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Paper prepared for the 34th IARIW General Conference

Dresden, Germany, August 21-27, 2016

Session 4C: Globalization, Growth and Jobs II

Time: Tuesday, August 23, 2016 [Afternoon]

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Abstract

This paper examines empirically the relation between offshoring and the onshore workforce composition in the US, Japan, and fifteen high-income European countries. Building up from detailed occupation information in labour force surveys we provide a novel characterization of the workforce classified by a generic set of functions, such as R&D, production, logistics, sales and marketing. Offshoring is measured using annual world input-output tables for the period from 1995 onwards. Estimating a system of variable demands for business functions, our results suggest that industries in advanced economies with faster growth in offshoring lower their demand for production and back-office activities, while demand for logistics, sales and marketing increases. Offshoring to advanced economies is associated with reduced onshore demand for R&D and engineering activities. The decline in demand for production activities indirectly affects R&D and engineering activities as these are found to be complementary to production.

Key words: Business functions, Offshoring, Elasticities of substitution, Iterated Seemingly Unrelated Regressions
JEL: J22,J23,F14,F66

⋆ We are grateful to Robert Inklaar, Marcel Timmer, Xianjia Ye, and seminar participants at the University of Groningen for their help and comments.

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1 Introduction

A key issue in international economics is understanding the implications of global production fragmentation for the onshore composition of the labour force. Due to declining communication and coordination costs, multinational firms find it profitable to fragment their business activities across borders, which carries deep implications for national labour markets (Baldwin, 2006). Recent international sourcing surveys by statistical offices in the US and Europe document that firms engaged in offshoring most often offshore their production activities (Nielsen, 2008; Brown et al., 2014). This aligns well with a large empirical literature that finds offshoring benefits skilled non-production workers relative to unskilled production workers (see e.g. Feenstra and Hanson (1999); Hijzen et al. (2005); Foster-McGregor et al. (2013)), and with the Heckscher-Ohlin model where trade induces advanced economies to specialize in activities that make intensive use of the relative abundantly available skilled workers.

But the international sourcing surveys indicate that globalisation has a wider impact on the workforce composition. For example, in the EU survey of international sourcing about 25 percent of firms that offshore report they internationally outsource Information and Communication Technology (ICT) services. And about 15 percent offshore (some of) their R&D activities (Nielsen, 2008). The 2010 National Organizations Survey in the US also indicates that offshoring is spread across all business functions (Brown et al., 2014). Indeed, there has been a recent expansion in the amount of high-tech investment and innovative activities carried out by US and European multinational firms offshore (OECD, 2008; Abramovsky et al., 2010). This suggests offshoring not only affects demand for skilled relative to unskilled workers, but also the relative onshore demand for workers in business activities. A dichotomous split between skilled versus unskilled workers appears insufficient to fully capture the impact of globalisation for jobs (Baldwin, 2006).

Our contribution in this paper is to use a novel approach to examine the impact of offshoring on the functional structure of labour demand in advanced economies. We classify workers by the type of activities they undertake. We will refer to these activities as functions. Based on Sturgeon and Gereffi (2009), nine generic functions are distinguished, namely production, R&D, sales and marketing, logistics, customer services, management, technology development, back-office, and facility maintenance. This is a comprehensive list of functions that all firms must either do, or have done elsewhere. Since these functions are generic, they can be applied to any workplace or firm, whether or not their main output is a physical product or a service.

The idea to use occupational data to analyse functional labour demand is not new, and has been applied in empirical work in Urban Economics and Economic Geography. For example, Duranton and Puga (2005) show how cities in the U.S. specialize in support functions such as logistics and marketing, while production activities concentrate in less urbanised regions based on the occupational structure of the labour force. What is new in this paper is that we relate changes in the functional structure of labour demand to offshoring.

We have collected time series occupational wage and employment data by detailed industries for the US, Japan, and the fifteen 'old' European countries (those countries that joined the EU before 2004) from labour force surveys and (in the case of Japan) population censuses from 1995 onwards. The detailed occupation information allows us to map workers into business functions. The functions are identified by the labour income of workers that perform the function. Changes in the function labour cost shares within industries are related to panel data on offshoring that is available in the World Input-Output Database (Timmer et al., 2015), where we control for the effects from technological change by including ICT capital stocks in the analysis. We estimate relative demand for functions derived from a translog cost framework, which is common in this field of analysis. [1] We simultaneously estimate the system of variable functional labour demands using panel data techniques as in Hijzen et al. (2005) and Timmer and Ye (2015).

This paper contributes to the literature in at least three ways. First, we are among the first to look at the impact of offshoring on changes in labour demand for business activities in advanced economies. Previous work classified workers by their skill level and examined the relation between offshoring and the skill structure of labour demand. For example, Feenstra and Hanson (1999), Hijzen et al. (2005) and Foster-McGregor et al. (2013) find that offshoring increases the relative demand for skilled workers in high-income countries. Offshoring on average appears to benefit skilled relative to unskilled workers (Grossman and Rossi-Hansberg, 2008), but globalisation may have more pervasive consequences for the activities kept at home and those offshored (Baldwin, 2006). We know from firm-level analyses that the occupational structure is changing. For example, in an analysis of changes in French manufacturing firms, Maurin and Thesmar (2004) find that demand for designers and marketeers of new products rose whereas the demand for high-skilled workers in administration-related activities declined. An open question is whether and how offshoring is related to these changes in the functional structure of labour demand.

A second contribution is that we examine the relation between offshoring and the demand for business activities in a cross-country cross-industry panel setting. So far, the analysis has been confined to firm-level studies and it is there-

[1] See e.g. Feenstra and Hanson (1999); Strauss-Kahn (2004); Hijzen et al. (2005); Foster-McGregor et al. (2013) and Michaels et al. (2014).

fore difficult to quantify the aggregate implications for advanced economies. One strand in the Economic Geography literature has examined the location determinants of MNE functions (Defever, 2006, 2012; Crescenzi et al., 2013; Ascani et al., 2015), but does not consider onshore changes in function shares. In recent years, statistical offices have carried out international sourcing surveys that ask firms about the business functions they offshore and related changes in onshore jobs. These surveys are promising, but cover a select sample of firms and a limited time period. In this paper we quantify and analyse the relation between offshoring and the demand for activities across manufacturing and services industries in advanced economies for the period from 1995 to 2007.

