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Labor Market Effects of International Outsourcing: How Measurement Matters

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Abstract

As regards labor market effects of International Outsourcing, empirical studies have difficulties in confirming theoretical results. The use of different indices adds to the puzzle. The paper examines whether measurement differences are one reason for the mismatch between empirical and theoretical findings. In fact, considering the properties of various outsourcing indices and applying a panel data estimation of the effects on the within industries' wage gap in Germany, theory and empirics can be reconciled: while the wage gap increases in the aggregate, the service sector and the high skill intensive industries, it decreases in the low skill intensive industries – which is in line with theoretical findings by Arndt (1997, 1998).

Keywords: International Outsourcing; wage differential

JEL classification: F16; J31

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1 Introduction

Since International Outsourcing moved into the focus of political and social discussion, it has been blamed to reduce relative demand for low skilled labor. Thus, beside skill-biased technical change, International Outsourcing is seen as one main culprit for labor market disruptions in industrialized countries. While Outsourcing is defined as the procurement of inputs from an external supplier, it is the international component, namely the use of a production fragment produced abroad, that achieves most attention in public discussion as well as in economic research.[1] In order to investigate the determinants and the effects of International Outsourcing, a huge area of theoretical and empirical research emerged.

Jones and Kierzkowski (1990) focus on the importance of producer services to link fragmented production blocks and, thus, very early present a non-formal model to describe the process of International Outsourcing. Based on this model, they deepen the discussion on determinants and adjustment effects of International Outsourcing in several following contributions.[2] Feenstra and Hanson (1996a,b) focus on labor market adjustment effects and show that International Outsourcing increases the relative wage of high skilled labor in both, the insourcing as well as the outsourcing country. With this framework, Feenstra and Hanson first present International Outsourcing, beside skill-biased technical change, as an additional explanation of the decline of relative low skilled labor demand and, thus, relative wages of the low skilled. Within a series of papers, Arndt (1997, 1998a,b) embeds International Outsourcing into a general equilibrium international trade model and investigates industry specific effects. Since producers shed their less competitive production blocks to get more effective competitors on world markets, International Outsourcing increases relative wages in labor intensive industries, whereas relative wages in capital intensive industries decrease. With this pattern Arndt concludes that the aggregate welfare-reducing implications of International Outsourcing may be exaggerated. Deardorff (2001a,b) shows within a combination of a Ricardian and a Heckscher-Ohlin model, that the adjustment effects of International Outsourcing strongly depend on the nature of fragmentation, in particular the factor intensities of the relocated production blocks. Depending on the effects on terms of trade, International Outsourcing can either increase or lower a countries welfare. Deardorff additionally mentions that International Outsourcing may be a force toward factor price equalization. Embedding International Outsourcing into an increasing returns to scale framework, Burda and Dluhosch (2001, 2002) present different determinants as well as labor market adjustment effects compared to the re-

[1] For a detailed definition of International Outsourcing see e.g. Jones and Kierzkowski (1990), Arndt (1998b), or Deardorff (2001b).

[2] See e.g. Jones and Kierzkowski (2001a,b, 2004, 2005)

sults achieved with traditional Heckscher-Ohlin models. As a reaction of monopolistic competition, International Outsourcing increases the skill wage premium and, thus, behaves similar to skill-biased technical change in the short run. They additionally note, that, when firms enter the market, results may change.

In order to test theory, a lot of empirical work emerged measuring the level and estimating adjustment effects of International Outsourcing. Since it is not possible to directly observe International Outsourcing at an aggregated macro level, there is a need to proxy it. Therefore, several indices were developed and a few of them are very common in use. Campa and Goldberg (1997) e.g. measure International Outsourcing using an index called vertical specialization. Within a descriptive analysis they show that, from 1974-1993, International Outsourcing increased strongly in the United States (US), Canada and the United Kingdom (UK), but not in Japan. Hummels et al. (2001) measure International Outsourcing as imported inputs used to produce products that are afterward exported. Based on OECD input-output tables they document several key aspects of International Outsourcing for various countries. Yeats (2001) uses the measure of imported inputs in total imports and concludes for a variety of countries that International Outsourcing is already at a quite high level.

The use of different indices to measure International Outsourcing turns out to be a serious problem when it comes to the estimation of labor market adjustment effects. Berman et al. (1993) proxy International Outsourcing with parts and components purchased from abroad and, thus, use a very narrow measure. Regressing the share of high skilled wages in total wages on the components of a quasi-fixed cost function, including their International Outsourcing proxy, they investigate the shift from unskilled toward skilled labor in the US manufacturing industries during the 1980s. As results Berman et al. show that International Outsourcing has only small effects while it is the labor saving technical change that turns out to be the main driving force. By contrast, Feenstra and Hanson (1996a,b, 1999) use a more general index of International Outsourcing, namely the imported inputs in total inputs. As estimation result they present a positive, highly statistically significant effect of International Outsourcing on the change in the non production wage share of the US manufacturing industry. Thus, they highlight the importance of International Outsourcing for understanding changes in labor demand and first note that measurement differences can be one crucial point of achieving different results. Egger and Egger (2002) examine the effects of International Outsourcing within the involved low-wage countries. As proxy they use the imported inputs in total imports as well as intermediate goods exports in total exports and find a significant positive (negative) effect of imports (exports) on wages in the manufacturing industry. Focusing on the manufacturing sector in France, Strauss-Kahn (2003) shows that International Outsourcing contributes significantly to the decline of the share of unskilled workers in employment. She bases her calculations on an index

