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Service Offshoring and the Demand for Less-Skilled Labor:

Evidence from Germany

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Service Offshoring and the Demand for Less-Skilled Labor: Evidence from Germany

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Abstract

Besides material offshoring, economists have started to analyze the impact of service offshoring on domestic employment. Services are of particular interest since their significance has grown in terms of both quantity and quality. One decade ago, most services were considered non-tradable, but the emergence of new information and communication technologies has contributed to overcoming geographical distance. The move towards the liberalization of international service trade has further accelerated this process.

The empirical part of this paper first calculates German service offshoring intensities on a sectoral basis using input-output data. This measurement represents the proportion of imported service inputs used in home production. Germany's average service offshoring intensity more than doubled from 1991 to 2003. In a next step, the impact of service offshoring on the demand for heterogeneous labor in Germany is estimated at a sectoral level including 28 manufacturing sectors. The partial static equilibrium model is based on a variable unit cost function in the general translog form allowing for quasi-fixed input factors. Two different skill-levels are taken into account. The estimation results indicate that service offshoring reduced the relative demand for less-skilled labor in the German manufacturing sectors by on average -0.06 to -0.16% per year between 1991 and 2000.

JEL No. F1, F2
Key words: service offshoring, labor demand, less-skilled labor, globalization, technological change

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1. Introduction

Intensifying globalization processes have coincided with low economic growth rates and high unemployment in Germany especially in the 1990s. Globalization in the economic sense comprises the transnational movement of production factors, commodities and services, which is reflected in a higher integration of international goods, money and capital markets (Reining, 2003). Trade and investment flows, in particular, have increased, which often leads to the one-sided conclusion that growing globalization causes negative labor market effects. This popular belief, which could also contribute to the increasingly pessimistic attitude of the working population in Germany, demands academic clarification.

Globalization processes have an impact on domestic labor markets via three main channels. First, integrated product markets intensify he international commodity and service trade which influences the home labor market. Second, domestic labor markets can also be affected by economic integration via Foreign Direct Investment (FDI) and the fragmentation of production. Both channels have an indirect effect on national labor markets, whereas the third channel focuses on the direct labor market integration via migration (Landesmann, 2000). Regarding offshoring-induced labor market effects, economists distinguish between quantitative labor market effects, i.e. the *overall level of home employment*, and qualitative aspects such as *employment or income distribution*.

Offshoring is used as a general term to describe all kinds of entrepreneurial activities taking place in a country other than the domestic one in order to support a company's business. Often, terms such as outsourcing, international outsourcing, offshoring or offshore outsourcing[1] refer to the same phenomenon but, strictly speaking, do not mean the same. A clear definition of offshoring is required, beginning with a distinction between outsourcing and offshoring. Outsourcing asks for the "source" of production, i.e. if the input is produced by an internal source (self-production or subsidiary) or an external source (independent supplier/subcontracting) wherever the source might be located geographically. Offshoring, on the other hand, asks for the "shore", or the country of production, i.e. if the input is produced at home or abroad regardless of the source. *Figure 1* shows the 4 possible combinations of both criteria: (a) internal production in the home country (captive home production), (b) external production in the home country (onshore outsourcing), (c) internal production abroad

[1] Fragmentation and even foreign direct investment (FDI) is also used.

(captive offshoring or FDI) and (d) external production abroad (offshore outsourcing or international outsourcing). Offshoring comprises both internal and external production in a foreign country (c and d).

In the US, economists have started to consider the damaging potential of offshoring on domestic employment. Samuelson (2004) argued with a theoretical Ricardian model that offshoring might provoke negative domestic labor market effects when the trade partner has productivity gains in its initially import-competing sector. That means that the trade partner gains some of the comparative advantage that was previously limited to the domestic economy. In this case, technological innovation could permanently reduce the per capita income in the country of origin (Samuelson, 2004). Free trade advocate Alan Blinder's (2007a) estimations on the potential offshorability of 30 to 40 million American service jobs is quoted lately in newspaper articles, such as "Pain from free trade spurs second thoughts" in the Wall Street Journal on March 28th 2007 (Wessel and Davis, 2007) or "Free trade's great, but offshoring rattles me" in the Washington Post on May 6th 2007 (Blinder, 2007b).

Recently, the newer phenomenon of *service offshoring* seems to have spread to Germany. The discussion has become more relevant due to the geographical and cultural proximity of the new Central and Eastern European Countries (CEEC) that have joined the EU. Services are of particular interest since their significance has grown in terms of both quantity and quality. One decade ago, most services were considered non-tradable, but the emergence of new information and communication technologies (ICT) has contributed to overcoming geographical distance.

While the above classification refers to offshoring in general, the following paragraph aims at giving an appropriate definition of service offshoring. Service trade has been fostered by global drivers that have appeared simultaneously. Thus, *developments in ICT* have led to what is sometimes called the digital-electronic revolution. For a long time, services, unlike commodities, were considered intangible and invisible and thus not storable or transferable.[1] Hence, direct contact between the producer and consumer of a service was required (*uno-actu-principle*). According to the uno-actu-principle either the consumer of a service had to seek the producer out (e.g. retail, wholesale, tourism sector) or vice versa (e.g. transport sector, waste disposal). Recent developments in ICT have made it possible to uncouple

[1] This distinction between services and commodities should not be understood in a strict sense. Some services have features of commodities and are tangible (e.g. the printed report of a management consultant) or visible (e.g. theatre). Beyond this, most commodities depend on service inputs in their production and vice versa.

information from its physical memory, rendering the transfer of huge amounts of data possible within a few seconds (‘disembodied services’). Thus, the generality of the uno-actu-principle has been called into question. Besides the developments in ICT, the move towards the *liberalization of international service trade* has further accelerated this process.

Service offshoring in the broader sense comprises all kinds of foreign service activity of a multinational company (MNC) aimed at supporting its domestic production. The motives behind an offshoring decision can be market-oriented, cost-oriented, or procurement-oriented. Service offshoring is expected to have the potential for harming employment when formerly home-produced services are transferred for cost reasons. Therefore, my definition of service offshoring in the narrower sense focuses on cost-oriented motives:

“Service offshoring designates the provision of service inputs from a foreign supplier that are produced abroad mainly for cost reasons and re-imported to the home country. Here, the foreign procurement either happens externally, via an independent supplier (offshore outsourcing), or internally within the multinational company (captive offshoring).”

2. Literature Overview

Empirical research on *service offshoring* and possibly related employment effects is indispensable as it can give ideas about the direction and the extent to which offshoring has influenced labor demand. However, the service offshoring debate in Germany is not yet well established. Even in the Anglo-Saxon countries there is shortage of empirical research. The impact of service and material offshoring on the *domestic employment level* for the relevant ICT-period has been empirically measured at a sectoral level for the US (e.g. Amiti and Wei, 2004, 2006), the UK (Amiti and Wei, 2005) and Germany (Schöller, 2007a, b).

German empirical studies that focus on *service inputs* and their related effects on the national markets are rare. Falk and Koebel (2002), for instance, only consider the impact of domestically purchased services and imported material inputs on the national labor demand structure. Moreover, they use data from 1978 to 1990 which does not cover the relevant ICT-period. Görzig and Stephan (2002) analyze the impact of outsourcing on firm-level performance, but do not differentiate between domestic and foreign service purchases. The McKinsey Global Institute report, for instance, measures the welfare gain of service offshoring but does not clearly reveal the underlying method (Farrel, 2004; McKinsey Global Institute, 2005). Schöller (2007a, b) studies the impact of service offshoring on labor demand and finds evidence of a negative impact of service offshoring on German manufacturing employment between 1991 and 2000.

The effects of *material offshoring* on the *relative demand for heterogeneous labor* have been analyzed for the first time by Feenstra and Hanson (1996, 1999). They find that imported material inputs increased the relative demand for skilled labor in the US manufacturing sectors between 1979 and 1990. Falk and Koebel (2002) and Geishecker (2002) studied the effects of material offshoring on the demand for less-skilled labor in Germany. Falk and Koebel find no evidence that unskilled labor is substituted for imported materials in the manufacturing sectors between 1978 and 1990. Geishecker finds that material offshoring had a negative impact on the demand for less-skilled workers in German manufacturing sectors between 1991 and 2000, but skill-biased technological change is at least as important as offshoring to explain the decrease of the relative demand for less-skilled labor.

Strauss-Kahn (2004) finds that imported material inputs had a negative impact on the demand for unskilled workers in the French manufacturing sectors in the period of 1977 to 1993. Hijzen, Görg and Hine (2005) demonstrate a strongly negative material offshoring-induced effect on unskilled labor in the manufacturing sectors for the UK between 1982 and 1996. Ekholm and Hakkala (2006) analyze the impact of offshoring on workers with different educational attainments for Sweden between 1995 and 2000. They distinguish between offshoring to low-income and high-income countries and find that offshoring to low-income countries tends to shift labor demand away from domestic workers with an intermediate level of education.

None of the aforementioned studies consider the effects of service offshoring. My contribution is to distinguish between service and material offshoring when analyzing the impact on the demand for heterogeneous labor. Offshoring intensities measure the proportion of imported service and material inputs used in home production; they are calculated on a sectoral basis using input-output data. I include 28 manufacturing sectors for the period between 1991 and 2000, and distinguish between production and non-production workers.[1] A variable unit cost function in the general translog form is specified following Geishecker (2002, 2006).

The structure of the paper is the following. The next chapter examines how offshoring intensities are measured and shows the development of German service and material offshoring intensities between 1991 and 2003. German offshoring intensities are then compared to UK and US intensities. Chapter 4 proceeds with the impact of service offshoring

[1] A further study distinguishing between different levels of educational instead of occupational attainment is planned.

on the demand for less-skilled labor. The empirical model and its specification are explained before presenting the estimation results.

3. Service Offshoring Intensity

3.1 Two Different Measures of Service Offshoring Intensity

The following analysis for Germany uses input-output data from the Federal Statistical Office which originally comprises 71 sectors. I consider all 36 manufacturing sectors plus 7 selected service sectors (see *Appendix I*). The primary sector (sectors 1-3) and the sectors 'mining' and 'quarrying' of the secondary sector (sectors 4-8) are dropped, as they generally do not represent offshoring sectors. The selection of the 7 service sectors out of 27 includes *tradable business activities* in the broader sense according to the aggregation of Kalmbach et al. (2005) except for the wholesale sector[1]. Consumer-related[2] and social services[3] are not considered, since the former in general do not represent typical offshoring services and the latter are not tradable. Business activities comprise 'other business activities' in a narrower sense (sector 62), as well as the following 6 sectors: post and telecommunications; financial mediation (except insurance and pension funding); activities related to financial mediation; rental of machinery and equipment; computer and related activities; research and development (sectors 54, 55, 57, 59-61).