Third, because we estimate the demand for activities using a translog cost framework we can examine complementarity and substitutability between business activities. [2] Defever (2012) finds that multinational firms co-locate R&D and production activities when making investment decisions abroad. Furthermore, He and Xiao (2011) argue that production activities benefit from specialized labor and knowledge spillovers, which are abundantly available in R&D activities. Clustering innovation and production activities may be desirable for workers to coordinate their work. Any problems and modifications to products that arise during production can be settled directly with little interruption to the manufacturing process and without innovators having to travel (Baldwin, 2006). The insight that some activities benefit from being clustered contrasts with models of offshoring that order tasks based on their relative comparative advantage (Grossman and Rossi-Hansberg, 2008). It increases uncertainty about the impact of globalisation as 'tipping points' might occur where a fall in coordination costs induces firms to offshore a bundle of activities. This indicates the need to examine the complementarity between R&D and production activities. Financial and timeliness considerations may imply that other activities are also clustered (Baldwin, 2006). Hence, we also examine complementarity and substitutability between other business functions in greater detail. Thereby, we aim to contribute to our understanding of the 'glue' that results in the bundling of various activities that remain at home (Baldwin, 2006).

The remainder of this paper is laid out as follows. In Section 2 we present the main trends in functional labour shares. The system of variable demands for business functions, which is used to examine the role of offshoring in determining changes in function shares is discussed in 3. Empirical results are presented in Section 4, followed by various extensions in Section 5. Concluding remarks are in Section 6.

[2] A different strand of literature explores the viscidity of tasks (Lanz et al., 2012) and the impact of offshoring on the demand for tasks (see e.g. Becker and Muendler (2014)).

2 Trends in function shares and international outsourcing in advanced economies

Labour market data is aggregated up from survey and census data. For European countries we use the European labour force surveys for occupational employment data and the structure and earnings surveys for their relative wages. For the United States we use the wage and employment data available in the Occupational Employment Statistics (OES) and for Japan we combine occupational employment data from the population census with wage structure surveys. For European countries we have occupational data at the three digit level following the International Standard Classification of Occupations (ISCO) 1988, which distinguish 116 occupations. For the US the OES distinguishes 800 occupations; and for Japan there are 231 different occupations. In total, we collect occupational employment and wage bill shares within 31 industries (of which 13 manufacturing industries) across 17 countries from 1995 onwards. This very detailed occupational dataset, which is described in more detail in the appendix, allows us to map workers into business activities.

For the mapping of occupations to activities, we use the list of business functions proposed by Sturgeon and Gereffi (2009), which itself is derived from a list of generic business functions first proposed by Porter (1985). There is no standardized classification of business activities (Brown, 2008), but typically the main distinction is between production and headquarter (Markusen, 2002). We keep that distinction, but further split headquarter into R&D and various other activities. Table 1 provides the business functions that we distinguish and it also provides some examples of mapping occupations to business activities. The examples in this table are based on occupation descriptions at the three digit level ISCO 1988 occupation classification used in the European labour force surveys. [3]

The occupation descriptions that we list in table 1 suggest that occupations can be reasonably mapped into the various business activities described. For many occupations this is indeed the case. However, it is not straightforward to match each occupation to a particular business function. Indeed, statisticians have argued that the occupational classification lacks a direct tie to the firm's internal organisation (Brown, 2008). Instead they prefer new surveys that directly inquire firms about their business activities. Brown et al. (2014) describe the results from one such survey, namely the National Organizations Survey (NOS). The NOS asked a sample of U.S. organizations about their

[3] The full set of concordances of occupations to business functions is available upon request. Note that we group management and back-office functions in table 1 to facilitate comparison to the 2010 NOS survey, but will distinguish these business activities in our analysis later on.

offshoring of business functions in 2010. It also inquired about the domestic distribution of workers across business activities. The pen-ultimate column in table 1 shows these domestic employment shares obtained from the 2010 NOS survey (Brown et al., 2014). For comparison we have added the distribution of employment shares that we obtain for goods producing industries in the US using the OES (the latest year we use is 2007). [4]

The employment shares shown in table 1 match reasonably well, which suggests that our mapping of occupations to business activities provides a reasonable approximation. In particular, the shares of R&D, technology development and production activities are fairly comparable across the 2010 NOS and our approximation using the OES. However, the estimated shares differ for sales and logistics activities, suggesting that the further split of headquarter activities might be less accurate. Note, however, that in our empirical analysis we will look at cost shares (which combines employment with relative wages), which are not given in the NOS. In addition, we will look at changes over time, which is not possible based on a survey for a single year. Finally, note that the mapping of occupations is exhaustive since a generic set of functions is used. That is, the employment shares by business functions within each industry sum to one. Combining employment data with relative wages, we also create an exhaustive split of shares in labour compensation within industries (further information is provided in the appendix).

We will relate changes in business function shares to offshoring. We use the narrow and broad definition of offshoring Feenstra and Hanson (1999). These measures of offshoring are obtained from the annual World Input-Output Tables (Timmer et al., 2015), and include offshoring to foreign affiliates and/or arm's length transactions in intermediates. The narrow definition of international outsourcing only considers imported intermediates by an industry from that same industry as a share in total non-energy intermediates. The broad definition considers all imported intermediates by an industry as a share in total non-energy intermediates. [5] Feenstra and Hanson (1999) prefer to use the

[4] We show results for goods producing industries, because the 2010 NOS survey asked the firm about its core activity. In the case of goods producing industries this maps to production activities. For services firms this need not be the case. For example, the core activity of a logistics company is providing transport services. In the 2010 NOS the employment related to the provision of transport services would appear as its core activity whereas in our mapping it will show up in the business activity transportation, logistics, and distribution making direct comparisons difficult.

[5] The excluded energy inputs are mining and quarrying (International Standard Industry Classification (ISIC) revision 3, industries 10 to 14), manufacture of coke, refined petroleum products and nuclear fuel (industry 23), and electricity, gas and water supply (industries 40 and 41). This categorization of energy inputs is larger compared to conventional definitions (O'Mahony and Timmer, 2009), which consid-

Table 1
Mapping occupations to activities

Business function	Example occupation(s)	NOS 2010	OES 2007
1. Production activities	Assemblers; Other machine operators and assemblers	61.1	57.6
2. Research and Development of Products, Services, or Technology	Architects, engineers and related professionals	5.6	6.7
3. Sales and Marketing	Business professionals	7.5	5.0
4. Transportation, Logistics, and Distribution	Transport labourers and freight handlers	5.6	9.1
5. Customer and After-Sales Services	Client information clerks	4.3	5.6
6. General and strategic management; Administration, and Back Office Functions	General managers; Office clerks	9.7	8.8
7. Technology and process development	Computing professionals	2.6	2.8
8. Facilities Maintenance	Painters, building cleaners and related trades workers	3.7	4.5

Notes: The examples of mapping occupations to business activities are based on the three digit level ISCO 1988 occupation classification. The final columns show employment shares for the United States based on the National Organizations Survey (NOS) 2010, see the row 'goods producing' industries in table 2 of (Brown et al., 2014) and our estimates based on Occupational Employment Statistics (OES) 2007.

narrow definition of offshoring as it is thought to come closer to the essence of fragmentation which necessarily takes place within an industry. In our main analysis we therefore use the narrow definition, although we examine the robustness of the results to using the broad measure. [6]

Ideally, we would also like to map tangible and intangible capital investments to the various business functions. However, currently available data only distinguishes capital by asset types, which does not allow for such a mapping. In addition, the national accounts data we use is based on the System of National Accounts 1993, which does not capitalize R&D investments. Future releases of national accounts data that follow the System of National Accounts 2008 will include R&D investment data. In addition with new intangible investment data (Corrado et al., 2014), this may enable an extension of the analysis

ers ISIC rev. 3 industries 10 to 12, 23 and 40. Our industry data is not disaggregated enough to exactly conform to this definition. Our results are robust to not excluding energy inputs.