called vertical specialization and, like Berman et al. (1993) and Feenstra and Hanson (1996b, 1997), estimates labor market effects using a cost share equation of a translog function. She recommends policy to focus on education and relocation subsidies and not, like sometimes mentioned by globalization critics, to restrict International Outsourcing since it tends to increase average welfare. For the UK, Hijzen et al. (2004) estimate the effects of International Outsourcing on labor demand in the manufacturing sector over the period 1984-1996. Only considering the imported inputs in a given industry from the same industry, they use a very narrow measure. As main result they show that International Outsourcing nevertheless has a strong negative effect on the demand of low skilled workers and, thus, is an important component in explaining the changing skill structure. Geishecker and Görg (2005) show for the German economy that International Outsourcing may have different adjustment effects in different industries. As index they use imported inputs in total output. While for the manufacturing sector as a whole, effects of International Outsourcing are not significant, results differ when considering a more disaggregated industry level. Estimating a microeconomic log wage equation they show that, while low skilled workers in the low skill intensive industries experience significant reductions in their real wage, there is no such effect for low skilled workers in the high skill intensive industries. On the other hand, high skill workers significantly gain from fragmentation only in the high skill intensive industries while the effect on their real wage in the low skill intensive industries is not significant. Amiti and Wei (2004) investigate the role of service outsourcing for the US and the UK, showing that it is much lower but increases at a faster pace than material outsourcing in both countries. Using imported inputs in total inputs, they estimate labor market adjustment effects with a standard labor demand equation (as shown e.g. in Hamermesh (1993)). As result they present only insignificant effects of service outsourcing on job growth in the UK.[3] Thus they summarize that service outsourcing does not induce a fall in aggregate employment but could lead to overall positive effects since it increases the productivity within industries.[4]

As this literature review shows, empirical investigations failed to test some important effects stated by theory. In particular, there is no empirical contribution showing that International Outsourcing increases relative wages in labor intensive industries but reduces them in capital intensive ones (e.g. shown by Arndt (1997, 1998a,b)), or showing that International Outsourcing leads to an increase of the relative wage of

[3] In a companion paper Amiti and Wei (2005) show for the US economy that a negative effect occurs when looking at a more disaggregated industry level, but this effect disappears when considering aggregated sectors.

[4] With respect to service outsourcing, a big amount of descriptive analysis emerged in the last years. The McKinsey Global Institute (2003) presents a widely quoted study and predict job losses due to service outsourcing from 2003 to 2015. However, they note that the amount of job losses is only a relative small share of the overall job losses due to business cycle.

high skilled labor at the aggregated whole economy level (e.g. mentioned by Feenstra and Hanson (1996a,b, 1999)). Rather, empirical results differ strongly and, thus, a quite blurry picture emerges. The different estimation results are not only due to different data, but also due to the use of different International Outsourcing indices, what makes the puzzle additionally confusing. This contribution investigates if measurement differences may be one reason for the difficulties of empirical contributions in testing important theoretical findings. In section (2), the design of different indices gets examined. Therefor, five commonly used indices are accurately defined and compared with respect to their theoretical differences. In section (3), International Outsourcing is measured with these indices from 1991-2000 in Germany to assess their descriptive properties. To investigate the quality of the indices, several shift-share analysis are applied in section (4). Thus, the indices' variance is decomposed in order to examine if they really capture International Outsourcing activities or if they are mainly driven by other forces. To investigate their performance when it comes to the estimation of labor market adjustment effects, several panel data analysis are applied in section (5), using data from the German Socio Economic Panel (SOEP). With a very direct form of estimating adjustment effects, the within industries' wage differential is regressed on the different indices. Section (6) concludes by summarizing the major findings. As it turns out, fundamental differences exist between the International Outsourcing indices. With respect to these differences and with the kind of panel data estimation focusing more directly on the effects on the wage differential, highly significant results occur confirming the above mentioned theoretical findings. Within the period 1991-2000, International Outsourcing significantly increases the wage gap in Germany in the whole economy, the service sector and the high skill intensive industries, but not in the low skill intensive industries. There, the wage gap decreases.

2 Design: First Theoretical Differences

To start with the analysis, this section investigates theoretical differences of five International Outsourcing indices that are very common in use. Since some of them miss a concrete definition, they first get accurately defined. By comparing their designs and extracting theoretical differences, a picture emerges providing first hints with respect to their properties as descriptive measures.

Imported Inputs as Share of Total Imports

One index to proxy International Outsourcing is the share of "Imported Inputs in Total Imports" (*IITM*). This index is used e.g. by Yeats (2001) to measure the magnitude and the nature of global production sharing for several OECD countries in 1995. Egger

and Egger (2002) calculate this share for seven central and eastern European Countries. While Egger (2003) and Egger and Egger (2003) refer to the results presented in Yeats (2001) only to measure the magnitude of International Outsourcing, they turn to another index described below (imported inputs as share of gross output) to measure the development of International Outsourcing. Chen et al. (2005) also use IITM to proxy International Outsourcing for 10 OECD countries and different years during the period 1968-1998. The *IITM* index can be calculated using

$$IITM_t = \frac{\sum_{j=1}^{n} \sum_{w=1}^{z} i_{wjt}}{\sum_{w=1}^{z} m_{wt}} \tag{1}$$

with i_{wjt} as imported inputs from industry $w = 1, \ldots, z$ used to produce output in industry $j = 1, \ldots, n$ at point of time t and m_{wt} as total imports of good w. To obtain the desired level of industry aggregation, different industries j can be aggregated.[5] To obtain total imports, one has to aggregate over w goods. To calculate the International Outsourcing indices, most empirical contributions use input-output tables.[6]

Equation (1) directly clarifies one problem arising with the *IITM* index: the lack of information on total imports m at the disaggregated industry level j. While input-output tables provide information on the imports of commodity w used as inputs in production of industry j, they do not observe total imports of good w used in industry j. With respect to total imports, input-output tables do not differentiate between the industries j where they are used. Thus, it is only possible to match imported inputs i and total imports m at the aggregated whole economy level but not at a disaggregated industry level j. When the *IITM* index is calculated for disaggregated industries, imported inputs used in industry j are related to total imports of commodity w (with $w = j$ due to the symmetry of input-output tables). Thus, the numerator and the denominator are referred to different dimensions, what may result in values difficult to interpret. This problem gets magnified with the examination of time series and, thus, when focusing on the change of International Ousourcing. However, all of the mentioned papers recently used the *IITM* index intuitively considered this problem and only calculated this index for one period t at an aggregated level. To analyze

[5] Within the whole paper, different levels of industry aggregation are considered, namely the whole economy, the manufacturing industry, the low skill intensive industries of the manufacturing sector, the high skill intensive industries of the manufacturing sector as well as the service industry.