I calculate two different measures of offshoring intensity (a) and (b). The service offshoring intensity $OSS_{ist}(a)$ measures the share of service import *s* by sector *i* at time *t* in total non-energy inputs used by sector *i* at time *t* and is calculated as follows:

$$OSS_{ist}(a) = \frac{(imported\ input\ purchases\ of\ service\ s\ by\ sector\ i)_t}{(total\ non\text{-}energy\ inputs\ used\ by\ sector\ i)_t}$$

The service offshoring intensity $OSS_{it}(a)$ for sector *i* at time *t* is calculated by taking the sum over all $OSS_{ist}(a)$:

$$OSS_{it}(a) = \sum_s OSS_{ist}(a)$$

The denominator contains all 36 non-energy manufacturing inputs, plus the 7 service sectors selected above (see *Appendix 1*). German input-output data differentiates between

[1] The sector 'wholesale, trade and commission excl. motor vehicles' (sector 46) was dropped due to strong fluctuations in the data between 1991 and 1995.

[2] Sectors within the classification of the Federal Statistical Office: 45, 47-53, 56, 58, 69-71

[3] Sectors within the classification of the Federal Statistical Office: 63-68

domestically purchased inputs and imported inputs, whereas import data at a sectoral level is not available for the US and the UK according to Amiti and Wei (2004, 2005, 2006). Therefore, they apply the methodology of Feenstra and Hanson (1996, 1999) who calculate offshoring intensities of material imports to the US. This second measure of service offshoring intensity $OSS_{ist}(b)$ for a given sector *i* at time *t* is a *proxy* for the proportion of the imported service input *s* used in home production. Besides the $OSS_{ist}(a)$ measure, I also calculate the $OSS_{ist}(b)$ measure for Germany to allow for international comparability. The second measure is defined as follows:

$$OSS_{ist}(b) = \left[\frac{(input\ purchases\ of\ service\ s\ by\ sector\ i)_t}{(total\ non\text{-}energy\ inputs\ used\ by\ sector\ i)_t}\right]\left[\frac{(imports\ of\ service\ s)_t}{production_{st} + imports_{st} - exports_{st}}\right]$$

The first bracket calculates the share of the purchased service input *s* in total non-energy inputs for sector *i* at time *t*. However, the first ratio does not distinguish between domestically and foreign purchased service inputs, while service offshoring solely focuses on services from a foreign source. Therefore, the second bracket calculates the share of total imported service *s* (numerator) in the entire domestic disposability of this service *s* (denominator), which is composed of home production plus imports minus exports at time *t*. This data is retrieved from the input-output tables. The service offshoring intensity $OSS_{ist}(b)$ of service *s* in sector *i* is calculated by multiplying both ratios. This proxy assumes the same overall import share of service *s*, regardless of sectoral differences. In Germany, for instance, the overall import share of other business activities was 4.5% in 2003. Hence, an import share of 4.5% is assumed for each sector *i*.

The service offshoring intensity $OSS_{it}(b)$ for sector *i* at time *t* is calculated by taking the sum over all $OSS_{ist}(b)$:

$$OSS_{it}(b) = \sum_{s} OSS_{ist}(b)$$

The sectoral service offshoring intensity OSS_{it} should not be confused with OSS_{st}, which represents the average offshoring intensity of a certain service *s* across all sectors *i*. This is calculated by aggregating the respective OSS_{ist}, weighted by their sectoral output, which is:

$$OSS_{st} = \sum_{i} OSS_{ist} * (Y_{it} / Y_t)\text{, where } Y_t = \sum_{i} Y_{it}\ .$$

Adding all OSS_{st} yields the average service offshoring intensity OSS_t over all sectors *i* and services *s* at time *t*. The material offshoring intensities OSM_t are calculated analogously.

The definition of the offshoring intensity suffers from three related shortcomings. The first two caveats concern both offshoring intensity measures, whereas the last one only holds for the $OSS_t(b)$ measure. First, the measures underestimate the actual offshoring values, since import prices are generally lower than the actual purchase prices of these services. Second, the total non-energy inputs only include the purchased inputs, but not the self-produced inputs used by sector *i*. Third, the application of the same import share for each sector *s* (in the second bracket) in $OSS_t(b)$ is not accurate, since not every sector uses imports to the same extent. Thus, the offshoring intensity cannot be exactly measured (Amiti and Wei, 2005). Anyhow, the offshoring intensities, especially $OSS_t(a)$, present a good measure for the proportion of imported service inputs being used in home production at time *t*.

3.2 Results

The first column of *Table 1* presents the *average service offshoring intensities* OSS_{st} (weighted by sectoral output) of the 7 selected services *s* over all 43 sectors *i* in 1991, 2000 and 2003. The next column shows the (unweighted) mean, standard deviation, as well as the minima and maxima over the 43 sectors. The 1991 and 2000 data is in unrevised form, whereas the 2003 data is revised. Both are not fully comparable due to changes in the classification[1]. The average service offshoring intensity $OSS_t(a)$ has more than doubled from 1.47% in 1991 to 3.17% in 2000. At the services level, computer and related activities grew strongly from the 2nd smallest share of 0.03% in 1991 to the 2nd largest share of 0.60% in 2000. Other business activities have almost quadrupled their intensities from 0.37% in 1991 to 1.44% in 2000. The last three service sectors (computer and related activities, research and business development, and other business activities) that are typically associated with service offshoring formed more than a third (2.31%) of the total $OSS_t(a)$ in 2000. The revised 2003 intensities differ somewhat from the 2000 data, especially in financial mediation and related activities, which constitute a much higher share in 2003. This is probably due to the data revision, as bank charges are now added to the sector of financial services.

Figure 2 plots the development of the *average* $OSS_t(a)$ *and* $OSM_t(a)$ *intensities* in Germany between 1991 and 2003. The service offshoring intensity has grown considerably by 8.49% per year from 1.47% in 1991 to 3.90% in 2003 possibly due to the increased use of ICT. The material offshoring intensity has risen by 0.78% per year from 17.29% in 1991 to 18.98% in

[1] The revision of the input-output tables integrates, for instance, all the changes of the national accounts revision of 2005 and the new service statistics of the Federal Statistical Office.

2003. The CAGR between the low level year 1993 and 2003 is 2.78%. The stronger growth between 1993 and 2000 can be explained by the fall of the iron curtain and the subsequent FDI towards the CEEC, and likewise by the growing significance of the Asian markets. Over the whole period, the material offshoring intensities seem to have stagnated. An interpretation would be that the process of material offshoring, which has already started in the 1980s, has probably reached its capacity whereas service offshoring has not realized its full potential yet.

Finally, an *international comparison* between Germany, the UK and the US follows. Data for the UK and the US are based on the studies of Amiti und Wei (2004, 2005, 2006). One could object that comparability of OSS_{it} and OSM_{it} is not given, since the respective sectoral classifications differ and are more disaggregated for the Anglo-Saxon countries. However, such differences disappear in OSS_t and OSM_t, as they represent a weighted aggregation (by sectoral output) of all sectoral offshoring intensities. Comparability of the three countries then requires that similar manufacturing and service sectors are chosen. There should be no problem with the manufacturing sector, since all manufacturing industries are included in the three countries. Country-specific differences could only arise in the selection of the service sectors. *Table 2* shows that the selected services are similar with respect to their activities. All services have an equivalent in the other countries which allows for comparison.

Table 3 compares the *average German service and material offshoring intensities with UK and US intensities* for the period of 1992 to 2001. Only the four columns on the right hand side using the offshoring (b) measure are comparable. UK data is not directly available, but was reconstructed from Figure 2 in Amiti and Wei (2005). Regarding service offshoring the UK shows the highest intensities. Between 1992 and 2001, they were on average 0.5%-points higher than the German $OSS_t(b)$ and reached a peak of 2.60% in 2000. This is remarkable, as one would expect service offshoring to be more relevant for the UK due to its former colonial ties and the lower linguistic barriers. The US intensities, both in the older (Amiti and Wei, 2004) and the recent calculation (Amiti and Wei, 2006) are far below the German level and were always less than 1%. Nevertheless, they follow an increasing trend. Germany shows the highest CAGR (1992-2001) of 9.75% compared to the UK (7.55%) and the US (5.60% resp. 6.14%).

As regards material offshoring, in 2001, the UK had the strongest intensity (28.09%), followed by Germany (19.88%) and the US(I) (11.47%). Over the entire period, both German and US intensities were much lower than the UK intensities. The old and recent $OSM_t(b)$ calculations for the US strongly diverge. The old US(I) calculation has much lower intensities, whereas recent US (II) measurements are closer to the German levels. $OSM_t(b)$ in the US grew nearly continuously between 1992 and 2000/2001, unlike Germany and the UK. In the UK, it grew slightly until 1995/1996 and fell back to its initial level showing no clear trend. The German $OSM_t(b)$ started at a very high level in 1991 and fell to a low in 1993 before growing constantly until 2000.

4. Empirical Analysis

4.1 Empirical Model

A *variable unit cost function CV* is specified following Geishecker (2002, 2006)

$$CV = CV(w_{HS}, w_{LS}, Y, \frac{K}{Y}, T) \tag{1.1}$$

where w_{HS} and w_{LS} are the exogenous wages for the *variable input factors* high skilled labor L_{HS} and less-skilled labor L_{LS}. Y denotes the output. Capital is considered a *quasi-fixed input factor* in the form of the capital coefficient *K/Y*. The *technology shifter* $T = T(RD/Y, OSS, OSM)$ is a linear function of R&D intensity *RD/Y* and offshoring intensities *OSS* and *OSM, and* represents a change of the production function due to technological progress or international trade (offshoring).