[6] Note that because we focus on trade in intermediates, we ignore the possibility of outsourcing the final production stage.

presented here to allocate investments across business functions.

Our analysis will be based on changes in the cost shares of functional labour demand and we will treat capital as quasi-fixed in the short run in our analysis (further discussed in the next section). For capital, we will distinguish between Informations and Communications Technology (ICT) capital stocks and non-ICT capital stocks. We make this distinction in order to control for the role of new technologies in accounting for changes in the demand for activities. Information on ICT capital is obtained from the EU KLEMS database (O'Mahony and Timmer, 2009). We use information on ICT capital stocks and non-ICT capital stocks in 1995 prices. For most country-industries, ICT capital stock information is available until 2007 in the March 2011 update of EU KLEMS. However, for several countries the analysis is restricted to 2005 as capital stock data was not updated. [7] The other data needed for our analysis, namely value added, labour compensation and employment are also taken from the EU KLEMS database.

Table 2 shows mean values and average annual changes for the key variables of interest. The top rows show the business function shares. S_{RD} is the labour cost share of the business functions Research and Development and Technology and Process Development; S_{PROD} is the labour cost share of production activities; and S_{OTH} is the labour cost share of the other business functions. We will refer to S_{RD} as the labour cost share of R&D and engineering (or for short R&D). In table 2 we distinguish between manufacturing and services, partly because in an extension analysis later on we examine manufacturing and services industries separately. But also because the patterns observed appear more pronounced in manufacturing.

The mean values indicate that R&D constitutes about 10 percent of labour cost. On average, it is higher for manufacturing and lower for services (see Table 2). About half of the labour costs in manufacturing are due to production activities, whereas the majority of labour costs in services is in other functions. Over time, we observe an increase in the share of R&D and a decline in production. This is a general pattern across the high-income countries included in our analysis, see Figure 7, although the level and pace appears to differ across countries. The patterns are observed in both manufacturing industries and other sectors, but it is more pronounced in manufacturing.

At the same time, Table 2 indicates that both narrow and broad offshoring increased during the period considered. Again, this pattern appears more pronounced in manufacturing compared to services. Also, the share of internationally sources intermediates is higher from other advanced countries, but the

[7] These countries are France, Hungary, Ireland, Luxembourg, and Portugal.

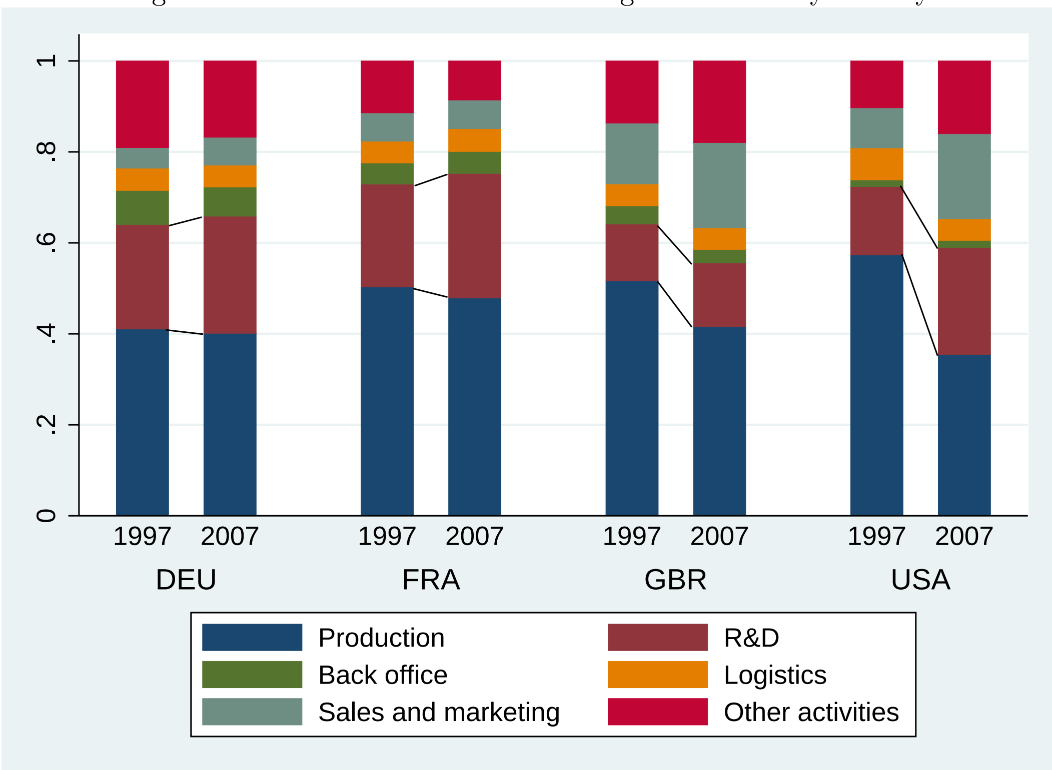
Table 2
Average cost shares and annual changes

	Average			Annual changes		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
S_{RD}	5269	0.108	0.101	4892	0.004	0.043
in manufacturing	*2273*	*0.131*	*0.107*	*2107*	*0.005*	*0.052*
in services	*2996*	*0.090*	*0.092*	*2785*	*0.003*	*0.034*
S_{PROD}	5269	0.309	0.234	4892	-0.011	0.092
in manufacturing	*2273*	*0.491*	*0.130*	*2107*	*-0.012*	*0.085*
in services	*2996*	*0.171*	*0.199*	*2785*	*-0.010*	*0.098*
S_{OTH}	5269	0.582	0.250	4892	0.007	0.083
in manufacturing	*2273*	*0.377*	*0.107*	*2107*	*0.006*	*0.074*
in services	*2996*	*0.738*	*0.212*	*2785*	*0.007*	*0.089*
Narrow offshoring share	5269	0.069	0.105	4924	0.001	0.015
to advanced economies	*5269*	*0.053*	*0.085*	*4924*	*-0.0001*	*0.013*
to developing economies	*5269*	*0.013*	*0.023*	*4924*	*0.001*	*0.006*
in manufacturing	*2273*	*0.124*	*0.119*	*2122*	*0.002*	*0.019*
in services	*2996*	*0.028*	*0.068*	*2802*	*0.0004*	*0.013*
Broad offshoring share	5269	0.266	0.233	4924	0.004	0.026
to advanced economies	*5269*	*0.199*	*0.199*	*4924*	*0.001*	*0.023*
to developing economies	*5269*	*0.075*	*0.096*	*4924*	*0.003*	*0.017*
in manufacturing	*2273*	*0.333*	*0.192*	*2122*	*0.004*	*0.025*
in services	*2996*	*0.215*	*0.249*	*2802*	*0.003*	*0.026*
Other variables						
ln Real value added	5269	9.769	2.484	4924	0.024	0.089
ln ICT capital stock	5269	7.425	2.82	4924	0.129	0.136
ln Non-ICT capital stock	5269	10.329	2.617	4924	0.023	0.039

