide against double-weighting. Any weighting scheme results in exposure measures that are weakly monotonically decreasing as one moves upwards in the corporate hierarchy because ownership shares are weakly less than one. Double-weighting aggravates this property. Revisit Example 1 in Figure 1 and suppose firm 201 conducts FDI. Single-weighting assigns 50 percent of 201's exposure to affiliate 908, double-weighting only 12.5 percent. If 908 itself conducts the FDI, single-weighting assigns 25 percent of its own FDI exposure to 908, double-weighting only 6.25 percent. In economic terms, double-weighting downplays the decision power of intermediate hierarchies in the corporate group further than single-weighting so that we favor single-weighting. Recall that purely laterally related firms (sisters, aunts and nieces) are excluded from our foreign-expansion group so that firms 202 and 909 in Example 1 of Figure 1 are not relevant for the choice of weighting scheme.

percent in our single-weighting assignment of FDI exposure to domestic jobs throughout the corporate group.

C Construction of tasks measures

Our main tasks measures build on an extensive set of 81 questions referring to tools and devices used at work. We deliberately classified the use of these tools and devices indicative of the nature of the tasks performed with them. Since any classifications is subject to some degree of judgement, in order to probe robustness we two sets of classifications for both non-routine and interactive tasks, which we refer to as conservative and liberal definitions. In the conservative definitions, we only classify tasks as non-routine (interactive) if we feel very strongly about the tools as being related to non-routine (interactive) tasks. In the liberal definitions, we try to be more generous and classify tools as indicative of non-routine (interactive) tasks in more cases. Table 11 shows the classifications in detail. Based on these classifications, we compute the task intensity of occupations as described in section (??? CORRECT X-REFERENCE ???).

As a robustness check to our own classification of tasks based on tools and devices used by the worker, we employed the classification defined by Spitz-Oener (2006) in her work on IT and labor demand. Her mapping is in this context more restrictive in that it is based on a smaller (and non-overlapping) set of questions in the survey.[18] She classifies the following tasks as interactive ... inte = (v189 + v190 + v194 + v195 + v198) ... and the following ones as (manual) non-routine: ma = (v192 + v200) ... from where we deduct the fraction of non-routine tasks and the fraction of interactive tasks as the number of tasks performed out of a total of 15 tasks taken into account: gen totaltasks = v189+v190+v191+v192+v193+v194+v195+v196+v197+v198+v199+v200+v201+v223+v224 gen iaso = inte / (totaltasks) gen routso = ma / (totaltasks) gen nrso = 1-routso

[18] We thank Alexandra Spitz-Oener for sharing the relevant parts of her code with us.

Table 11: Classification of tasks as non-routine or interactive

	Non-routine tasks		Interactive tasks	
	(conserv. def.)	(liberal def.)	(conserv. def.)	(liberal def.)
	(1)	(2)	(3)	(4)
Work with tools, devices				
Simple tools	0	0	0	0
Precision-mechanical, special tools	1	1	0	0
Power tools	0	0	0	0
Other devices	0	1	0	0
Soldering, welding devices	0	0	0	0
Stove, oven, furnace	0	0	0	0
Microwave oven	0	0	0	0
Work with machines, plants				
Hand-controlled machines	0	0	0	0
Automatic machines	0	1	0	0
Computer-controlled machines	0	0	0	0
Process plants	0	0	0	0
Automatic filling plants	0	0	0	0
Production plants	0	0	0	0
Plants for power generation	0	0	0	0
Automatic warehouse systems	0	0	0	0
Other machines, plants	0	1	0	0
Work with measuring instruments, diagnostics				
Simple measuring instruments	0	1	0	0
Electronic measuring instruments	0	1	0	0
Computer-controlled diagnosis	0	1	0	0
Other measuring instruments, diagnosis	0	1	0	0
Work with computers				
Personal/ office computers	0	1	0	0
Connection to internal network	0	1	0	0
Internet, e-mail	0	1	0	0
Portable computers (laptops)	0	1	0	1
Scanner, plotter	0	1	0	0
CNC machines	0	1	0	0
Other computers, EDP devices	0	1	0	0
Work with office and communication tools				
Simple writing material	0	1	0	1
Typewriter	0	1	0	1
Desktop calculator, pocket calculator	0	0	0	0
Fixed telephone	1	1	0	0
Telephone with ISDN connection	1	1	0	0
Answering machine	1	1	0	0
Mobile telephone, walkie-talkie, pager	1	1	0	0
Fax device, telecopier	0	0	0	0
Speech dictation device, microphone	0	1	1	1
Overhead projector, beamer, TV	1	1	1	1
Camera, video camera	1	1	1	1
Occupation with means of transport				
Bicycle, motorcycle	0	0	1	1
Automobile, taxi	0	0	1	1
Bus	0	0	1	1
Truck, conventional truck	0	0	1	1
Trucks for hazardous good, special vehicles	0	1	1	1
Railway	0	1	1	1
Ship	0	1	1	1
Aeroplane	0	1	1	1
Simple means of transport	0	0	1	1
Tractor, agricultural machine	0	0	0	0
Excavating, road-building machine	0	0	1	1
Lifting-aids on vehicles	0	0	1	1
Forklift, lifting truck	0	0	0	1
Lifting platform, goods lift	0	0	0	1
Excavator	0	0	0	0
Crane in workshops	0	0	0	1
Erection crane	0	0	0	1
Crane vehicle	0	0	0	1
Handling system	0	0	0	0
Other vehicles, lifting means	0	1	0	1
Other tools, aids				
Therapeutic aids	1	1	1	1
Musical instruments	1	1	1	1
Weapons	1	1	1	1
Surveillance camera, radar device	0	1	0	1
Fire extinguisher	1	1	1	1
Cash register	0	0	1	1
Scanner cash register, bar-code reader	0	0	1	1
Other devices, implements	0	1	0	1
Only to persons working with computers				
Word processing program	0	1	0	0
Spreadsheet program	0	1	0	0
Graphics program	1	1	0	0
Database program	0	1	0	0
Special, scientific program	1	1	0	0
Use of other software	0	1	0	0
Only to persons working with computers				
Program development, systems analysis	1	1	0	1
Device, plant, system support	1	1	0	1
User support, training	1	1	1	1
To all workers				
Professional use: private computer	1	1	0	1
Only to persons working with machines				
Operation of program-controlled machines	0	0	0	0
Installation of program-controlled machines	1	1	0	0
Programming of program-controlled machines	1	1	0	0
Monitoring of program-controlled machines	1	1	0	0
Maintenance, repairs	1	1	1	1

Source: BIBB/IAB Qualification and Career Survey 1998/1999.
Authors' classification of tasks as non-routine or interactive. Liberal and non-routine definitions refer to two sets of classifications: one set of indicators where we make a conservative assessment and one set of indicators where we are more liberal in linking a yes to non-routine and interactive tasks.

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