The following *general transcendental logarithmic (translog) form*[1] of a variable unit short-run cost function as introduced by Brown and Christensen (1981) is used, allowing for *l* variable input factors ($P_j : j = 1, \ldots, l$) and *m* quasi-fixed input factors ($Z_j : j = 1, \ldots, m$) (for the theoretical model see *Appendix 2*):

$$\begin{aligned}\ln CV = {} & \alpha_0 + \alpha_Y \ln Y + \sum_{j=1}^{l} \alpha_j \ln P_j + \sum_{j=1}^{m} \beta_j \ln Z_j \\ & + \frac{1}{2}\gamma_{YY}(\ln Y)^2 + \frac{1}{2}\sum_{j=1}^{l}\sum_{k=1}^{l}\gamma_{jk}\ln P_j \ln P_k + \frac{1}{2}\sum_{j=1}^{m}\sum_{k=1}^{m}\delta_{jk}\ln Z_j \ln Z_k \\ & + \sum_{j=1}^{l}\zeta_{Yj}\ln Y \ln P_j + \sum_{j=1}^{l}\sum_{k=1}^{m}\zeta_{jk}\ln P_j \ln Z_k + \sum_{j=1}^{m}\eta_{Yj}\ln Y \ln Z_j \\ & + \theta_T T + \frac{1}{2}\theta_{TT}T^2 + \theta_{TY}T\ln Y + \sum_{j=1}^{l}\theta_{Tj}T\ln P_j + \sum_{j=1}^{m}\rho_{Tj}T\ln Z_j\end{aligned} \tag{1.2}$$

[1] The translog cost function in the empirical work on trade and the demand for heterogeneous labor was first introduced by Berman, Bound and Griliches (1994) and applied by e.g. Feenstra and Hanson (1996), Geishecker (2002, 2006), Strauss- Kahn (2004), Hijzen et al. (2005) and Ekholm and Hakkala (2006).

In this partial static equilibrium framework, there are two variable input factors, l = 2, namely $P_1 = w_{HS}$ and $P_2 = w_{LS}$. I denote the corresponding coefficients by α_{HS} and α_{LS}. Also, there is only one quasi-fixed input factor, $m = 1$, namely $Z_1 = K/Y$. Now (1.2) specializes to:

$$\begin{aligned}
\ln CV = {} & \alpha_0 + \alpha_Y \ln Y + \alpha_{HS} \ln w_{HS} + \alpha_{LS} \ln w_{LS} + \beta_K \ln \frac{K}{Y} + \frac{1}{2}\gamma_{YY}(\ln Y)^2 \\
& + \frac{1}{2}\gamma_{HSLS} \ln w_{HS} \ln w_{LS} + \frac{1}{2}\gamma_{HSHS}(\ln w_{HS})^2 + \frac{1}{2}\gamma_{LSHS} \ln w_{LS} \ln w_{HS} + \frac{1}{2}\gamma_{LSLS}(\ln w_{LS})^2 \\
& + \frac{1}{2}\delta_{KK}(\ln \frac{K}{Y})^2 + \zeta_{YHS} \ln Y \ln w_{HS} + \zeta_{YLS} \ln Y \ln w_{LS} \\
& + \zeta_{HSK} \ln w_{HS} \ln \frac{K}{Y} + \zeta_{LSK} \ln w_{LS} \ln \frac{K}{Y} + \eta_{YK} \ln Y \ln \frac{K}{Y} \\
& + \theta_T T + \frac{1}{2}\theta_{TT} T^2 + \theta_{TY} T \ln Y \\
& + \theta_{RDHS} \frac{RD}{Y} \ln w_{HS} + \theta_{RDLS} \frac{RD}{Y} \ln w_{LS} \\
& + \theta_{OSSHS} OSS \ln w_{HS} + \theta_{OSSLS} OSS \ln w_{LS} \\
& + \theta_{OSMHS} OSM \ln w_{HS} + \theta_{OSMLS} OSM \ln w_{LS} \\
& + \rho_{TK} T \ln \frac{K}{Y}
\end{aligned} \tag{1.3}$$

For symmetry reasons the following parameter restrictions are imposed:

$\gamma_{jk} = \gamma_{kj}$ and $\delta_{jk} = \delta_{kj}$.

In order for homogeneity of degree one in input prices to hold, the following linear restrictions are required:

$$\sum_j^l \alpha_j = 1$$

$$\sum_j^l \gamma_{jk} = \sum_j^l \gamma_{kj} = \sum_j^l \zeta_{jk} = 0 \qquad \text{for all } k$$

$$\sum_j^l \zeta_{Yj} = \sum_j^l \theta_{Tj} = 0$$

Applying Shephard's Lemma yields the respective factor demand which is the *factor's share in total variable costs* as the cost function is in logarithmic form:

$$\frac{\partial \ln CV}{\partial \ln w_{HS}} = \frac{\partial CV / CV}{\partial w_{HS} / w_{HS}} = \frac{w_{HS}}{CV}\frac{\partial CV}{\partial w_{HS}} = \frac{w_{HS} L_{HS}}{CV} = S_{HS} \tag{2.1}$$

$$\frac{\partial \ln CV}{\partial \ln w_{LS}} = \frac{\partial CV / CV}{\partial w_{LS} / w_{LS}} = \frac{w_{LS}}{CV}\frac{\partial CV}{\partial w_{LS}} = \frac{w_{LS} L_{LS}}{CV} = S_{LS} \tag{2.2}$$

where L_{HS} and L_{LS} is the demand for high-skilled and less-skilled labor with $L_{HS} = \partial CV / \partial w_{HS}$ and $L_{LS} = \partial CV / \partial w_{LS}$. S_{HS} and S_{LS} is the cost share of L_{HS} and L_{LS} in variable costs *CV*. Since in equations (2.1) and (2.2) w_{HS} and w_{LS} are the only variable costs, *CV* is determined by the sum of the products of the variable factor costs with their respective factors: $CV = w_{HS} L_{HS} + w_{LS} L_{LS} = wL$, where *w* designates the average wage per labor *L*, regardless of the qualification.

Thus, S_{HS} and S_{LS} can be determined as follows:

$$S_{HS} = \frac{w_{HS} L_{HS}}{w_{LS} L_{LS} + w_{HS} L_{HS}} = \frac{w_{HS} L_{HS}}{wL} \quad (2.1') \qquad S_{LS} = \frac{w_{LS} L_{LS}}{w_{LS} L_{LS} + w_{HS} L_{HS}} = \frac{w_{LS} L_{LS}}{wL} \quad (2.2')$$

Since L_{HS} and L_{LS} are the only variable inputs, and thus $S_{HS} + S_{LS} = 1$, only one cost share is linearly independent. The first partial derivative of equation (1.3) with respect to $\ln w_{LS}$ yields:

$$\begin{aligned} \frac{\partial \ln CV}{\partial \ln w_{LS}} = S_{LS} = \alpha_{LS} + 1/2\gamma_{HSLS} \ln w_{HS} + 1/2\gamma_{LSHS} \ln w_{HS} + \gamma_{LSLS} \ln w_{LS} \\ + \zeta_{YLS} \ln Y + \zeta_{LSK} \ln \frac{K}{Y} + \theta_{RDLS} \frac{RD}{Y} + \theta_{OSSLS} OSS + \theta_{OSMLS} OSM \end{aligned} \tag{3.1}$$

According to (2.2'), a decrease of S_{LS} can reflect both a fall in L_{LS} and/or a fall in w_{LS}, which implies according to (2.1') a rise in S_{HS} and thus an increase in L_{HS} and/or in w_{HS}. Hence, the composite term S_{LS} can be considered as the relative demand for less-skilled labor. Due to symmetry and homogeneity, we have $\gamma_w = \gamma_{HSLS} = \gamma_{LSLS} = -\gamma_{LSLS} = -\gamma_{HSHS}$. Hence equation (3.1) leads to the following model:

$$\begin{aligned} S_{LS,it} = \alpha_{LS} + \gamma_w \ln \frac{w_{HS,it}}{w_{LS,it}} + \zeta_Y \ln Y_{it} + \zeta_K \ln \frac{K_{it}}{Y_{it}} \\ + \theta_{RD} \frac{RD_{it}}{Y_{it}} + \theta_{OSS} OSS_{it} + \theta_{OSM} OSM_{it} + \varepsilon_{it} \end{aligned} \tag{3.2}$$

where *i* designates the sector dimension, *t* the time dimension, and ε_{it} the idiosyncratic error term.

One expects a lower S_{LS} and thus a lower cost share of L_{LS} in variable costs *CV* when relative wages for high-skilled labor as part of *CV* rise ($\gamma_w < 0$). The composite term S_{LS} is correlated with (w_{HS} / w_{LS}), since $S_{LS} = (w_{LS} L_{LS} / wL)$. Despite the definitional relationship between S_{LS} and relative wages, the relative wage variable should be included as it controls for the variation in the relative wages of S_{LS}, whereas the variation in relative employment of S_{LS} is controlled by the other exogenous variables (see Geishecker 2002, 2006). The sign of the coefficient ζ_Y of output *Y* is not unambiguously predictable. An increase in *Y* normally leads to a higher overall wage bill and hence to larger *CV*. If the cost increase is equally distributed among less-skilled and high-skilled labor, there should be no influence on S_{LS}. If the wage bill of high-skilled labor increases over-proportionally, e.g. due to a better bargaining power, this results in a higher L_{HS} and/or w_{HS}, and S_{LS} is expected to fall ($\zeta_Y < 0$). A higher capital coefficient is predicted to reduce S_{LS}, since capital can be considered as a substitute for less-skilled labor ($\zeta_K < 0$). The influence of *RD/Y*, *OSS*, *OSM* on S_{LS} is not easily predictable, as all variables could be substitutes for less-skilled ($\theta_{RD} < 0,\ \theta_{OSS} < 0,\ \theta_{OSM} < 0$) or for high-skilled labor ($\theta_{RD} > 0,\ \theta_{OSS} > 0,\ \theta_{OSM} > 0$). One might rather expect a demand shift away from less-skilled labor.

4.2 Empirical Specification

The following section measures the impact of service and material offshoring on the relative demand for less skilled labor in the manufacturing sector including 28 manufacturing[1] and 7 service sectors in a panel regression analysis. Due to the input-output data revision and a possible structural break, my analysis includes only the unrevised data from 1991 to 2000. In a first step, the *correct estimation model* is selected. In the presence of unobserved time-constant sector-specific effects c_i, one considers the following panel data model $y_{it} = \alpha + \beta x_{it} + c_i + \varepsilon_{it}$. We distinguish two cases. (1.) If c_i (e.g. productivity) is correlated with some explanatory variables x_{it} (e.g. OSS), usual pooled OLS regression would be biased and inconsistent. Transforming the pooled OLS using first differences or the fixed effects estimator, washes these time-invariant effects c_i out. Thus, first differences and fixed effects models allow for a correlation between c_i and some x_{it}, and c_i is estimated as part of the intercept $(\alpha + c_i)$. (2.) If c_i is not correlated with some x_{it}, it is considered a stochastic variable or random effect. In such a case, c_i is assumed to be independent and identically

[1] The 36 manufacturing sectors of the input-output classification (see *Appendix 1*) are aggregated to 28 sectors to match the wage and employment data (see *Appendix 3*).

distributed over the panels (sectors) and considered as part of the composite error term $v_{it} = c_i + \varepsilon_{it}$. The existence of random effects is tested using the extended Breusch-Pagan test of Baltagi and Li (1990) for unbalanced panels. The null hypothesis of no unit specific random effect is rejected (Prob>chi2=0.0000). Furthermore, the Hausman test (1978) is run to test the null hypothesis that c_i is uncorrelated with some x_{it}. H_0 cannot be rejected with Prob>chi2=1.0000, so that the GLS random effects estimator is used in the following.