Notes: S_{RD} is the labour cost share of the business functions Research and Development and Technology and Process Development; S_{PROD} is the labour cost share of production activitiess; and S_{OTH} is the labour cost share of the other business functions (see table 1).

annual growth rates suggest that offshoring to developing countries increases faster compared to advanced countries. The decline in production activities and the increase in offshoring to developing economies provide circumstantial evidence of the offshoring of production activities by firms in advanced economies. Baldwin (2012) distinguishes three drivers of the decline in pro-

Fig. 1. Share in domestic manufacturing labour cost by activity



duction activities in advanced economies. First, there is the cost reduction due to specialization according to comparative advantage. Second, western multinational firms combine their capital and technologies with low wages in low-skilled labour abundant countries. And third, the standardized nature of low-skilled tasks and thereby the high degree of competition keeps downward pressure on their wages. In contrast, activities less offshored tend to be activities where firms have more market power due to e.g. design, branding, and product differentiation. We will formally examine the relation between offshoring and the functional structure of labour demand in the next sections.

3 Empirical model

To analyze the role of offshoring for changes in the functional structure of labour demand, we use a translog cost function framework as introduced by Christensen et al. (1973). This framework has frequently been used in studies about the impact of offshoring and technology on skill demand, [8] partly because an attractive feature of the translog function is that it can approximate any functional form and it allows for varying elasticities of substitution.

[8] see e.g. Feenstra and Hanson (1999); Hijzen et al. (2005); Baltagi and Rich (2005); Foster-McGregor et al. (2013); Michaels et al. (2014).

Instead of estimating single equations of labour demand as for example in Michaels et al. (2014), we simultaneously estimate a system of variable functional labour demands using panel data techniques as in Hijzen et al. (2005) and Timmer and Ye (2015). Estimating a system of variable demands generates more efficient results than single equation estimations whenever disturbances are correlated across equations. Because the right-hand side variables in the equations are the same and there are cross-equation restrictions, it is highly likely that the disturbances are correlated.

The variable factors of labour demand are business functions. In our main analysis we examine three business functions, namely R&D, production and all other activities. Together these sum to the total labour share in value added. In an extension analysis we will also consider other business functions that are in the main analysis subsumed under other activities. Capital is assumed to be quasi-fixed. Hence, both output and capital are treated as exogenous in the short run, as for example in Berman et al. (1994), Feenstra and Hanson (1999) and Hijzen et al. (2005). We estimate the model using a fixed-effects (within) estimator. This within estimator is consistent with the specification of a short run cost function, because it emphasises the short run dimension of the data.

We assume the industry cost functions can be approximated by a translog function, which is twice differentiable, linearly homogeneous and concave in the wages of workers in business functions. Omitting industry subscripts we have

$$
\begin{aligned}
lnC(w,x) = \alpha_0 + \sum_{i=1}^{F} \beta_i lnw_{it} + \sum_{k=1}^{K} \beta_k lnx_{kt} + \frac{1}{2}\sum_{i=1}^{F}\sum_{j=1}^{F} \gamma_{ij} lnw_{it} lnw_{jt} \\
+ \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \gamma_{kl} lnx_{kt} lnx_{lt} + \frac{1}{2}\sum_{i=1}^{F}\sum_{k=1}^{K} \gamma_{ik} lnw_{it} lnx_{kt}, \quad (1)
\end{aligned}
$$

where C refers to total variable costs and is a function of prices w_i for business functions i=1,...,F; and the quantities of ICT and non-ICT capital stocks, value added and narrow or broad offshoring, x_k=1,...,K.

A well-known and useful property of the cost function comes from taking the first order derivative, $\delta lnC/\delta lnw_i = (\delta C/\delta w_i)(w_i/C)$. Using Shephard's lemma it follows that $\delta C/\delta w_i$ equals the demand for the chosen business function i, and hence $\delta lnC/\delta lnw_i = (\delta C/\delta w_i)(w_i/C)$ equals the payments to business function i relative to total variable costs, which we will denote by the cost shares S_i. Hence, assuming cost minimization and differentiating equation (1) with respect to lnw_i, we obtain

$$S_i = \beta_i + \sum_{j=1}^{F} \gamma_{ij} lnw_{jt} + \sum_{k=1}^{K} \gamma_{ik} lnx_{kt}, \tag{2}$$

where S_i is the labour cost share of a business function in total labour compensation and $\sum_{i=1}^{F} S_i = 1$.[9] We follow the common approach and impose constant returns to scale to ensure the cost function is linearly homogeneous in prices of the variable business functions, hence $\sum_{i=1}^{F} \beta_i = 1$ and $\sum_{j=1}^{F} \gamma_{ij} = 0$ for any i. Symmetry implies that $\gamma_{ij} = \gamma_{ji}$. And since the summation of the cost shares of all business functions is equal to one by definition we have that $\sum_{i=1}^{F} \gamma_{ik} = 0$

The system of share equations with the parameter restrictions is estimated by iterating Zellner's method for Seemingly Unrelated Regression (SUR) equations. Since the business function shares sum to one, the disturbance covariance matrix of the system is singular and one equation needs to be dropped. In contrast to standard SUR, the estimation results from the iterated SUR (ISUR) are invariant to the equation deleted. Therefore, we combine the iterated SUR estimator with country and industry fixed effects to estimate the system given by equation (2).[10] The parameter estimates of the cost function are used to examine the effect of offshoring and technology on the functional structure of labour demand.

In addition, we will report the elasticities of substitution and the elasticities of business function demand. Among others, these are used to examine whether R&D and production activities are complementary to each other. Note that the coefficients γ_{ij} in equation (2) are the second order derivatives with respect to the business function prices. Hence, a negative estimate of γ_{ij} can loosely be interpreted as a net-complementarity between business function i and j, because it implies a price increase of business function j decreases the cost share paid to business function i and hence the usage of i must have decreased. More formally, the substitution elasticities between business functions (σ_{ij}) are given by the Allen-Uzawa partial elasticities of substitution:

$$\sigma_{ij} = \frac{\gamma_{ij}}{s_i s_j} + 1 \quad (\text{for } i \neq j), \tag{3}$$

[9] We take logarithms for all explanatory variables in equation (2), except for offshoring which is measured as a share.