[6] As Chen et al. (2005) mention, input-output tables have several advantages in measuring International Outsourcing activities. One of the attractive features is that they contain information on imported inputs at a disaggregated industry level. Thus, they provide the possibility to exactly identify the industries abroad from which the inputs get imported and the industries in the home country that use the imported intermediates in production.

the development of International Outsourcing or the amount at a more disaggregated industry level, they proceeded with other International Outsourcing indices.

Imported Inputs as Share of Total Inputs

Another frequently used index to measure International Outsourcing activities is the ratio of "Imported Inputs to Total Inputs" (*IITI*). Feenstra and Hanson (1996b) use this index to measure International Outsourcing for the US manufacturing sector. Amiti and Wei (2004) calculate *IITI* for the UK and differ between service and manufacturing inputs. Bardhan and Kroll (2003) also use the index to measure International Outsourcing for the US. In addition to the manufacturing sector, they calculate this share for the high-tech-manufacturing industries. The European Economic Advisory Group (2005) also refers to the *IITI* index and present results for several European countries in the years 1995 and 2000. The *IITI* measure can be calculated using

$$IITI_t = \frac{\sum_{j=1}^{n}\sum_{w=1}^{z} i_{wjt}}{\sum_{j=1}^{n}\sum_{w=1}^{z} q_{wjt}} = \frac{\sum_{j=1}^{n}\sum_{w=1}^{z} i_{wjt}}{\sum_{j=1}^{n}\sum_{w=1}^{z} (i_{wjt} + d_{wjt})} \tag{2}$$

with i_{wjt} as imported inputs from industry $w = 1,\ldots,z$ used to produce output in industry $j = 1,\ldots,n$ at point of time t and q_{wjt} as the value of total inputs from industry w used in industry j.[7] Total inputs q_{wjt} can also be separated into imported inputs i_{wjt} and domestically produced inputs d_{wjt}. To obtain the measure for different levels of industry aggregation, the factors of *IITI* can be aggregated over the desired j industries. By contrast to *IITM*, the *IITI* index relates comparable values and, thus, achieves interpretable results also at disaggregated industry levels as well as for the development of International Outsourcing over time.

Imported Inputs as Share of Gross Output

A third measure of International Outsourcing is the index "Imported Inputs as share of Gross Output" (*IIGO*). The *IIGO* index is e.g. used in Egger and Egger (2003). They calculate the average annual change of International Outsourcing between 1990 and 1997 at the 3-digit NACE industry aggregation for 11 European countries. As results, Egger and Egger show that, on average, International Outsourcing increased, especially in the southern EU member states. Geishecker and Görg (2005) use this

[7] Since Feenstra and Hanson (1996b) and Amiti and Wei (2004) do not use typical input-output tables as data, they have no information of the value of imported inputs i. Thus, they estimate i similar as described for the vertical specialization index below.

index to calculate the share of International Outsourcing in the manufacturing sector for Germany from 1991-2000. Additionally, they show results for several disaggregated industries and refer to the overall increase of this measure. The *IIGO* index can be calculated using

$$IIGO_t = \frac{\sum_{j=1}^{n} \sum_{w=1}^{z} i_{wjt}}{\sum_{j=1}^{n} o_{jt}} \tag{3}$$

with i_{wjt} as imported inputs from industry $w = 1, \ldots, z$ used for production in industry $j = 1, \ldots, n$ at time t and o_{jt} as gross output of industry j at time t. Summarizing the two factors over j industries results in the outsourcing activity in period t for the desired level of industry aggregation. Since gross output o_{jt} is an aggregated value at industry level j per definition, there is no need to aggregate different input sources w, what has to be done when measuring International Outsourcing with the *IITM* or the *IITI* index described above. Like *IITI*, the *IIGO* index relates imported inputs to a comparable value within the industry and thus is interpretable for disaggregated values and the development over time as well. Since industries' j gross output o is naturally bigger than the industries' total inputs q, the value of International Outsourcing measured with *IIGO* needs to be smaller than the value measured with *IITI*.

Vertical Specialization

The next measure examined within this contribution is the index called "Vertical Specialization" (*VS*). Campa and Goldberg (1997) present this index as imported inputs into production and calculate shares for the US, Canada, the UK and Japan. Feenstra (1998) summarizes different tables from Campa and Goldberg (1997) and, additionally to the whole manufacturing sector, presents results for several disaggregated industries. Strauss-Kahn (2003) also uses the *VS* index to measure International Outsourcing in France for the years 1977 and 1993. In addition to the whole economy, Strauss-Kahn measures vertical specialization at a disaggregated industry level, presenting very different results for different industries.[8] The *VS* index measures the share of International Outsourcing using

$$VS_t = \sum_{j=1}^{n} \sum_{w=1}^{z} \frac{f_{wt} \cdot q_{wjt}}{p_{jt}} = \sum_{j=1}^{n} \sum_{w=1}^{z} \frac{\frac{m_{wt}}{d_{wt}} \cdot q_{wjt}}{p_{jt}} \tag{4}$$