5. Estimation Results

In a first step, the pooled OLS model is tested for possible *heteroscedasticity* by performing a White test of the null hypothesis of homoscedasticity against unrestricted forms of heteroscedasticity. H_0 can be rejected (Prob>chi2=0.0000).[1] Secondly, a test for *autocorrelation* in ε_{it} of linear panel-data models is run as discussed by Wooldridge (2002). The null hypothesis of no first-order autocorrelation is also rejected (Prob>F=0.0000). Therefore, the estimations include the "robust cluster" option which produces standard errors robust to both heteroscedasticity (Huber-White sandwich estimators) and any form of intra-cluster correlation. Since the clusters are sectors in our case, this option corrects for intra-sector serial correlation and any other correlation provoked by common intra-sector shocks. Some specifications integrate fixed year effects D_t, i.e. time-specific cross-sectoral effects, such as common shocks influencing all sectors at time *t*.

The *results* of the GLS random effect estimators are shown in columns 1 and 2 of *Table 4.* Relative wages, real output, capital, and OSM_t influence S_{LS} negatively in column 1 at the 1% significance-level. R&D-intensity and OSS_t have a positive impact on S_{LS}, but none of them is significant. When fixed year effects are included in column 2 the coefficient signs remain the same, but only relative wages and the capital coefficient are significant.

Employment effects are not always instantaneous, which is why one-period time lags of the independent variables are added in columns 3 and 4 of *Table 4*. The coefficient of $\ln(w_{HS}/w_{LS})_t$ remains negative, while $\ln(w_{HS}/w_{LS})_{t-1}$ has a positive sign. The overall effect remains negative and the null hypothesis H_0 of no joint significance is rejected (p>F=0.0000). The overall impact of real output on S_{LS} remains negative, too, which is only significant when

1 A further test for heteroscedasticity in the random effects model is run as suggested by Greene "Econometric Analysis" (1993, page 395). This test amounts to a likelihood ratio test of the null hypothesis of homoscedasticity. H0 is rejected (Prob>chi2=0.0000). The STATA command hetgrot is used as proposed by Nunziata (see http://www.decon.unipd.it/personale/curri/nunziata/software.htm).

no fixed year effects are added. The capital coefficient also has an overall negative impact on S_{LS} in both specifications. The overall effect of the R&D-intensity is positive in column 4, but the F-tests cannot reject H_0 of no joint significance. OSS_t has a negative effect on the relative demand for less-skilled labor which is offset by the positive impact of OSS_{t-1}. The overall effect is positive (p>F=0.0000) in both columns. Material offshoring has a negative overall effect, which is significant in both specifications.

5.1 Outliers

In the case of short time series and a limited number of sectors *outliers* could lead to biased results. Therefore, the model is re-estimated dropping the two identified outliers – the 'office accounting, computer machinery' sector and the 'pharmaceuticals' sector – as their service offshoring intensities are extremely high compared to the average sample. The results are found in columns 5 to 8 of *Table 4*. All variables except for OSS_t of columns 5 and 6 maintain their coefficient signs compared to columns 1 and 2. Surprisingly, OSS_t now shows (insignificant) negative coefficients.

Columns 7 and 8 add one-period lags of each explanatory variable. Most of the coefficient signs are comparable to those of columns 3 and 4. OSS_t becomes very high and negative which is significant at the 10%-level in both columns. The null hypothesis of no joint significance of OSS_t and OSS_{t-1} cannot be rejected at the 10%-level in both specifications. Material offshoring still has a negative overall impact on S_{LS}, which is only significant when fixed year effects are not added (column 7).

5.2 Additional Control Variable

The offshoring variables might be swelled due to other omitted correlated variables. I addressed this problem by *adding the shares of total imports in total output* by sector in columns 9 to 12 of *Table 4* as suggested by Amiti and Wei (2006). The higher the import share of a sector, the more probable is service and material offshoring. The import shares variables are highly significant and negatively correlated with $S_{LS.}$ The coefficient signs and magnitudes of relative wages, real output and capital coefficient hardly change. Considering service offshoring, the instantaneous effect remains negative in all four specifications and the overall negative effect of service offshoring remains the same when import share is added. Most surprisingly, material offshoring now has a positive impact on S_{LS}, which is significant for OSM_t when fixed year effects are added, and for the lagged OSM_{t-1}.

The correlation matrix in *Appendix 4* shows that import shares are to more than 80% correlated with material offshoring. In the case of imperfect collinearity between import shares and material offshoring, the estimators are still efficient and unbiased. The problem is that collinearity creates large estimator variances and hence large confidence intervals. In the case of collinearity, the joint influence of the (inter-)correlated independent variables material offshoring and import share on the dependent variable S_{LS} is given, but the estimation of the individual coefficients is difficult to obtain. This is not due to a misspecification of the model, but due to insufficient information in the data.

5.3 Endogeneity

The random effects estimator is only valid when strict exogeneity of the explanatory variables is assumed. It is plausible that more productive sectors aim at increasing their technology shifter and thus self-select into offshoring and/or spending more on R&D. Similarly less productive sectors might hope to benefit from offshoring and/or R&D in order to increase their technology shifter (see Amiti and Wei, 2006). Furthermore, the relative wage variable might be treated as endogenous if sectoral wages and the relative demand for less-skilled labor are simultaneously determined (see Geishecker, 2006). Finally, there might be no significant cross-sectional variation in the relative wage changes over time, as some of the variation might be due to different skill levels within the sectors (*price changes*), while some could be due to a skill-upgrading of the whole sector (*quality changes*) (see Berman, Bound and Griliches, 1994). Hence, these variables are tested for endogeneity using the first three period lags as instruments.[1] Exogeneity of $\ln(w_{HS} / w_{LS})_t$ cannot be rejected with a $Chi^2(1)$ p-value = 0.6188. Concerning the technology shifter *T*, R&D-intensity has a $Chi^2(1)$ p-value = 0.1456, OSS_t a $Chi^2(1)$ p-value = 0.1867 and OSM_t a $Chi^2(1)$ p-value = 0.1369. The relative wage variable should be treated as exogenous, whereas the three variables of the technology shifter show quite low p-values and can thus not unambiguously be treated as exogenous. Specifying all three technology shifter variables as potentially endogenous yields the $Chi^2(4)$ p-value = 0.0779. Thus, the null hypothesis of exogeneity is rejected and the three are treated as endogenous.

[1] This homoscedasticity-robust test is carried out using the Stata command ivreg2 with the endog option. The endog option tests for endogeneity of one or more regressors under the null hypothesis that the specified endogenous regressors are exogenous (see Baum, Schaffer and Stillman, 2007).

Therefore, a *two-stage least squares* (2SLS) *instrumental variables estimator* is used to control for potential endogeneity of R&D-intensity and the offshoring variables (as well as import share variable). I use the first three lags of potentially endogenous variables as instruments for $(RD/Y)_t$, OSS_t and OSM_t (and $(IM/Y)_t$). The results are shown in *Table 5*. All of the specifications add fixed year effects and exclude the above identified two outliers.

The first 4 columns apply the consistent *2SLS random-effects estimator* due to Baltagi and Chang (2000). The standard errors cannot be corrected for heteroscedasticity and autocorrelation. The first two specifications in columns 1 and 2 only regard instantaneous effects of the explanatory variables. Service offshoring has a significant negative effect on the relative demand for less-skilled labor, whereas the impact of material offshoring is only negative when import shares are not added (column 1). Columns 3 and 4 additionally use one-period lags of all explanatory variables except for the instrumented variables. The significantly negative effect of service offshoring is confirmed, while the effect of material offshoring depends on the consideration of import shares.

For comparison, columns 5 to 8 of *Table 5* use a *2SLS fixed-effects (within) estimator* which produces standard errors robust to both heteroscedasticity (Huber-White sandwich estimators) and any form of intra-cluster correlation.[1] The fixed effects estimators are consistent, but less efficient than the random effects estimators. Columns 5 and 6 consider only instantaneous effects of the explanatory variables. Service offshoring has a negative coefficient sign which becomes significant when the additional control variable import share is added in column 6. Material offshoring influences the relative demand of less-skilled labor negatively in column 5, but turns positive in column 6. Under consideration of additional one-period lags of the remaining explanatory variables in columns 7 and 8, service and material offshoring almost show the same results compared to the random effects estimators in columns 3 and 4. Hence, the consistent fixed effects estimators controlling for potential endogeneity of the offshoring and import variables confirm the statements that have been derived from Table 4.

Another alternative is to apply the *dynamic General Method of Moments (GMM) estimator* as proposed by Arellano-Bond (1991). This GMM estimator uses the lagged levels of the dependent and the predetermined variables, and the differences of the strictly exogenous variables as instruments. First differences remove the assumed fixed sector effects c_i. Additionally, the one-period lag of the dependent variable ΔS_{LS} is included, making the model

[1] The Stata command xtivreg2 is used. See Schaffer and Stillman (2007) for further information.

dynamic. R&D-intensity, service and material offshoring, as well as import shares are treated as *predetermined variables*. Predetermined variables assume that $E[x_{ir}\varepsilon_{it}] \neq 0$ for $r < t$, but $E[x_{ir}\varepsilon_{it}] = 0$ for all $r \geq t$. Thus, idiosyncratic shocks ε_{it} in t have an influence on subsequent x_{it}. The results are shown in *Table 6*.

The specifications in columns 1 to 4 consider the instantaneous effects of the strictly exogenous variables relative wage, real output and capital coefficient. As before, the latter show all negative coefficient signs, that are significant in most cases. Service offshoring has a negative effect on ΔS_{LS}, which is significant at the 1%-level. The negative impact of material offshoring becomes positive, when import shares are included in the specifications (columns 3 and 4). The Sargan test rejects the null hypothesis that the over-identifying restrictions are valid in columns 1 and 2[1], hence one might prefer the specifications with import shares. All of the four specifications show no second-order autocorrelation, which would have made the estimators inconsistent.