[10] The standard one-step SUR combines multiple equations into one stacked form and estimates it using ordinary least squares. The iterated SUR is estimated using maximum likelihood. We use the latter and although it might not always converge, it did in all our applications in the main analysis but not in various extensions. Also note the empirical results from iterated SUR are close to the standard one-step SUR.

The price elasticity of demand for business function i with respect to price of j (ϵ_{ij}) is given by:

$$\begin{aligned} \epsilon_{ij} &= \sigma_{ij} s_j \quad \text{(for } i \neq j\text{)} \\ \epsilon_{ii} &= \frac{\gamma_{ij}}{s_i} + s_i - 1 \quad \text{(for } i = j\text{)}. \end{aligned} \tag{4}$$

The elasticity of demand for business function i with respect to a change in a fixed variable is given by:

$$\epsilon_{ik} = \frac{\gamma_{ik}}{s_i} \tag{5}$$

As is clear from these definitions, elasticities depend on cost shares that vary across observations. We follow common practice and evaluate the elasticities on the basis of the average cost shares across all observations that are included in the regression analysis. [11]

4 Main results

Table 3 reports the results of estimating the system of equations using the fixed effects iterative Zellner or seemingly unrelated regression estimator (fixed effects iSUR). In the first specification we use the narrow definition of offshoring and in the second specification the broad definition. The cost functions are well behaved if they are concave in wages. That is, the Hessian matrix of second-order derivatives with respect to factor prices must be negative semi-definite. We examined whether the curvature conditions are satisfied at each observation using the approach suggested by Diewert and Wales (1987). The curvature conditions are not satisfied at all points in our estimates, but it is in the majority. We follow Hijzen et al. (2005) and require that curvature conditions are satisfied on average. Hence, the elasticities are evaluated on the basis of the simple average cost shares across industries, consistent with our unweighted regression analysis. [12]

[11] We use a small letter s in equations (3) to (5) to denote that the elasticity is evaluated at the mean share for business function i.

[12] We also estimated the system of equations using the average real value added shares by industries as analytical weights to account for differences in economic importance of industries and measurement error. The results are robust using the narrow definition of offshoring, but the negative effect of the broad offshoring measure on the demand for production activities is no longer significant.

Our findings suggest offshoring is not related to the demand for R&D activities, but negatively affects the demand for production activities (see Table 3). This result holds for both the narrow and the broad measure of offshoring, see the first and third column. Hence, industries in advanced economies with faster growth in offshoring lower their demand for production workers. Consistent with Hijzen et al. (2005), our finding is not affected by the inclusion of a proxy for technological change namely the ICT capital stock. Industries that increase their ICT capital stock also significantly increase their demand for (skilled) R&D workers (Michaels et al., 2014). In contrast, more ICT investments lowers the demand for workers involved in production activities. The opposite result is observed for increases in the non-ICT capital stock.

Column (2) and (4) of Table 3 show the effect of offshoring by geographic destination on the onshore demand for activities. The narrow offshoring measure suggests that offshoring to both advanced and developing countries lowers the demand for production activities, consistent with the total effect from offshoring in column (1). However, the broad offshoring measure to other advanced economies is positive, perhaps because the wider variety of imported inputs raises learning or quality of domestic production within industries. Interestingly, once we distinguish between the geographic destination of offshoring we find opposing effects on the onshore demand for R&D activities. Narrow and broad offshoring to developing countries increases the demand for R&D activities, while offshoring to advanced economies reduces the demand for onshore R&D activities. This contrasts to the findings by Abramovsky et al. (2010) who find that multinational firms that offshore innovative activities increase their onshore demand for inventors. Our findings suggest that the firm-level analysis by Abramovsky et al. (2010) may not apply in aggregate, although the analysis is not exactly compatible as we examine R&D activities whereas Abramovsky et al. (2010) examine demand for high-skilled researchers. Below, we show these findings also apply when we solely examine manufacturing industries.

The role of price changes on changing demand for business functions can be inferred from the other parameter estimates. However, the interpretation of these (and the structural) parameters is not straightforward, because the factor prices on the right-hand side are in natural logarithms whereas the dependent variables are not. Instead, results are discussed on the basis of estimated elasticities reported in the top panel of table 4. A necessary (but not sufficient) condition for concavity in factor prices is that all the own price elasticities are negative. The signs on the main diagonal indeed reveal that elasticities are negative. Interestingly, the own-price elasticity is high for R&D activities. For workers in R&D activities, the self-price elasticity is -0.726, which means that a 1 percent decrease in the wage of R&D workers corresponds to a 0.726 percent increase in the R&D cost share. This elasticity is much higher compared to the own-price elasticity for production workers (-0.330).

Table 3
Fixed effects iterated SUR

	(1)	(2)	(3)	(4)
γ_{RD}	0.016***	0.016***	0.016***	0.015***
$\gamma_{RD,Prod}$	-0.013***	-0.013***	-0.012***	-0.012***
$\gamma_{RD,Oth}$	-0.003	-0.003	-0.003	-0.003
$\gamma_{RD,ICT}$	0.007***	0.006***	0.007***	0.006***
$\gamma_{RD,nonICT}$	-0.005***	-0.005***	-0.005***	-0.005***
$\gamma_{RD,Y}$	0.018***	0.017***	0.018***	0.017***
$\gamma_{RD,Offnarrow}$	0.007			
$\gamma_{RD,Offnarrow,toadvanced}$		-0.033**		
$\gamma_{RD,Offnarrow,todeveloping}$		0.310***		
$\gamma_{RD,Offbroad}$			-0.0003	
$\gamma_{RD,Offbroad,toadvanced}$				-0.022***
$\gamma_{RD,Offbroad,todeveloping}$				0.071***
γ_{Prod}	0.112***	0.113***	0.113***	0.114***
$\gamma_{Prod,Oth}$	-0.099***	-0.100***	-0.100***	-0.102***
$\gamma_{Prod,ICT}$	-0.013***	-0.012***	-0.013***	-0.011***
$\gamma_{Prod,nonICT}$	0.011***	0.010***	0.010***	0.011***
$\gamma_{Prod,Y}$	-0.001	0.001	-0.001	0.001
$\gamma_{Prod,Offnarrow}$	-0.152***			
$\gamma_{Prod,Offnarrow,toadvanced}$		-0.065***		
$\gamma_{Prod,Offnarrow,todeveloping}$		-0.846***		
$\gamma_{Prod,Offbroad}$			-0.031***	
$\gamma_{Prod,Offbroad,toadvanced}$				0.027**
$\gamma_{Prod,Offbroad,todeveloping}$				-0.169***
Observations	5269	5269	5269	5269
R^2_{RD}	0.791	0.792	0.791	0.792
R^2_{Prod}	0.894	0.896	0.893	0.894

Notes: Estimation of parameters determining factor costs shares in system of equations as given in equation 2 are shown. All regressions include country and industry dummies. ***,** and * refer to 1%, 5% and 10% significance levels. subscript RD refers to the business functions Research and Development and Technology and Process Development; subscript $Prod$ is Assemblers; Operations, primary activity of the business. The R^2 is reported for each regression equation.