[8]The index used in Chen et al. (2005) is also named "vertical specialization" though it is a more narrow measure of International Outsourcing, considering only the imported inputs used to produce products that finally get exported. Thus, it is not the *VS* index considered in this paper.

with q_{wjt} as the total value of inputs from industry $w = 1, \ldots, z$ to produce output in industry $j = 1, \ldots, n$ in year t and f_{wt} as the fraction of imported goods m_{wt} to domestically used goods d_{wt}. As imported and domestically used goods, the VS measure in literature mostly considers final, intermediate as well as capital goods. Thus, the numerator of (4) can be seen as an estimation of imported inputs by industry j at time t (comparable with the numerators of the indices described above) which is related to the value of total production p_{jt}. Depending on the desired level of aggregation, the factors can again be summed over $j = 1, \ldots, n$ industries. As the above mentioned $IITM$, the VS index also uses total imports m not available at the industry level j. But by contrast, VS does not relate these imported goods from industry w with other factors at the industry level j. Instead, the imports m_{wt} get related to the domestic use of goods d_{wt} and thus the m/d fraction uses the same dimensions in the numerator as well as in the denominator. This solves the above mentioned problem with the $IITM$ index. Thus, similar to the $IITI$ and $IIGO$ indices it is possible to obtain interpretable values at a disaggregated industry level as well as for the development of the index over time.

Value Added as Share of Production

As a fifth proxy of International Outsourcing activities, an index frequently cited in a debate on the German economy is examined. As Sinn (2003) called the German economy a "bazaar economy" whose growth of value added by domestic manufactures declines and has already fallen behind the growth of production, he started a new round of discussion using a well known index to measure the declining share of domestic "Value Added in Production" (VAP). He highlights the strong fall after 1995 and illuminates unequal developments in different industries.[9] The VAP measure can be calculated using

$$VAP_t = \frac{\sum_{j=1}^{n} v_{jt}}{\sum_{j=1}^{n} p_{jt}} \tag{5}$$

with v_{jt} as value added and p_{jt} as the value of production in industry $j = 1, \ldots, n$ at time t. Again, depending on the desired level of aggregation, j can be summed over

[9] With respect to the huge discussion about the bazaar economy it has to be mentioned, that the critics of Sinn's thesis base their argumentation on other indices. Bofinger (2005) e.g. argues that the term "bazaar economy" is inappropriate as long as the domestically produced share of exports is larger than 50 percent. Thereby he refers to calculations of the German Federal Statistical Office (Statistisches Bundesamt, 2004), showing that, while the import share of the exporting industries has risen indeed, the domestically value added share of GDP increased also. For a detailed investigation of this discussion see Sinn (2005).

different industries. The VAP index also relates factors directly comparable at the industry level j and, since International Outsourcing should lead to lower value added in the home industries, the index is expected to be an inverse proxy of International Outsourcing activities. Thus, VAP can be seen as an indirect International Outsourcing index measuring exactly the opposite, the decrease of an industries' value added since it relocates fragmented production blocks e.g. to a relative low wage country.

Since all the equations described above measure International Outsourcing at time t one can use a standard index formula like

$$IO^z_{0,t} = \frac{IO^z_t}{IO^z_0}, \tag{6}$$

with IO^z denoting the respective International Outsourcing index ($z = IITO, IITI, IIGO, VS$ or VAP), to achieve the development of International Outsourcing over time.

As these theoretical definitions show, the $IITM$ index may lead to trouble since it relates values not comparable at a disaggregated industry level. Thus, it is difficult to make any expectations about the behavior of the index as a proxy of International Outsourcing activities, except that the values of the index should be relatively high since import values are relatively small compared with total inputs ($IITI$), gross output ($IIGO$) or total production (VS). Another important result is the expectation of the VAP index to evolve inverse to International Outsourcing activities and, thus, to the other three indices $IITI$, $IIGO$ and VS. Since the value of total inputs is necessarily smaller than the value of total production or gross output, the $IITI$ index should result in higher values than the $IIGO$ and the VS. However, $IITI$ and $IIGO$ are designed as very direct measures of International Outsourcing and, thus, can be assumed to be quite good proxies. With respect to VS, the quality as well as the performance of the index depend on the goodness of the m/d-ratio (see equation (4)) as a proxy for the "international" component of an industries' production pattern. If this ratio turns out to capture an industries' international activity quite well, the index should have similar properties as the $IITI$ and the $IIGO$ index and, thus, could also be expected to be a good proxy for International Outsourcing activities.

After comparing the theoretical design of the different International Outsourcing indices, the next section uses these indices to measure the level as well as the development of International Outsourcing within the German economy.

3 Measurement: Analyzing Descriptive Properties

While empirical literature mostly focus on econometrical estimations, only few attention is set on descriptively measuring International Outsourcing. This section inves-

Table 1: Values of International Outsourcing in Germany

	IITM	*IITI*	*IIGO*	*VS*	*VAP*
			1991		
Whole Economy	57%	16%	7%	7%	51%
Manufacturing Industry	52%	24%	12%	11%	37%
Low Skill Industries	61%	25%	13%	13%	34%
High Skill Industries	46%	24%	11%	10%	40%
Service Industry	146%	9%	3%	3%	59%
			1995		
Whole Economy	58%	15%	6%	6%	52%
Manufacturing Industry	50%	24%	12%	12%	35%
Low Skill Industries	57%	23%	12%	12%	33%
High Skill Industries	46%	24%	11%	11%	37%
Service Industry	144%	8%	3%	3%	61%
			2000		
Whole Economy	55%	19%	8%	9%	50%
Manufacturing Industry	48%	29%	14%	15%	33%
High Skill Industries	56%	28%	14%	14%	33%
Low Skill Industries	44%	29%	14%	15%	33%
Service Industry	133%	11%	4%	5%	59%

tigates the behavior of the indices when used as descriptive measurements. Within a first step, the amount of International Outsourcing in Germany is calculated for the years 1991, 1995 and 2000. A second step investigates the development of International Outsourcing from 1991-2000 (additionally differentiating between the two sub-periods 1991-1995 and 1995-2000). All the calculations in this section are based on input-output tables from the German Federal Statistical Office.[10]