Columns 5 to 8 add one-period lags of the strictly exogenous variables. The overall negative effects of the latter remain the same, but the overall effect of relative wages becomes much smaller as $\Delta \ln(w_{HS} / w_{LS})_{t-1}$ shows large positive coefficient signs. Service offshoring still has a significantly negative effect on ΔS_{LS} with smaller coefficient signs. Again, the negative effects of material offshoring turn positive when import shares are added. The Sargan test cannot reject the null hypothesis that the over-identifying restrictions are valid in the four specifications, and none of them shows second-order autocorrelation.

5.4 Discussion of Results

The results show that service offshoring had an overall negative effect on the relative demand for less-skilled labor in the German manufacturing sectors from 1991 to 2000. Including import shares and fixed year effects, the results are interpreted. The overall coefficients of the GLS Random Effects Estimations are -1.18 and -1.24, respectively. Controlling for endogeneity, the coefficients of service offshoring in the instrumental variables 2SLS estimations vary between -2.03 and -2.39. Applying the GMM Arellano-Bond dynamic estimators, the coefficients are lower and are-1.31 and -0.91, respectively. Between 1991 and 2000, the CAGR of service offshoring was 6.67% for the manufacturing sector. Thus, service offshoring reduced the demand for less-skilled labor by on average -0.06 to -0.16% per year.

[1] The rejection of the null hypothesis could also be due to heteroscedasticity.

6. Concluding Remarks

Since the new tradability of services has made services vulnerable to relocation, the public awareness of service offshoring and its potential labor market effects has increased significantly. This paper first aims at giving an understanding what service offshoring concretely means. The empirical part of this paper first calculates German service offshoring intensities on a sectoral basis using input-output data. This measurement represents the proportion of imported service inputs used in home production. German $OSS_t(a)$ more than doubled from 1.47% in 1991 to 3.90% in 2003. The comparison between German, UK and US intensities reveals that German $OSS_t(b)$ are only slightly lower than UK intensities and show the highest CAGR between 1992 and 2001. In a next step, the impact of service offshoring on the demand for heterogeneous labor in Germany is estimated at a sectoral level including 28 manufacturing sectors. The partial static equilibrium model is based on a variable unit cost function in the general translog form allowing for quasi-fixed input factors. Two different skill-levels are taken into account. The estimation results indicate that service offshoring reduced the relative demand for less-skilled labor in the German manufacturing sectors by on average -0.06 to -0.16% per year between 1991 and 2000.

There are some *caveats* concerning studies on service offshoring and their effects on labor demand. First, long-term effects cannot be predicted yet because of the novelty of the phenomenon. Thus, positive effects are possible in the long term, when domestic companies reinvest their efficiency gains in new jobs. Second, the relationship between offshoring and employment is complex as it links foreign trade, home production and gross fixed investments which can provoke direct and indirect as well as static and dynamic effects (Tüselmann, 1998). Hence, the sign and extent of offshoring in existing studies should not be considered universally valid (Tüselmann, 1998). Third, the diverse offshoring motives do only associate labor market effects, since the underlying cause for the domestic employment reduction – especially in the case of cost-oriented motives – is not offshoring, but high labor costs. Offshoring then is rather a symptom than a cause of domestic labor market problems (Roling, 1999). Fourth, the main cause of the increase in service offshoring is not clearly determinable. Service offshoring can be traced back not only to increased service trade as a consequence of globalization but also to technological progress (ICT). Despite the caveats the estimation results allow for the conclusion that service offshoring reduced the relative demand for less-skilled labor in the German manufacturing sectors between 1991 and 2000 when a partial static equilibrium framework is assumed.

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Table 1: Service Offshoring Intensities in Germany (1991, 2000 and 2003)

OSS_{1991}(a)					
Service s	**OSS_{s1991}** (weighted average)	**Mean**	**Std Dev**	**Min**	**Max**
Post and telecommunications	0.60%	0.54%	2.92%	0.00%	19.24%
Financial intermediation (except insurance & pension fund.)	0.01%	0.01%	0.02%	0.00%	0.10%
Activities related to financial intermediation	0.22%	0.18%	0.82%	0.00%	4.20%
Renting of machinery and equipment	0.10%	0.12%	0.32%	0.00%	2.15%
Computer and related activities	0.03%	0.04%	0.13%	0.00%	0.76%
Research and development	0.13%	0.29%	1.48%	0.00%	9.58%
Other business activities	0.37%	0.24%	0.37%	0.03%	2.25%
Total OSS_{1991}(a)	**1.47%**	**1.43%**	**3.31%**	**0.12%**	**19.53%**

OSS_{2000}(a)					
Service s	**OSS_{s2000}** (weighted average)	**Mean**	**Std Dev**	**Min**	**Max**
Post and telecommunications	0.56%	0.43%	2.51%	0.00%	16.53%
Financial intermediation (except insurance & pension fund.)	0.04%	0.03%	0.05%	0.00%	0.35%
Activities related to financial intermediation	0.26%	0.26%	1.21%	0.00%	6.78%
Renting of machinery and equipment	0.01%	0.00%	0.02%	0.00%	0.15%
Computer and related activities	0.60%	0.72%	3.14%	0.00%	19.73%
Research and development	0.27%	0.65%	3.45%	0.00%	22.42%
Other business activities	1.44%	0.61%	1.71%	0.00%	10.85%
Total OSS_{2000}(a)	**3.17%**	**2.70%**	**5.68%**	**0.00%**	**23.00%**

OSS_{2003}(a)					
Service s	**OSS_{s2003}** (weighted average)	**Mean**	**Std Dev**	**Min**	**Max**
Post and telecommunications	0.69%	0.47%	2.97%	0.00%	19.51%
Financial intermediation (except insurance & pension fund.)	0.19%	0.17%	0.10%	0.00%	0.56%
Activities related to financial intermediation	0.45%	0.71%	4.15%	0.00%	27.13%
Renting of machinery and equipment	0.00%	0.00%	0.00%	0.00%	0.00%
Computer and related activities	0.53%	0.64%	2.05%	0.00%	12.28%
Research and development	0.33%	0.67%	3.08%	0.00%	19.27%
Other business activities	1.71%	0.72%	1.96%	0.00%	12.54%
Total OSS_{2003}(a)	**3.90%**	**3.39%**	**6.68%**	**0.00%**	**27.55%**

Source: Own calculations, Data: Federal Statistical Office, input-output tables 1991 and 2000 (unrevised form) und 2003 (revised form).

Table 2: Comparison of Selected Services in Germany, the UK and the US

Germany	UK	US
Post and telecommunications	Telecommunications	Telecommunications
Financial intermediation, activities related to financial intermediation	Banking and finance, insurance and pension funds and auxiliary financial services	Insurance, Finance
Renting of machinery and equipment	Renting of machinery	Other Business services
Computer and related activities	Computer services	Computing and Information
Research and development	Research and development	Other Business services
Other business activities	Legal activities, accountancy services, market research and management consultancy	Other Business services
Other business activities	Architectural activities and technical consultancy	Other Business services
Other business activities	Advertising	Other Business services
Other business activities	Other business services	Other Business services

Source: German classification: Federal Statistical Office, UK classification: UK National Accounts, US classification: IMF Balance of Payments Statistics.

NB: Other business services in the US (IMF classification) include merchanting and other trade-related services, operational leasing services and miscellaneous business, professional and technical services.

Table 3: Offshoring Intensity in Germany, the UK and the US

Service Offshoring Intensity					
Year	**Germany (a)**	**Germany (b)**	**UK**	**US(I)**	**US(II)**
1991	1.47%	1.01%	-	-	-
1992	1.47%	0.98%	1.35%	0.49%	0.18%
1993	1.46%	0.98%	1.58%	0.53%	0.18%
1994	1.41%	0.94%	1.64%	0.56%	0.20%
1995	2.03%	1.01%	1.62%	0.58%	0.20%
1996	2.15%	1.11%	1.82%	0.61%	0.21%
1997	2.52%	1.33%	1.66%	0.64%	0.23%
1998	2.70%	1.40%	2.00%	0.66%	0.24%
1999	3.01%	1.59%	2.22%	0.75%	0.29%
2000	3.17%	1.74%	2.38%	0.76%	0.29%
2001	3.61%	2.26%	2.60%	0.80%	-
2002	3.56%	2.21%		-	-
2003	3.90%	2.05%			
CAGR 92-01	10.48%	9.75%	7.55%	5.60%	6.14%
Material Offshoring Intensity					
Year	**Germany (a)**	**Germany (b)**	**UK**	**US(I)**	**US(II)**
1991	17.29%	18.49%	-	-	-
1992	15.58%	16.46%	28.19%	8.74%	11.72%
1993	14.43%	14.93%	29.49%	9.24%	12.68%
1994	14.66%	16.00%	29.77%	9.92%	13.41%
1995	15.43%	16.89%	30.70%	10.47%	14.18%
1996	15.26%	16.90%	30.66%	10.38%	14.32%
1997	15.93%	18.32%	29.67%	10.51%	14.55%
1998	16.70%	18.97%	28.00%	10.48%	14.94%
1999	16.85%	19.05%	28.00%	10.78%	15.55%
2000	18.73%	21.51%	28.56%	11.94%	17.33%
2001	16.77%	19.88%	28.09%	11.47%	-
2002	16.21%	19.69%	-	-	-
2003	18.98%	20.45%			
CAGR 92-01	0.82%	2.12%	-0.04%	3.07%	5.01%
Service Sectors	7	7	9	5	5
Manufacturing Sectors	36	36	69	96	96

Source: Own calculations for Germany (a) and (b). Weighted average across all sectors i by outputs at time t. *Germany* (a): $\sum_s$ [(imported input purchases of service s by sector i)$_t$/(total non energy inputs used by sector i)$_t$]. *Other measures* (b): $\sum_s$ [(input purchases of service s by sector i)$_t$/(total non energy inputs used by sector i)$_t$]* [(imports of service s)$_t$/(production$_{st}$ + imports$_{st}$ - exports$_{st}$). Data: input-output tables, Federal Statistical Office. Revised data only for 2001-2003.

Calculations for the UK: Amiti and Wei (2005). Data: input-output tables, UK National Statistics, IMF: Balance of Payments Statistics. NB: UK data is not directly available, but can be reconstructed from Figure 2 in Amiti and Wei (2005).

Calculations for the US: (I): Amiti and Wei (2004); (II): Amiti and Wei (2006). Data: input-output tables, US National Statistics, IMF: Balance of Payments Statistics.