Of additional interest for our analysis is the viscidity of business functions. The elasticities of substitution among business functions are shown in the bottom part of table 4. An elasticity below one indicates they are complementary. R&D activities appear somewhat complementary to other head quarter activities. But in particular we find a low substitution elasticity of R&D with production activities, suggesting they are particularly complementary. This confirms the firms level analysis by Defever (2012), where firms co-locate R&D and production activities when investing abroad. It implies that offshoring may not directly affect the demand for R&D and engineering activities, but indirectly it does as production activities disappear in advanced economies. We will investigate in greater depth the elasticity of substitution between business functions in the next section.

Table 4
Elasticities based on the fixed effects iterated SUR

	Implied price elasticity		
	R&D	Production	Other activities
R&D	(-0.726)***		
Production	0.041***	(-0.33)***	
Other activities	0.076***	0.151***	(-0.227)***
ICT capital	0.082***	(-0.042)***	0.011***
Non ICT capital	(-0.062)***	0.033***	(-0.009)**
Narrow offshoring	0.084	(-0.482)***	0.241***
Output	0.222***	-0.009	(-0.029)***
	Implied elasticity of substitution		
	R&D	Production	Other activities
R&D			
Production	0.506***		
Other activities	0.939***	0.479***	

Notes: The elasticity results correspond to the regression results in table 3 using the narrow offshoring measure. R&D refers to the business functions Research and Development and Technology and Process Development; Production to Assemblers; Operations, primary activity of the business; and Other activities to the other business functions. ***,** and * refer to 1%, 5% and 10% significance levels, where the significance of the elasticities is estimated using the Delta method.

Our main analysis includes agriculture, manufacturing industries and service sectors. Firms in services sectors such as in finance and business services are actively engaged in international activities (Jensen, 2011), and therefore we include them in our main analysis. However, existing research mostly focuses on manufacturing since offshoring is thought to particularly effect jobs in manufacturing industries (Brown, 2008). We redid the analysis for manufacturing industries and services sectors separately. The regression results are reported in appendix table B1, which indicate that offshoring lowers the demand for production and standardize services activities in advanced economies. In table 5, the price and substitution elasticities are shown for the regression results of manufacturing industries (for services sectors, see Appendix table B2). The own-price elasticities are negative, except for other activities, and as before stronger for R&D activities. Also, ICT capital is again positively related to R&D activities and negatively for production activities. Again, R&D appears complementary to production activities. The slightly lower elasticity of substitution for manufacturing (0.459) compared to all sectors (0.506, see table 4) suggests complementary is stronger in manufacturing. But for manufacturing industries, it appears R&D substitutes for other head quarter activities. We will further investigate the effect of offshoring on and the complementarity of business activities in the next section.

Table 5
Elasticities based on the fixed effects iterated SUR for manufacturing industries

	Implied price elasticity		
	R&D	Production	Other activities
R&D	(-0,589)***		
Production	0,100***	(-0,092)***	
Other activities	0,638***	(-2,085)***	1,258***
ICT capital	0,031***	(-0,030)***	0,185***
Non ICT capital	-0.009	(-0,021)**	0,260***
Narrow offshoring	-0.02	(-0,107)**	1,214***
Output	0,083***	-0.018	(-0,065)***
	Implied elasticity of substitution		
	R&D	Production	Other activities
R&D			
Production	0,459***		
Other activities	2,937***	(-3,842)***	

Notes: The elasticity results correspond to the regression results for manufacturing industries in Appendix table B1 using the narrow offshoring measure. R&D refers to the business functions Research and Development and Technology and Process Development; Production to Assemblers; Operations, primary activity of the business; and Other activities to the other business functions. ***,** and * refer to 1%, 5% and 10% significance levels, where the significance of the elasticities is estimated using the Delta method.

5 Exploring the viscidity of business functions in greater detail

So far, our main interest has been on the relation between offshoring and the demand for R&D and production activities, as well as the complementarity between both. However, the more detailed data on business activities allows us to further explore the relation between offshoring and the demand for activities. In this section, we follow Defever (2012) and distinguish R&D, production, back office, logistics, sales and marketing, and other activities. Estimating this system of six equations is demanding in terms of the parameters that need to be estimated. As a result, we were not able to estimate the system using maximum likelihood estimates. Instead, we estimated the system in a single step SUR instead of an iterated SUR where the multiple equations are stacked and estimated via OLS.

The resulting elasticities are shown in table 6, and the regressions results in Appendix table B2. As before, offshoring is unrelated to the demand for R&D activities, whereas it significantly reduces the demand for production activities. In addition, the regression results reported in Appendix table B2 suggest that industries which offshore activities significantly lower their demand for back office activities. In contrast, offshoring industries increase their demand for logistics, and sales and marketing activities.

The substitution elasticities in the bottom part of table 6 suggest that our finding of complementarity of R&D and production activities is robust to distinguishing more business activities and estimating a more elaborate system of equations. Although the substitution elasticities are less precisely estimated, they suggest that R&D and logistics and marketing activities are complementary. Also, they suggest production and back-office activities are substitutes, but production is complementary to logistics and marketing activities. Overall, these elasticities suggest that the various head quarter activities distinguished are complementary, except for back-office activities. Hence, offshoring has a direct effect on reducing the demand for production and back-office activities.

6 Concluding remarks

This paper examined the relation between offshoring and the functional structure of labour demand. Building up from micro data, we provided a novel characterization of the workforce, classified by business functions. We distinguished eight such functions, namely production, R&D, sales and marketing, logistics, customer services, management, technology development and facility maintenance. In our main analysis we distinguished production, R&D and engineering, and grouped all other head quarter activities. Our results suggest

Table 6
Elasticities based on the fixed effects iterated SUR for broader set of business functions

	Implied price elasticity					
	R&D	Production	Back-Office	Logistics	Marketing	Other
R&D	(-0,672)***					
Production	0,045***	(-0,355)***				
Back-Office	(-0,169)***	0,483***	(-1,053)***			
Logistics	-0.049	0,119***	0,345***	(-0,339)***		
Marketing	0,422***	(-0,058)**	0,164***	(-0,059)***	(-0,445)***	
Other	(-0,661)***	0,139***	0,086***	-0.0001	-0.006	(-0,661)***
ICT capital	0,070***	(-0,037)***	(-0,033)***	0.008	0,070***	0.007
Non ICT capital	(-0,045)**	0,036***	0,110***	-0.002	(-0,055)***	(-0,037)***
Narrow offshoring	0.185	(-0,452)***	(-0,308)***	0,713***	1,098***	0.037
Output	0,243***	-0.003	(-0,098)***	(-0,099)***	0,062***	(-0,022)***
	Implied elasticity of substitution					
	R&D	Production	Back-Office	Logistics	Marketing	Other
R&D						
Production	0,567***					
Back-Office	(-2,129)***	1,531***				
Logistics	-0.62	0,379***	3,730***			
Marketing	5,318***	(-0,184)**	1,775***	(-0,889)***		
Other	0,754***	0,440***	0,933***	-0.002	-0.069	