Table (1) summarizes the amount of International Outsourcing in Germany for the years 1991, 1995 and 2000 and for different levels of industry aggregations, namely the whole economy, the manufacturing industry, additionally separated into the high and low skill intensive industries, as well as the service industry.[11]

With nearly 60 percent, the *IITM* index measures the highest values of International Outsourcing in Germany. However, as mentioned in section (2), problems occur when calculating *IITM*, especially at the disaggregated industry level. By contrast, the results of the *IITI*, the *IIGO* and the *VS* index show much lower values. As expected with the theoretical design of the indices, the values of the *IITI* index are in any case higher than those of the *IIGO* and the *VS* index. With respect to *IITI*, the lowest share of International

[10]To calculate the indices from input-output tables, the equations presented in section (2) have to be slightly rearranged into some matrix-algebra. The necessary formulas are presented in Appendix I.

[11]To differ between high and low skill intensive industries of the manufacturing sector the paper refers to a cluster analysis done by Geishecker and Görg (2005). The results of this cluster analysis are presented in Appendix II.

Table 2: Development of International Outsourcing in Germany

	IITM	*IITI*	*IIGO*	*VS*	*VAP*
			1991-2000		
Whole Economy	−3%	20%	19%	28%	−2%
Manufacturing Industry	−7%	20%	18%	29%	−12%
Low Skill Industries	−7%	14%	11%	6%	−2%
High Skill Industries	−4%	24%	25%	47%	−17%
Service Industry	−9%	29%	30%	38%	−1%
			1991-1995		
Whole Economy	1%	−6%	−7%	−6%	2%
Manufacturing Industry	−3%	−1%	1%	3%	−5%
Low Skill Industries	−6%	−6%	−5%	−6%	−2%
High Skill Industries	0%	3%	5%	11%	−7%
Service Industry	−1%	−4%	6%	−9%	2%
			1995-2000		
Whole Economy	−4%	27%	27%	37%	−4%
Manufacturing Industry	−4%	21%	17%	26%	−7%
Low Skill Industries	−1%	21%	16%	14%	−1%
High Skill Industries	−4%	21%	19%	33%	−11%
Service Industry	−8%	35%	38%	51%	−3%

Outsourcing occurs in the service industry with around 10 percent, followed by the whole economy. The highest values are measured within the manufacturing industry as well as the high skill and the low skill intensive industries. The *IIGO* and the *VS* index present a quite similar picture of International Outsourcing in Germany. Compared to the other indices they result in the smallest values, with the manufacturing as well as the high skill and low skill intensive industries around $10-15$ percent, the whole economy around 7 percent and the service sector around $3-5$ percent. In line with the results of the *IITI* index, the indices show similar between industry structures of International Outsourcing. Thus, the relatively small amount of International Outsourcing in the service industry compared to the manufacturing industry (already shown by several other country studies, e.g. Amiti and Wei (2004)) can also be confirmed for the German economy. The *VAP* index results in relatively high values of International Outsourcing and, thus, lies between the *IITM* and the other three indices.

To analyze the development of the indices, table (2) presents the percentage change of International Outsourcing in Germany for different time periods.

The table clearly shows the inverse behavior of the *VAP* index. From 1991-2000, the index decreased for all levels of industry aggregations. The effect was extraordinary within the manufacturing industry and the high skill intensive industries with a decline of 12 percent and 17 percent, respectively. A much lower, but still decreasing effect occurred in the whole economy and in the low skill intensive industries, while in

the service industry, value added was only marginally decreasing. Considering an additional separation in two time periods, value added in production seems to be more stable during the first period (1991-1995) than in the second period (1995-2000), where the main decrease occurred. With respect to the *IITM* index, most of the industries also show an inverse pattern of International Outsourcing.[12] Due to an enormous decrease of the index for the service sector in the second period (1995-2000), this sector also depicted the strongest fall over the whole time period. However, the problems mentioned above should be kept in mind. Considering the other three indices *IITI*, *IIGO* and *VS*, results show similar patterns of the development of International Outsourcing over time but, however, with noticeable differences. Considering the whole period, the service industry is exposed to very high growth rates with around $30 - 40$ percent. Another remarkable pattern is the stronger increase of International Outsourcing activities in high skill intensive industries compared to the low skill intensive industries. The *VS* index generally shows very intense patterns of the development of International Outsourcing with an extraordinary high increase of 47 percent in the high skill intensive industries. With a bigger variance, results are most above or below the *IITI* or the *IIGO* index. While in the first years (1991-1995), the indices more or less fluctuated, the big increase of International Outsourcing occurred in the second period (1995-2000).

Summarizing the descriptive properties of the indices it turns out, that International Outsourcing increased in Germany during the considered time period. In most parts of the economy International Outsourcing fluctuated slightly during the first years (1991-1995), but increased sharply within the second time period (1995-2000). The service sector shows the strongest increase of International Outsourcing, but is still on a fairly low level. An important pattern to note is that International Outsourcing is at a higher level and increases faster in the high skill intensive industries than in the low skill intensive ones. Beside these general findings, noticeable differences exist between the different indices. Due to the above mentioned problems, the *IITM* index seems to be inadequate to measure the value as well as the development of International Outsourcing. Thus, results differ strongly from the results achieved with the other three indices *IITI*, *IIGO* and *VS*. They behave quite similar and present an increase of International Outsourcing activities with the *VS* index depicting changes more intensively than the other two indices. As expected from the theoretical definitions in section (2), the *VAP* index is an inverse measure of International Outsourcing. However, this does not hold for the service sector. There, value added stayed nearly stable. Thus, in the service industry Germany focuses a strong increase of International Outsourcing without losing value added. This could e.g. be due to the high rate of innovation and firm start ups in parts of the service sector.