Table 4: GLS Random Effects Estimations (1991-2000)

Dependent variable: $S_{LS,t}$												
	GLS Random-effects: all sectors				GLS Random-effects: w/o outliers[1)]				GLS Random-effects: w/o outliers plus import share			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\ln(w_{HS}/w_{LS})_t$	-0.2388***	-0.1607***	-0.3404***	-0.2733***	-0.2901***	-0.1768***	-0.3796***	-0.2985***	-0.2645***	-0.1634***	-0.3367***	-0.2576***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\ln(w_{HS}/w_{LS})_{t-1}$			0.0807*	0.0762**			0.1104**	0.0969**			0.1043***	0.0918***
			(0.056)	(0.036)			(0.016)	(0.013)			(0.006)	(0.008)
$\ln(real\ Y)_t$	-0.0961***	-0.0119	0.1285*	-0.0429	-0.0785***	-0.0016	0.1596**	-0.0099	-0.0895***	-0.0131	0.1164*	-0.0287
	(0.000)	(0.656)	(0.055)	(0.426)	(0.001)	(0.951)	(0.035)	(0.831)	(0.000)	(0.576)	(0.072)	(0.537)
$\ln(real\ Y)_{t-1}$			-0.2043***	0.0106			-0.2135***	-0.0089			-0.1818***	0.0021
			(0.001)	(0.819)			(0.003)	(0.830)			(0.004)	(0.954)
$\ln(K/Y)_t$	-0.1430***	-0.0703**	0.1068	-0.0850	-0.1202***	-0.0496	0.1451*	-0.0418	-0.1127***	-0.0455**	0.1064	-0.0533
	(0.000)	(0.021)	(0.141)	(0.101)	(0.000)	(0.102)	(0.082)	(0.343)	(0.000)	(0.032)	(0.119)	(0.224)
$\ln(K/Y)_{t-1}$			-0.2083***	-0.0018			-0.2281***	-0.0235			-0.1939***	-0.0154
			(0.000)	(0.960)			(0.001)	(0.511)			(0.001)	(0.630)
$(RD/Y)_t$	0.0910	0.1330	0.0006	0.1851	0.3187***	0.3123***	0.1185	0.1902	-0.0088	0.0085	0.0835	0.1377
	(0.642)	(0.427)	(0.998)	(0.308)	(0.004)	(0.000)	(0.570)	(0.339)	(0.948)	(0.959)	(0.715)	(0.488)
$(RD/Y)_{t-1}$			-0.0109	-0.1019			0.0630	0.0181			-0.1082	-0.1280
			(0.956)	(0.562)			(0.792)	(0.935)			(0.728)	(0.665)
$(OSS)_t$	0.2518	0.4892	-0.4582	-0.5476	-1.6591	-1.0376	-2.1106*	-1.2424*	-1.7404	-1.1790	-1.8227*	-1.0271*
	(0.623)	(0.241)	(0.554)	(0.182)	(0.386)	(0.406)	(0.060)	(0.092)	(0.275)	(0.207)	(0.076)	(0.077)
$(OSS)_{t-1}$			1.4125***	1.3999***			0.3752	-0.0207			0.1194	-0.2169
			(0.000)	(0.000)			(0.711)	(0.978)			(0.878)	(0.713)
$(OSM)_t$	-0.2605***	-0.0509	-0.0510	0.0542	-0.3058***	-0.1040	-0.1022*	0.0119	0.0263	0.1933***	-0.0209	0.1040**
	(0.007)	(0.709)	(0.427)	(0.479)	(0.002)	(0.474)	(0.065)	(0.870)	(0.670)	(0.009)	(0.663)	(0.015)
$(OSM)_{t-1}$			-0.1827**	-0.1488			-0.1655*	-0.1622			0.1128*	0.1223*
			(0.029)	(0.125)			(0.057)	(0.113)			(0.054)	(0.054)
$(IM/Y)_t$									-0.1538***	-0.1441***	-0.0453	-0.0634**
									(0.000)	(0.000)	(0.168)	(0.030)
$(IM/Y)_{t-1}$											-0.1084***	-0.0938***
											(0.000)	(0.000)
Fixed year effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Joint significance:												
$\ln(w_{HS}/w_{LS})_t + \ln(w_{HS}/w_{LS})_{t-1} = 0$			p>F=0.0000	p>F=0.0000			p>F=0.0000	p>F=0.0000			p>F=0.0000	p>F=0.0000
$\ln(real\ Y)_t + \ln(real\ Y)_{t-1} = 0$			p>F=0.0000	p>F=0.4584			p>F=0.0003	p>F=0.7394			p>F=0.0000	p>F=0.5170
$\ln(K/Y)_t + \ln(K/Y)_{t-1} = 0$			p>F=0.0000	p>F=0.0116			p>F=0.0000	p>F=0.0714			p>F=0.0000	p>F=0.0087
$(RD/Y)_t + (RD/Y)_{t-1} = 0$			p>F=0.9969	p>F=0.5783			p>F=0.3965	p>F=0.2337			p>F=0.9264	p>F=0.7861
$OSS_t + OSS_{t-1} = 0$			p>F=0.0000	p>F=0.0000			p>F=0.1652	p>F=0.1782			p>F=0.2054	p>F=0.2090
$OSM_t + OSM_{t-1} = 0$			p>F=0.0845	p>F=0.0804			p>F=0.0695	p>F=0.1285			p>F=0.1538	p>F=0.0192
$(IM/Y)_t + (IM/Y)_{t-1} = 0$											p>F=0.0000	p>F=0.0000
Observations	280	280	252	252	260	260	234	234	260	260	234	234
R-squared (within)	0.59	0.71	0.65	0.72	0.63	0.73	0.69	0.74	0.74	0.83	0.78	0.83

Source: Own calculations. p*<0.1, p**<0.05, p***<0.001 (p-values in parentheses). 1) Outliers: ‘office accounting, computer machinery’ and ‘pharmaceuticals’

Table 5: Instrumental Variables 2SLS Estimations (1991-2000)

Dependent variable: $S_{LS,t}$								
	Instrumental Variables 2SLS: GLS Random Effects w/o outliers[1]				Instrumental Variables 2SLS: Fixed Effects w/o outliers			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\ln(w_{HS}/w_{LS})_t$	-0.1816***	-0.1546***	-0.1661***	-0.1446***	-0.2146***	-0.1853***	-0.2048***	-0.1675***
	(0.000)	(0.000)	(0.007)	(0.008)	(0.002)	(0.001)	(0.003)	(0.008)
$\ln(w_{HS}/w_{LS})_{t-1}$			-0.0045	0.0148			-0.0103	0.0077
			(0.943)	(0.791)			(0.886)	(0.904)
$\ln(real\ Y)_t$	-0.0173	-0.0222	0.0769	-0.0499	-0.0544	-0.0374	0.0674	-0.0486
	(0.321)	(0.162)	(0.210)	(0.386)	(0.336)	(0.403)	(0.306)	(0.324)
$\ln(real\ Y)_{t-1}$			-0.0894	0.0352			-0.1230*	0.0184
			(0.146)	(0.539)			(0.076)	(0.734)
$\ln(K/Y)_t$	-0.0491**	-0.0324*	0.0525	-0.0332	-0.0822	-0.0431	0.0394	-0.0348
	(0.011)	(0.065)	(0.371)	(0.537)	(0.134)	(0.285)	(0.509)	(0.384)
$\ln(K/Y)_{t-1}$			-0.1079*	-0.0233			-0.1257**	-0.0319
			(0.054)	(0.648)			(0.044)	(0.451)
$(RD/Y)_t$	-0.0492	-0.3739*	-0.0244	-0.2132	-0.0611	-0.4135*	-0.0520	-0.2266
	(0.828)	(0.065)	(0.917)	(0.309)	(0.713)	(0.088)	(0.803)	(0.472)
$(OSS)_t$	-2.0042**	-2.4414***	-2.0377**	-2.3426***	-1.5154	-2.1878*	-1.4662	-2.0295*
	(0.036)	(0.004)	(0.037)	(0.007)	(0.346)	(0.061)	(0.328)	(0.051)
$(OSM)_t$	-0.2153***	0.2740***	-0.1719**	0.3317***	-0.2718	0.2223	-0.2414	0.2969*
	(0.002)	(0.002)	(0.014)	(0.000)	(0.196)	(0.148)	(0.251)	(0.064)
$(IM/Y)_t$		-0.1667***		-0.1617***		-0.1659***		-0.1637***
		(0.000)		(0.000)		(0.000)		(0.000)
Fixed year effects	Yes	Yes	Yes		Yes	Yes	Yes	Yes
Joint significance:								
$\ln(w_{HS}/w_{LS})_t + \ln(w_{HS}/w_{LS})_{t-1} = 0$			p>F=0.0006	p>F=0.0029			p>F=0.0025	p>F=0.0055
$\ln(real\ Y)_t + \ln(real\ Y)_{t-1} = 0$			p>F=0.2915	p>F=0.4651			p>F=0.2010	p>F=0.5829
$\ln(K/Y)_t + \ln(K/Y)_{t-1} = 0$			p>F=0.0028	p>F=0.0054			p>F=0.0736	p>F=0.2200
First stage results:								
Test of excluded instruments:								
$(RD/Y)_t$					p>F=0.0000	p>F=0.0000	p>F=0.0000	p>F=0.0000
$(OSS)_t$					p>F=0.0000	p>F=0.0000	p>F=0.0000	p>F=0.0000
$(OSM)_t$					p>F=0.0000	p>F=0.0000	p>F=0.0000	p>F=0.0000
$(IM/Y)_t$						p>F=0.0000		p>F=0.0000
Shea Partial R-squared:								
$(RD/Y)_t$					0.5128	0.5853	0.4506	0.5265
$(OSS)_t$					0.5576	0.5720	0.5590	0.5739
$(OSM)_t$					0.3276	0.2620	0.2920	0.2381
$(IM/Y)_t$						0.5099		0.5359
Hanson J statistic[2] P-value					$X^2(6)=0.80$	$X^2(8)=0.21$	$X^2(6)=0.78$	$X^2(8)=0.37$
Observations	182	182	182	182	182	182	182	182
R-squared					0.56	0.69	0.59	0.71

Source: Own calculations. p*<0.1, p**<0.05, p***<0.001 (p-values in parentheses).

1) GLS Random effects estimators are not corrected for heteroscedasticity and autocorrelation in the error terms.