Notes: The elasticity results correspond to the regression results shown in appendix table X using the narrow offshoring measure. ***,** and * refer to 1%, 5% and 10% significance levels, where the significance of the elasticities is estimated using the Delta method.

that industries in advanced economies with faster growth in offshoring lower their demand for production workers and increase their demand for R&D activities. Indirectly offshoring affects R&D activities as these are complementary to production. We found that offshoring is also significantly negatively related to the demand for back office functions. However, offshoring increases the demand for other activities such as logistics and sales and marketing. Our results suggest that most head quarter activities are complementary to R&D and production activities, except for back office functions. Indeed, the viscidity of back-office functions with other activities appears small.

These results suggest that globalisation is affecting national labour markets at the level of stages of production. The typical distinction between skilled and unskilled workers is useful for understanding the uneven effects of globalisation, but our findings suggest the impact is more pervasive. Skilled workers are also affected by offshoring, depending on the business activity in which they are engaged and its complementarity to other activities. These findings imply that trade, eduction and industrial policies should not be solely sector-specific but rather pay attention to the type of activities carried out, taking into account patterns of vertical integration of production within and across countries.

This paper is a first attempt to examine the impact of globalisation and the 'glue' of business activities. Understanding whether and how activities are related is important as it helps to understand and predict changes in the demand for jobs due to globalisation. While useful, there is clearly a need for additional empirical data. Fortunately, there are ongoing attempts to provide fresh evidence on the macro-implications of firm-level internationalization strategies. In particular, new firm-level surveys are undertaken that measure the type of business functions that are carried out domestically and those that are offshored (Nielsen, 2008; Brown et al., 2014). As yet, these surveys are in a testing phase and not yet part of a regular statistical program. But once they will, our hope is this results in a more comprehensive understanding of offshoring and the demand for business activities.

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Appendices

A Detailed description of the data sources

For European countries, yearly occupational data by detailed industry are from the European Labour Force Survey (EU LFS). The EU LFS is a large household survey, which provides information on labour force participation of persons aged 15 and over. The Labour Force Surveys are conducted by the national statistical institutes across Europe and are centrally processed by Eurostat. These are sample surveys with appropriate weights to be representative of the entire workforce in each country. Besides employment data, we also need wages to derive shares in labour compensation. The EU LFS does not provide wage data by occupation, except by deciles in recent years. We built up relative wage data by occupation from the micro data provided in the Structure of Earnings Surveys (SES), waves 2002 and 2006. An overview of the availability of EU LFS and SES by country is provided in Appendix table A1.

The SES provides harmonized data on earnings in European countries. It is a large enterprise survey conducted by the national statistical institutes. We compute relative wages by 2-digit occupation for each European country. These relative wages are interpolated between the survey years. We keep relative wages equal to that of the 2002 wave in years before 2002, and likewise for relative wages in years after 2006 (the latest wave for which we have data). Structure and Earnings Surveys are available for most of the 27 EU countries. However, for several it is not and for these we substituted relative wages by occupation from countries at comparable levels of development. For Denmark, Ireland and Austria we assume relative wages approximate average relative wages in Belgium, the Netherlands, and Finland. For Greece, Malta, and Slovenia we assume relative wages approximate average relative wages in the Czech Republic, Cyprus, and Slovakia. For Turkey we assume relative wages approximate those in Hungary. We combine these relative wages with the occupational employment shares by industry from the EU LFS.

Employment and wages for the US are derived from the Occupational Employment Statistics (OES). The OES is a large dataset containing industry-level information on about 800 occupations. Data are reported in the SIC classification for the period 1997 to 2001 and in NAICS from 2002 onwards. We convert all industry codes into the ISIC rev. 3 classification, which allows matching to the industries distinguished in the World Input-Output Tables, using conversion tables from the Bureau of the Census. The OES uses the 2000 Standard Occupational Classification (SOC) system for the period from 1999 to 2009, and the 2010 SOC from 2010 onwards. The National Crosswalk

Table A1
Overview of occupation data for European countries

	Labour force survey	Structure of Earnings Survey
Austria	1995 - 2013	n.a.
Belgium	1995 - 2013	2002, 2006, 2010
Bulgaria	2000 - 2013	2002, 2006, 2010
Czech Republic	1997 - 2013	2002, 2006, 2010
Denmark	1995 - 2013	n.a.
Estonia	1997 - 2013	2002, 2006, 2010
France	1995 - 2013	2002, 2006, 2010
Finland	1997 - 2013	2002, 2006, 2010
Germany	1995 - 2013	2006, 2010
Greece	1995 - 2013	n.a.
Spain	1995 - 2013	2002, 2006, 2010
Cyprus	1999 - 2013	2002, 2006, 2010
Ireland	1995 - 2013	n.a.
Italy	1995 - 2013	2006, 2010
Latvia	1998 - 2013	2002, 2006, 2010
Lithuania	1998 - 2013	2002, 2006, 2010
Luxembourg	1995 - 2013	2002, 2006, 2010
Hungary	1996 - 2013	2002, 2006, 2010
Malta	2000 - 2013	n.a.
Netherlands	1995 - 2013	2002, 2006, 2010
Poland	2004 - 2013	2002, 2006, 2010
Portugal	1995 - 2013	2002, 2006, 2010
Romania	1997 - 2013	2002, 2006, 2010
Slovakia	1998 - 2013	2002, 2006, 2010
Slovenia	1996 - 2013	n.a.
Sweden	1997 - 2013	2002, 2006, 2010
Turkey	2007 - 2013	n.a.
United Kingdom	1995 - 2013	2002, 2006, 2010

Service Center provides a crosswalk of the 6-digit SOC occupation codes to

4-digit ISCO-88 categories. About 10 per cent of the 6-digit SOC occupations map into more than one 4-digit ISCO category. However, our matching of functions to occupations is done at the 3-digit level. In most cases we can easily identify a 3-digit ISCO category to which the 6-digit SOC occupation belongs. In other cases we can map occupations to ISCO based on the occupation description. The initial crosswalk constructed this way did not exactly match all the occupations distinguished in OES, perhaps because OES used its own classification system in the past and some occupation categories from that old system remained (see also below). We therefore take additional occupations not initially matched using the crosswalk and add these to the crosswalk. For example, the OES 2005 survey includes occupation 15-2091 titled "Mathematical technicians", which is not included in the SOC2000 x ISCO-88 crosswalk. We include it and it match it to ISCO-88 occupation 212 "Mathematicians, statisticians, and related professionals" Typically the additional matches were also easy to make, in particular at the three digit ISCO level. Data for earlier years are classified according to a system that is specific to OES at that time. The crosswalk between the 6-digit SOC system and the 4 digit ISCO-88 were used in combination with the detailed description of the occupation to match each of the about 900 occupations to an ISCO category. Since 2003, the OES data are released on a six-month basis instead of on a yearly basis. We use the May rounds, because the November round is not available for all years up to 2006. The OES occupation data for 2010 and 2011 use the 2010 SOC system. We use the crosswalk between the 2010 SOC and 2000 SOC provided by BLS. Again, the initial crosswalk constructed this way did not exactly match all the occupations distinguished in OES. We therefore take additional occupations not initially matched using the crosswalk and add these to the crosswalk. Subsequently we use the 2000 SOC to ISCO-88 crosswalk. In a final step we aggregate the occupation labour shares to activities and we match the industry data to the industries in the WIOTs.