[12] Appendix III presents some algebra showing the possibility of the *IITM* index to decrease even if International Outsourcing increases.

After examining the behavior of the International Outsourcing indices when being used as descriptive measurements, the next section investigates the quality of the different indices.

4 Quality: Extracting the Driving Forces

With respect to the design of the different indices, it is possible that they indeed capture International Outsourcing activities. However, there may be other forces at work, that drive the main part of their variance. If, e.g. a highly vertically specialized industry increases its share of production relative to economy wide production, the index is forced to increase even though the Outsourcing activity of the industry has not changed or even declined. Thus, the increase of an index could be due to structural changes, what would be an objectionable attribute. To examine if the indices are really driven by International Outsourcing activities, several shift-share analysis are applied within this section. Shift-share analysis are used to decompose the variance of an index into different components. While fixing one component the intrinsic variation of the other component (that is allowed to adjust flexible) can be extracted.[13]

To investigate the quality of an index in really capturing International Outsourcing activities, the indices' variance is decomposed into the change of the industries' International Outsourcing activity (the within component) and the relative structural change of the industry (the between component) using

$$\Delta IO^z = \Delta \sum_{j=1}^{n} \theta_j F_j = \sum_{j=1}^{n} \bar{\theta}_j \Delta F_j + \sum_{j=1}^{n} \bar{F}_j \Delta \theta_j \tag{7}$$

with IO^z as the value of the index ($z = IITM, IITI, IIGO, VS, VAP$), F_j as industries' j International Outsourcing activity and θ_j as the structural component of industry j. A bar over the variable denotes the statistical mean of the 1991 and the 2000 values and Δ indicates absolute changes. The structural component θ_j differs slightly with respect to the different indices. If the index e.g. relates Imported Inputs to Gross Output ($IIGO$), θ_j is the share of the output of industry j to economy wide output. The within component F_j really captures the variation of the industries' International Outsourcing activity by focusing on imported inputs. The results of the shift share analysis for the period 1991-2000 are summarized in table 3.

While the row "within" depicts the variation of the industries' International Outsourcing intensity ($\sum_{j=1}^{n} \bar{\theta}_j \Delta F_j$), the structural changes are shown in row "between"

[13] The fixed component works as a form of statistical data benchmark. As results differ with different benchmarks, it is important to decide which benchmark should be used. In this contribution the arithmetic mean value is used.

Table 3: Outsourcing vs. Industry Structure (1991-2000)

	IITM	*IITI*	*IIGO*	*VS*	*VAP*
			Whole Economy		
Within	−0.0078	0.0378	0.0149	0.0214	−0.0233
Between	−0.0077	−0.0058	−0.0022	−0.0022	0.0138
Total	−0.0154	0.0320	0.0127	0.0193	−0.0094
Within / Total	50%	118%	117%	111%	247%
			Manufacturing Industry		
Within	−0.0241	0.0533	0.0212	0.0326	−0.0433
Between	−0.0126	−0.0058	0.0002	0.0004	0.0004
Total	−0.0367	0.0475	0.0214	0.0330	−0.0429
Within / Total	66%	112%	99%	99%	101%
			High Skill Industries		
Within	0.0016	0.0571	0.0257	0.0463	−0.0625
Between	−0.0195	−0.0009	0.0016	0.0024	−0.0053
Total	−0.0179	0.0562	0.0273	0.0487	−0.0678
Within / Total	−9%	102%	94%	95%	92%
			Low Skill Industries		
Within	−0.0720	0.0475	0.0138	0.0100	−0.0133
Between	0.0287	−0.0124	−0.0001	−0.0018	0.0056
Total	−0.0433	0.0351	0.0137	0.0082	−0.0078
Within / Total	166%	135%	101%	122%	172%
			Service Industry		
Within	0.0957	0.0241	0.0106	0.0137	−0.0115
Between	−0.1666	0.0012	−0.0008	−0.0009	0.0060
Total	−0.0709	0.0252	0.0098	0.0129	−0.0055
Within / Total	−135%	95%	108%	107%	209%

($\sum_{j=1}^{n} \bar{F}_j \Delta\theta_j$). Row "total" shows the sum of the two different components and, thus, presents the overall change of the index (ΔIO^z). The row "within / total" presents the contribution of the change in real International Outsourcing activities to the total variation of the index. In line with measurement results in section (3), the indices increase over the whole period 1991-2000, except the inverse *VAP* and the *IITM* index. Since the shift-share analysis bases on calculations on the disaggregated industries, problems arise again for *IITM*. While the "within" component presents the ratio of imported inputs of industry j to imports of commodity w, the structural "between" component captures the change of imports of good w in total imports. Due to the vague separation of industries and commodities, it is difficult to interpret results reasonable. This problem additionally leads to "within / total" ratios far away from the aspired 100 percent, depicting that the *IITM* index may not be good in capturing International Outsourcing activities.