2) Over-identification test of all instruments

Table 6: GMM Estimations (1991-2000)

Dependent variable: $\Delta S_{LS,t}$								
	GMM Arellano-Bond dynamic estimator w/o outliers							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta\ln(w_{HS}/w_{LS})_t$	-0.1249***	-0.0996***	-0.1449***	-0.1223***	-0.2566***	-0.2372***	-0.2678***	-0.2505***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta\ln(w_{HS}/w_{LS})_{t-1}$					0.2253***	0.2249***	0.2143***	0.2115***
					(0.000)	(0.000)	(0.000)	(0.000)
$\Delta\ln(real\ Y)_t$	-0.0047	-0.0102	-0.0215*	-0.0235*	-0.0150	0.0002	-0.0400	-0.0248
	(0.700)	(0.455)	(0.069)	(0.064)	(0.630)	(0.995)	(0.192)	(0.439)
$\Delta\ln(real\ Y)_{t-1}$					-0.0066	-0.0150	0.0069	-0.0023
					(0.814)	(0.623)	(0.804)	(0.939)
$\Delta\ln(K/Y)_t$	-0.0275**	-0.0312**	-0.0371***	-0.0393***	-0.0297	-0.0141	-0.0509*	-0.0358
	(0.019)	(0.029)	(0.001)	(0.003)	(0.325)	(0.655)	(0.086)	(0.245)
$\Delta\ln(K/Y)_{t-1}$					0.0026	0.0025	0.0134	0.0094
					(0.916)	(0.929)	(0.576)	(0.731)
$\Delta(RD/Y)_t$	0.1633**	0.1579**	0.0296	0.0371	-0.0441	-0.0841	-0.0999	-0.1199
	(0.029)	(0.037)	(0.701)	(0.631)	(0.571)	(0.289)	(0.188)	(0.112)
$\Delta(OSS)_t$	-1.3872***	-1.2113***	-1.4644***	-1.3079***	-0.7934***	-0.8497***	-0.8878***	-0.9148***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.008)	(0.006)	(0.003)	(0.003)
$\Delta(OSM)_t$	-0.0204	-0.0229	0.0553**	0.0491*	-0.0413**	-0.0511**	0.0105	0.0028
	(0.320)	(0.273)	(0.031)	(0.062)	(0.040)	(0.012)	(0.687)	(0.915)
$\Delta(IM/Y)_t$			-0.0487***	-0.0458***			-0.0339***	-0.0328***
			(0.000)	(0.000)			(0.001)	(0.001)
$\Delta S_{LS,t-1}$	0.6426***	0.6920***	0.6426***	0.6920***	0.7625***	0.8013***	0.7213***	0.7476***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Fixed year effects	No	Yes	No	Yes	No	Yes	No	Yes
Joint significance:								
$\Delta\ln(w_{HS}/w_{LS})_t + \Delta\ln(w_{HS}/w_{LS})_{t-1} = 0$					p>F=0.0000	p>F=0.0000	p>F=0.0000	p>F=0.0000
$\Delta\ln(real\ Y)_t + \Delta\ln(real\ Y)_{t-1} = 0$					p>F=0.1568	p>F=0.4442	p>F=0.0116	p>F=0.0707
$\Delta\ln(K/Y)_t + \Delta\ln(K/Y)_{t-1} = 0$					p>F=0.0632	p>F=0.7224	p>F=0.0049	p>F=0.1380
Sargan test[1)]	$p>X^2=0.05$	$p>X^2=0.08$	$p>X^2=0.69$	$p>X^2=0.71$	$p>X^2=0.58$	$p>X^2=0.72$	$p>X^2=0.97$	$p>X^2=0.98$
H_0: no 2^{nd} order autocorrelation	p>z=0.70	p>z=0.34	p>z=0.59	p>z=0.28	p>z=0.43	p>z=0.27	p>z=0.47	p>z=0.28
Observations	208	208	208	208	208	208	208	208

Source: Own calculations. p*<0.1, p**<0.05, p***<0.001 (p-values in parentheses).

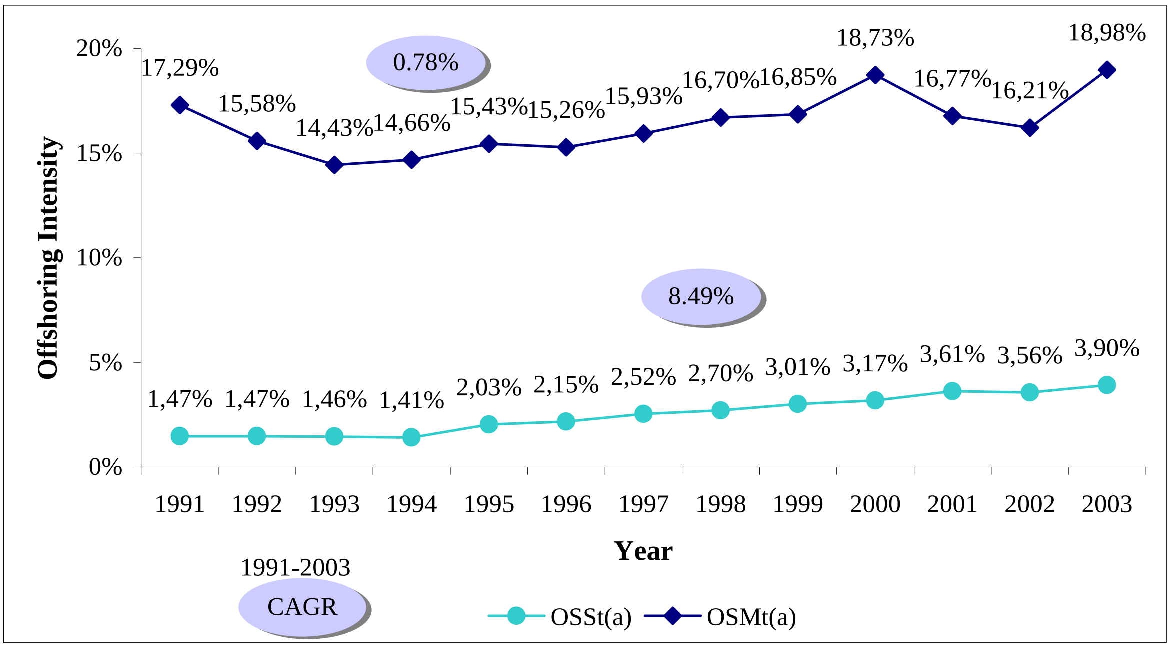
1) Null hypothesis that over-identifying restrictions are valid.

Figure 1: Classification of Offshoring

Criterion: Frontier	**outside** (Offshoring)	*Captive Offshoring / FDI*	*Offshore Outsourcing*
	inside (Onshoring)	*Captive Home Production*	*(Onshore) Outsourcing*
		inside (Insourcing)	**outside** (Outsourcing)
		Criterion: Boundary of the Firm	

Source: Own illustration.

Figure 2: Offshoring Intensity of Intermediate Inputs in Germany



Source: Own calculations. Federal Statistical Office, input-output tables (1991-2003). Weighted average across all sectors i by outputs at time t. Revised input-output tables only for 2001-2003.
Calculations for Germany (a): $\sum_s$ [(imported input purchases of service s by sector i)$_t$/(total non energy inputs used by sector i)$_t$].

Appendix 1: Sectoral Classification

	Manufacturing Sectors (36 Sectors)
1	Food products
2	Beverages
3	Tobacco products
4	Textiles
5	Wearing apparel, dressing and dying of fur
6	Leather, leather products and footwear
7	Wood and products of wood and cork
8	Pulp and paper
9	Paper products
10	Publishing
11	Printing
12	Coke, refined petroleum products and nuclear fuel
13	Pharmaceuticals
14	Chemicals exluding pharmaceuticals
15	Rubber products
16	Plastic products
17	Glass and glass products
18	Ceramic goods and other non-metallic mineral products
19	Iron and steel
20	Non-ferrous metals
21	Metal castings
22	Fabricated metal products, except machinery and equipment
23	Machinery and equipment, n.e.c.
24	Office, accounting and computing machinery
25	Electrical machinery and apparaturs, n.e.c.
26	Radio, television and communication equipment
27	Medical, precision and optical instruments
28	Motor vehicles, trailers and semi-trailers
29	Other transport equipment
30	Manufacturing n.e.c.
31	Recycling
32	Electricity, steam and hot water supply
33	Gas and gas supply
34	Collection, purification and distribution of water
35	Construction site and civil engineering
36	Construction installation and other construction
	Service Sectors (7 Sectors)
37	Post and telecommunications
38	Financial intermediation except insurance and pension funding
39	Activities related to financial intermediation
40	Renting of machinery and equipment
41	Computer and related activities
42	Research and development
43	Other business activities

Source: Input-output tables, Federal Statistical Office.
NB: Some of the 36 manufacturing sectors of the input-output classification have been merged to match the wage and employment data which leads to a total of 28 sectors. The sectors are: 1-2, 8-9, 13-14, 15-16, 17-18, 19-21 and 35-36.

Appendix 2: Theoretical Model

A linearly homogeneous production function *F* with constant returns to scale is described as follows:

$$Y = F(X_1,...,X_n), \quad F_j = \frac{\partial F}{\partial X_j} > 0, \; F_{jj} = \frac{\partial^2 F}{\partial X_j{}^2} < 0, \; F_{jk} = \frac{\partial^2 F}{\partial X_j \partial X_k} > 0 \quad \text{for all j, k =1,…, n} \qquad (1)$$

where *Y* is the output and *X* is a vector of homogeneous inputs *j*. Due to the homogeneity assumption, multiplying the inputs with a constant λ ($\lambda=2,3,\ldots$) augments production by λ^z, where *z* is constant and positive: $\lambda^z Y = F(\lambda X)$.

The labor demand functions are based on the cost minimization of a firm. On the assumption that a firm maximizes its profits and the production function has convex isoquants, total costs are calculated by summing up the products of optimal input demands and their respective factor prices. The *total cost function* dual to (1) can be described as follows:

$$CT = G(Y, P_1,\ldots, P_n) \qquad (2)$$

where P_j is the input price of X_j, *n* is the total number of inputs, and $CT = \sum_{j=1}^{n} P_j X_j$ is total cost conditional on the level of output *Y*.

Using *Shephard's Lemma*[1], the *conditional input demand function*, holding output *Y* constant, can be derived:

$$X_j{}^* = X_j^d(P_j, Y) = \frac{\partial CT(P_j, Y)}{\partial P_j} \qquad (3)$$

Allen (1938) defines the *elasticity of substitution* σ_{jk} between input factor X_j and input factor X_k as a consequence of an exogenous change in relative factor prices, holding output constant, as follows:

$$\sigma_{jk} = \frac{\partial \ln(X_k / X_j)}{\partial \ln(P_j / P_k)} = \frac{\partial \ln(X_k / X_j)}{\partial \ln(F_j / F_k)} = \frac{F_j F_k}{Y F_{jk}} \qquad (4)$$

If the factor price for input X_j increases relative to the factor price for input X_k, i.e. (P_j / P_k) rises, X_j will be substituted for input X_k, i.e. (X_k / X_j) increases. By this definition, σ_{jk} is

1 According to Shephard's Lemma (1953), the factor demand X_j* is determined by the first partial derivative of the cost function with respect to the corresponding factor price P_j, regardless of the kind of production function.

always nonnegative. The macro-economic explanation is that if the supply of other inputs X_k grows stronger than the supply of X_j, (P_j / P_k) will increase due to changes in the relative scarcity of the production factors (the scarcer factor X_j becomes, the more expensive it becomes relative to input X_k). Firms adapt to these supply changes by using more of input factor X_k relative to input factor X_j. Since output *Y* is considered constant, input factor X_j is thus substituted for input factor X_k.