For Japan, we use detailed five yearly occupational employment data by industry from the Japan Population Census for the year 1995, 2000, 2005, and 2010. Relative wage data is derived from the wage structure surveys by occupation for the same years. We match the industries distinguished to the WIOT industries, and we map the occupations in the wage structure surveys to the occupations distinguished in the population census. Occupations are then matched to our list of business functions. Subsequently, we measure the share of each activity in total labour compensation.

B Appendix tables and figures

Table B1
Fixed effects iterated SUR for manufacturing and other sectors

	Manufacturing		Other sectors	
γ_{RD}	0.042***	0.045***	0.002	0.002
$\gamma_{RD,Prod}$	-0.064***	-0.065***	0.00005	0
$\gamma_{RD,Oth}$	0.022***	0.021***	-0.002	-0.002
$\gamma_{RD,ICT}$	0.007***	0.005***	0.004***	0.004***
$\gamma_{RD,nonICT}$	-0.002	-0.001	0.001	0.001
$\gamma_{RD,Y}$	0.018***	0.017***	0.017***	0.017***
$\gamma_{RD,Offnarrow}$	-0.004		-0.012	
$\gamma_{RD,Offnarrowtoadvanced}$		-0.075***		-0.033*
$\gamma_{RD,Offnarrowtodeveloping}$		0.392***		0.204**
γ_{Prod}	0.199***	0.198***	0.083***	0.083***
$\gamma_{Prod,Oth}$	-0.135***	-0.133***	-0.083***	-0.083***
$\gamma_{Prod,ICT}$	-0.016***	-0.014***	-0.008***	-0.008***
$\gamma_{Prod,nonICT}$	-0.011**	-0.013***	0.009***	0.009***
$\gamma_{Prod,Y}$	-0.004	-0.002	-0.023***	-0.023***
$\gamma_{Prod,Offnarrow}$	-0.058**		-0.061**	
$\gamma_{Prod,Offnarrowtoadvanced}$		0.074***		-0.049
$\gamma_{Prod,Offnarrowtodeveloping}$		-0.816***		-0.161
Country dummies	YES	YES	YES	YES
Industry dummies	YES	YES	YES	YES
Observations	2273	2273	2996	2996
R^2_{RD}	0.781	0.786	0.829	0.83
R^2_{Prod}	0.706	0.717	0.869	0.869

Notes: Estimation of parameters determining factor costs shares in system of equations as given in equation 2 for manufacturing industries and other sectors of the economy. ***,** and * refer to 1%, 5% and 10% significance levels. subscript RD refers to the business functions Research and Development and Technology and Process Development; subscript $Prod$ is Assemblers; Operations, primary activity of the business. The R^2 is reported for each regression equation.

Table B2

Elasticities based on the fixed effects iterated SUR for services sectors

	Implied price elasticity		
	R&D	Production	Other activities
R&D	(-0,900)***		
Production	0,076**	0,133**	
Other activities	0,071***	(-0,111)***	(-0,367)***
ICT capital	0,057***	(-0,097)***	0,008*
Non ICT capital	0.017	0,114***	(-0,024)***
Narrow offshoring	-0.165	(-0,767)**	0,167**
Output	0,224***	(-0,304)***	0.08
	Implied elasticity of substitution		
	R&D	Production	Other activities
R&D			
Production	1,008**		
Other activities	0,942***	(-1,409)***	

Notes: The elasticity results correspond to the regression results for services sectors in Appendix table B1 using the narrow offshoring measure. R&D refers to the business functions Research and Development and Technology and Process Development; Production to Assemblers; Operations, primary activity of the business; and Other activities to the other business functions. ***,** and * refer to 1%, 5% and 10% significance levels, where the significance of the elasticities is estimated using the Delta method.

Table B3

Fixed effects iterated SUR for a broad set of business functions

	β	s.e.
$\gamma_{RD,ICT}$	0.005***	0.001
$\gamma_{RD,nonICT}$	-0.004***	0.001
$\gamma_{RD,Offnarrow}$	0.015	0.01
$\gamma_{RD,Y}$	0.016***	0.003
$\gamma_{Prod,ICT}$	-0.008***	0.002
$\gamma_{Prod,nonICT}$	0.012***	0.003
$\gamma_{Prod,Offnarrow}$	-0.142***	0.019
$\gamma_{Prod,Y}$	0.025***	0.005
$\gamma_{BO,ICT}$	-0.002**	0.001
$\gamma_{BO,nonICT}$	0.010***	0.001
$\gamma_{BO,Offnarrow}$	-0.027**	0.011
$\gamma_{BO,Y}$	-0.007***	0.003
$\gamma_{LOG,ICT}$	0	0.001
$\gamma_{LOG,nonICT}$	-0.001	0.001
$\gamma_{LOG,Offnarrow}$	0.047***	0.007
$\gamma_{LOG,Y}$	-0.010***	0.002
$\gamma_{MAR,ICT}$	0.004***	0.001
$\gamma_{MAR,nonICT}$	-0.004***	0.002
$\gamma_{MAR,Offnarrow}$	0.095***	0.011
$\gamma_{MAR,Y}$	-0.005*	0.003
Country dummies	YES	
Industry dummies	YES	
Observations	5021	
R^2_{RD}	0.826	
R^2_{Prod}	0.9	
R^2_{BO}	0.799	
R^2_{LOG}	0.896	
R^2_{MAR}	0.75	

Notes: Estimation of parameters determining factor costs shares in system of equations as given in equation 2, but for a wider set of business functions. For manufacturing industries and other sectors of the economy. Standard errors in column next to parameter estimates. ***,** and * refer to 1%, 5% and 10% significance levels. subscript RD refers to the business functions Research and Development and engineering; subscript $Prod$ is Assemblers; Operations, primary activity of the business; subscript BO is back office activities; LOG is logistics activities; and MAR is sales and marketing activities. The R^2 is reported for each regression equation.