The three indices *IITI*, *IIGO* and *VS* show similar results within different levels of industry aggregation. As the high values in the row "within / total" show, the change of the indices are mainly driven by the change of International Outsourcing. However, despite these similarities, there are significant differences as well. The strongest "total" increase can be measured with the *IITI* index. While the structural "between" component mostly decreases, the "within" component capturing International Outsourcing

increases in all the depicted sectors. This results in a "within / total" share mostly above 100 percent, showing that the *IITI* index slightly underestimates International Outsourcing activities. The difference of the "within / total" ratio from the 100 percent benchmark is slightly higher than the deviation of the results obtained with the other two indices *IIGO* and *VS*. The "total" variations of the *VS* index are mostly not so intense than those obtained with the *IITI*, but even stronger than those of the *IIGO* index. In all the considered aggregation levels, the increase of the index is mainly driven by the increase of the International Outsourcing component while the structural component decreases, except in the manufacturing industry and the high-skill intensive industries. Thus, the "within / total" ratio is quite high and, as the ratio of the *IIGO* index, very smooth nearby the 100 percent margin. The *IIGO* index shows a similar pattern but with slightly smaller variations of the total change as well as the structural component. With respect to the *VAP* index, the decrease in total change clearly shows the inverse structure of the index. While the "within" component (value added of industry j in the industries' production) decreases over all the different industry aggregation levels, the structural "between" component mostly increases, however, not as strong as the decrease of the inverse "within" component. This leads in some industries to a quite low "total" change and, thus, to very high "within / total" ratios.

These results show, that the *IIGO* and the *VS* index are quite good in proxying International Outsourcing activities and the *IITI* index is not far behind. However, the *IITM* index behaves not well and, thus, can be misleading measuring International Outsourcing activities. After examining the quality of the indices in really capturing International Outsourcing activities, the next section investigates the performance of the different indices when they are used to estimate labor market adjustment effects.

5 Performance: Estimating Adjustment Effects

As mentioned above, empirical contributions failed to test some theoretical key aspects of International Outsourcing. First, the result that International Outsourcing leads to an increase of relative wages in labor intensive industries but to a decrease of relative wages in capital intensive industries (shown e.g. by Arndt (1997, 1998a,b)). Since most of the empirical investigations focus on the manufacturing sector, the effects that International Outsourcing leads to an increase of relative wages of the high skilled in the whole economy (mentioned e.g. by Feenstra and Hanson (1996a,b, 1999)) could also not be shown. Rather, estimation results differ strongly due to the use of different indices and, thus, a quite blurry picture emerges. In this section, several panel data analysis are applied to investigate the labor market effects of different International Outsourcing indices. Thus, this section investigates if the mismatch between theoretical and empirical results can be due to measurement differences.

Data

The econometric analysis bases on the German Socio Economic Panel (covering the years 1984-2006) and on input-output tables from the Federal Statistical Office in Germany (covering the years 1991-2000). The input-output tables are used to calculate (i) the International Outsourcing indices as described in section (2) and (ii) the output of each industry (according to the 2-digit NACE classification). To estimate labor market effects, the wage gap per industry is calculated on base of the SOEP data. With respect to the waves $H/8$ to $Q/17$ (covering the years 1991-2000) the data includes information on the wages of around 40,000 individuals. In the sample, wages are observed as averaged real wages per hour, including additional payments like e.g. 13th or 14th month pay, holiday or Christmas bonuses. Since the SOEP data assigns each individual to the 2-digit NACE industry where she works and observes the education of each individual with respect to the international comparable ISCED classification, additional information is provided to aggregate the individual data in order to obtain the desired information on a macro level.[14] To aggregate the individual wages, the mean average within each 2-digit NACE industry is calculated, separated for high skilled and low skilled labor.[15] Thus, with the mean wage of high skilled as well as low skilled labor in each 2-digit NACE industry, with the output of each industry and with the International Outsourcing activity proxied by one of the five indices, the wide version of the desired panel data is completed and can simply be rearranged into the long version needed for the econometric analysis below.[16]

Estimation and Results

To provide a first overview of the correlation structure between the different International Outsourcing indices, table 4 presents the correlation matrix.

As the table shows, the *IITI* and the *IIGO* index are highly correlated with a correlation coefficient above 80 percent. The *VS* index is additionally similar to the *IITI* and *IIGO* index with positive and high correlations as well. As mentioned above, the *VAP* index is an inverse index of International Outsourcing with negative but also quite high correlations with the IITI, the IIGO and the VS indices. By contrast, the *IITM* index is

[14] The "International Standard Classification of Education" (ISCED) from UNESCO (1997) provides a standardized scheme classifying individuals in (1) primary education, (2) lower secondary education or second stage of basic education, (3) secondary education, (4) post-secondary, non tertiary education, (5) first stage of tertiary education or (6) second stage of tertiary education.

[15] In line with the ISCED, low skill educated workers are defined as individuals with primary, lower secondary or second stage of basic education whereas high skilled labor are individuals with some form of post secondary education.

[16] For detailed informations about the structure and the different variables of the SOEP see Haisken-DeNew and Frick (2005).

Table 4: Correlation Matrix of the Indices

	IITI	*IIGO*	*VS*	*VAP*	*IITM*
IITI	1.0000				
IIGO	0.8867	1.0000			
VS	0.6471	0.4378	1.0000		
VAP	−0.4126	−0.5124	−0.5038	1.0000	
IITM	−0.1164	−0.0711	−0.1521	0.0796	1.0000

also negatively correlated but with very low correlation coefficients.

To analyze the effects of International Outsourcing on the within industries' wage differential between high and low skilled workers,

$$lnWD_{jt} = \beta_0 + \beta_1 IO^z_{jt} + \beta_2 Y_{jt} + u_j + \epsilon_{jt} \tag{8}$$

is estimated, with WD_{jt} as the wage differential between high and low skilled workers in industry j at time t. The explanatory variable of interest is the International Outsourcing activity IO^z_{jt} measured with index z ($z = IITM, IITI, IIGO, VS, VAP$). As control variable, the output of each industry Y_{jt} is additionally included. The regression allows for an industry-level effect u_j expected to be correlated with the exogenous variables but not with the error term ϵ_{jt}. Equation (8) is estimated for the different levels of industry aggregation (whole economy, manufacturing industry, low skill industries, high skill industries and the service industry) using the fixed-effects (FE) panel estimator on the full sample. Since the level of International Outsourcing is expected to vary over the industries and thus, the explanatory variables to be correlated with the industry-level effect u_j, it is indicated to use the FE estimator from an economic point of view. In such cases, the FE estimator is assumed to be both, consistent and efficient. However, to confirm the use of the FE estimator additionally from a statistical point of view, the Hausman test is applied. The Hausman test analyzes the rejection of the null hypothesis $H0$ assuming that the orthogonality condition of the u_j, imposed by a random-effect estimator, holds. As results show, $H0$ can be mostly rejected indicating that the consistent and efficient FE estimator should be used.[17] Table 5 presents the estimation results of the industries' wage differential for the aggregated whole economy.