Under the assumption that *Y* is linearly homogeneous and therefore $CT(P_j, Y) = YCT(P_j, 1)$, the partial derivatives of the total cost function yield the elasticity of substitution σ_{jk} as shown by Uzawa (1962). Thus, the *static equilibrium elasticity of substitution* is as follows:

$$\sigma_{jk} = \frac{CT * CT_{jk}}{CT_j * CT_k} \qquad (5)$$

where $CT_j = \partial CT / \partial P_j$ and $CT_{jk} = \partial CT_j / \partial P_k$.

If one consider a *partial state equilibrium* as introduced by Brown and Christensen (1981), only the variable factor inputs are in the state equilibrium, and the remaining inputs *Z* are fixed or quasi-fixed. The introduction of quasi-fixed input factors relaxes the assumption of full static equilibrium. Then, the following *variable unit cost function CV*, conditional on *Y* and the remaining inputs *Z*, is assumed:

$$CV = H(Y, P_1,\dots, P_l, Z_1,\dots, Z_m), \qquad (6)$$

where Z_j is considered a subset of X_j which is not necessarily at a static equilibrium level, $l + m = n$ and $CV = \sum_{j=1}^{l} P_j X_j$.

The *partial static equilibrium elasticity of substitution* conditional on the level of output *Y* and the levels of fixed factors *Z* is derived from the variable cost function:

$$\sigma_{jk}^{P} = \frac{CV * CV_{jk}}{CV_j * CV_k} \qquad (7)$$

where $CV_j = \partial CV / \partial P_j$ and $CV_{jk} = \partial CV_j / \partial P_k$. σ_{jk}^{P} represents the elasticity of substitution only between the variable factor inputs, but not between the fixed and variable factors or among the fixed factor inputs.

Appendix 3: Data

German input-output tables are disaggregated to 71 sectors following the three-digit and, for some sectors, the four-digit NACE Rev. 1.1 classification (German Federal Statistical Office: unrevised input-output tables 1991 to 2000 in current prices; revised input-output tables 2001 to 2003, Fachserie 18 Reihe 2). Due to the input-output data revision of 2005 my empirical analysis only includes the unrevised data from 1991 to 2000. The 36 manufacturing sectors of the input-output classification are aggregated to 28 sectors in order to match the available wage and employment data. Thus, the empirical analysis covers 10 observations over time for 28 manufacturing industries which leads to a total number of 280 observations per variable.

Skill-specific data is needed to calculate both S_{LS} and relative wages. Labor data at a sectoral level is divided into the two occupational groups production workers and non-production employees. It is assumed that production workers rather represent less-skilled labor, whereas non-production employees represent high-skilled labor. As S_{LS} corresponds to the share of less-skilled labor in the total wage bill of companies, the numerator of (2.2') consists of total sectoral wages for less-skilled labor, while the denominator of (2.2') includes the sum of total sectoral wages and salaries for all workers and employees. Sectoral wages are calculated by dividing total sectoral gross wages and salaries by the number of workers and employees, respectively. The data is retrieved from the STATIS-Archive-CDs of the German Federal Statistical Office.

Output data Y is derived from the input-output tables. I calculated real output using sectoral producer price indices from the German Federal Statistical Office.[1] Capital input K is matched using the sectoral gross capital stock at replacement costs from the German Federal Statistical office.[2] R&D expenditures are retrieved from the OECD STAN Industrial Database (ANBERD, R&D Expenditure in Industry (ISIC Rev.3), Vol. 2006 release 01).

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[1] Producer price indices are available at several aggregation levels (28, 107 and 225 sectors). Since some producer prices at the required input-output aggregation level were not available, I used producer prices of more disaggregated sectors (within the same industry) as a proxy, because similar price trends can be expected there. This procedure was also used in a few cases where some years were missing.

[2] The two sectors 'publishing & printing' and 'electricity, steam and hot water supply & gas and gas supply' don't have data available at the input-output aggregation level. Therefore, disaggregation is acquired weighting the gross capital stock data by its sectoral output share to match the input-output classification.

Table 7: Summary Statistics

Variable	Obs	Mean	Std Dev	Min	Max
$S_{LS.\ t}$	280	0.51543	0.1477318	0.1276571	0.7946503
$S_{LS.\ t-1}$	252	0.518068	0.1475775	0.1344832	0.7946503
$\Delta S_{LS.\ t}$	252	-0.0065768	0.0100813	-0.0400257	0.0288794
$\Delta S_{LS.\ t-1}$	224	-0.0069347	0.010067	-0.0400257	0.0288794
$\ln(w_{HS}/w_{LS})_t$	280	0.4511249	0.141195	0.084199	0.8631626
$\ln(w_{HS}/w_{LS})_{t-1}$	252	0.4496741	0.1418264	0.084199	0.8631626
$\Delta\ln(w_{HS}/w_{LS})_t$	252	0.0034072	0.0251887	-0.170119	0.1001551
$\Delta\ln(w_{HS}/w_{LS})_{t-1}$	224	0.0037175	0.0262969	-0.170119	0.1001551
$\ln(real\ Y)_t$	280	10.22857	1.145036	7.038784	12.43754
$\ln(real\ Y)_{t-1}$	252	10.21179	1.141581	7.038784	12.43754
$\Delta\ln(real\ Y)_t$	252	0.0168947	0.0929153	-0.2697411	0.5948229
$\Delta\ln(real\ Y)_{t-1}$	224	0.0050173	0.0659223	-0.245923	0.2060642
$\ln(K/Y)_t$	280	0.0789171	0.6704588	-1.317293	2.048574
$\ln(K/Y)_{t-1}$	252	0.0920558	0.6645754	-1.317293	2.013558
$\Delta\ln(K/Y)_t$	252	0.0024701	0.1056753	-0.6314123	0.3579574
$\Delta\ln(K/Y)_{t-1}$	224	0.0163985	0.0788209	-0.2342387	0.2873528
$(RD/Y)_t$	280	0.0215588	0.0369407	0.0002741	0.1650839
$(RD/Y)_{t-1}$	252	0.0221163	0.0379578	0.0002741	0.1650839
$\Delta(RD/Y)_t$	252	-0.0006694	0.0061361	-0.0360919	0.0293593
$\Delta(RD/Y)_{t-1}$	224	-0.0002826	0.0055418	-0.0304632	0.0293593
$(OSS)_t$	280	0.0059753	0.0098477	0	0.064962
$(OSS)_{t-1}$	252	0.0057885	0.0093515	0	0.064962
$\Delta(OSS)_t$	252	0.0003377	0.0021111	-0.0050447	0.0181091
$\Delta(OSS)_{t-1}$	224	0.0003365	0.0022163	-0.0050447	0.0181091
$(OSM)_t$	280	0.2479504	0.1398093	0.0447137	0.6498865
$(OSM)_{t-1}$	252	0.2427849	0.1350766	0.0472041	0.6059635
$\Delta(OSM)_t$	252	0.0072969	0.0229603	-0.0781186	0.120617
$\Delta(OSM)_{t-1}$	224	0.0053484	0.0224285	-0.0781186	0.120617
$(IM/Y)_t$	280	0.4029574	0.4686724	0	2.703693
$(IM/Y)_{t-1}$	252	0.3941235	0.4566247	0	2.703693
$\Delta(IM/Y)_t$	252	0.0172437	0.0867111	-0.8650627	0.6814198
$\Delta\ (IM/Y)_{t-1}$	224	0.0210121	0.0664386	-0.1097091	0.6814198

Appendix 4: Correlation Matrix

	$\ln(w_{HS}/w_{LS})_t$	$\ln(w_{HS}/w_{LS})_{t-1}$	$\ln(real\ Y)_t$	$\ln(real\ Y)_{t-1}$	$\ln(K/Y)_t$	$\ln(K/Y)_{t-1}$	$(RD/Y)_t$	$(RD/Y)_{t-1}$	$(OSS)_t$	$(OSS)_{t-1}$	$(OSM)_t$	$(OSM)_{t-1}$	$(IM/Y)_t$	$(IM/Y)_{t-1}$
$\ln(w_{HS}/w_{LS})_t$	1.0000													
$\ln(w_{HS}/w_{LS})_{t-1}$	0.9841	1.0000												
$\ln(real\ Y)_t$	-0.1684	-0.1665	1.0000											
$\ln(real\ Y)_{t-1}$	-0.1714	-0.1708	0.9967	1.0000										
$\ln(K/Y)_t$	-0.3507	-0.3223	-0.3659	-0.3562	1.0000									
$\ln(K/Y)_{t-1}$	-0.3359	-0.3049	-0.3602	-0.3627	0.9874	1.0000								
$(RD/Y)_t$	0.4613	0.4755	0.0353	0.0262	-0.0556	-0.0407	1.0000							
$(RD/Y)_{t-1}$	0.4645	0.4748	0.0338	0.0191	-0.0587	-0.0330	0.9871	1.0000						
$(OSS)_t$	0.1538	0.1727	-0.0834	-0.1015	0.1861	0.2270	0.2427	0.2762	1.0000					
$(OSS)_{t-1}$	0.1281	0.1492	-0.0744	-0.0949	0.1794	0.2241	0.2100	0.2462	0.9815	1.0000				
$(OSM)_t$	0.6783	0.6764	-0.0580	-0.0685	-0.2334	-0.2018	0.4868	0.5045	0.1840	0.1771	1.0000			
$(OSM)_{t-1}$	0.6732	0.6729	-0.0566	-0.0648	-0.2345	-0.2084	0.4941	0.5106	0.1709	0.1640	0.9878	1.0000		
$(IM/Y)_t$	0.7028	0.7028	-0.3121	-0.3141	-0.0509	-0.0314	0.3316	0.3495	0.3492	0.3445	0.8325	0.8264	1.0000	
$(IM/Y)_{t-1}$	0.6944	0.6915	-0.2990	-0.3070	-0.0652	-0.0358	0.3171	0.3418	0.3541	0.3550	0.8342	0.8297	0.9843	1.0000

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