[17] However, for some indices in some industries, the $H0$ can not be rejected at a significant level and, thus, the RE estimator would lead to more efficient results. But even if the RE estimator would be more efficient, the FE estimator is still consistent. On the other hand, when the RE estimator is not efficient it is additionally not consistent. Thus, following the economic intuition and to decide in favor of consistence and comparability, the FE estimator is also used in the few cases where the RE estimator would be more efficient from a statistical point of view. However, all the models are additionally estimated with the RE estimator. Differences in results are only marginal, not affecting the core information.

Table 5: Effects of International Outsourcing on the Wage Gap

	Whole Economy				
	Model 1.1	Model 1.2	Model 1.3	Model 1.4	Model 1.5
	(*IITM*)	(*IITI*)	(*IIGO*)	(*VS*)	(*VAP*)
IO	0.0816	0.2122	10.8575**	3.0250	−3.7565***
	(1.52)	(0.14)	(2.25)	(0.93)	(−2.83)
Y	7.42*e*-06**	8.04*e*-06***	5.55*e*-06*	6.76*e*-06**	6.55*e*-06**
	(2.27)	(2.50)	(1.68)	(1.95)	(2.09)
Observations	342	383	385	385	385
Groups	42	47	48	48	48
R^2	0.0238	0.0206	0.0349	0.0228	0.0431
Prob > F	0.0277	0.0307	0.0026	0.0210	0.0006

(t-Statistics in parantheses)

* / ** / *** significant at 10 / 5 / 1 percent

The effects of International Outsourcing are depicted by variable *IO*, depending on the respective index. As the table shows, with each index (considering the inversity of the *VAP*), International Outsourcing increases the wage differential between high and low skilled workers within the aggregated whole economy. However, only for the *IIGO* and the *VAP*, the increasing effect is additionally statistical significant (with a t-Statistic of 2.25 and −2.83 respectively). The *VS*, the *IITI* and the *IITM* index confirm the increasing effect on the wage gap, but not within the statistical significant range. Thus, achieving significant results for the aggregated whole economy strongly depends on the index used to proxy International Outsourcing.

Since the R-squares are still at a quite low level, the goodness of the overall model does not seem to be very satisfying. Anyway, since the R-squares in longitudinal analysis do not have all the properties of the OLS R-squares, they should be handled with care and can be misleading when used as the main gauge for success.[18] Thus, the F-values that are with all estimation models significant at least on the 5 percent level are additionally presented and show that the models are fitted well.

The next series of panel data estimations investigate the effects of International Outsourcing on the wage gap for more disaggregated industry levels. Table 6 presents the results for the manufacturing and the service industry.

In the manufacturing industry, the positive effects obtained within the whole economy can not be confirmed. The estimated coefficients do not range within a common significance level and are additionally varying in tendency. Even the models as a whole

[18]The OLS R-squares have the property of being equal to both, the squared correlation between $\hat{y}$ and y and the fraction of the variation of y explained by $\hat{y}$. This is a special property of OLS estimates. In general, the squared correlation between y and $\hat{y}$ is not equal to the ratio of the variances. Thus with panel-data analysis, the R-squares are mostly calculated as correlations squared in three variants: overall, between and within. The R-squares in the tables 5 - 7 are the within-variants since they are ordinary ones for FE estimations. But however, interpreting them as the main gauge for success of the estimation can be misleading.

Table 6: Effects of International Outsourcing on the Wage Gap

	Manufacturing Industry				
	Model 2.1	Model 2.2	Model 2.3	Model 2.4	Model 2.5
	(*IITM*)	(*IITI*)	(*IIGO*)	(*VS*)	(*VAP*)
IO	0.4214	−2.3684	0.6317	−1.4105	−2.8304
	(0.45)	(−1.24)	(0.09)	(−0.35)	(−0.85)
Y	8.70*e*-06*	0.0000**	8.40*e*-06*	9.67*e*-06*	5.85*e*-06
	(1.92)	(2.20)	(1.66)	(1.78)	(1.05)
Observations	173	173	173	173	173
Groups	20	20	20	20	20
R^2	0.0247	0.0332	0.0234	0.0241	0.0280
Prob > F	0.1517	0.0781	0.1672	0.1579	0.1170
	Service Industry				
	Model 3.1	Model 3.2	Model 3.3	Model 3.4	Model 3.5
	(*IITM*)	(*IITI*)	(*IIGO*)	(*VS*)	(*VAP*)
IO	0.0810	5.1652**	17.4810**	9.4302	−4.3870
	(1.49)	(2.07)	(2.35)	(1.27)	(−1.47)
Y	6.41*e*-06	5.67*e*-06	5.01*e*-06	5.75*e*-06	7.74*e*-06*
	(1.36)	(1.33)	(1.15)	(1.25)	(1.83)
Observations	149	189	191	191	191
Groups	18	22	23	23	23
R^2	0.0295	0.0461	0.0526	0.0304	0.0336
Prob > F	0.1448	0.0198	0.0113	0.0771	0.0584

(t-Statistics in parantheses)

* / ** / *** significant at 10 / 5 / 1 percent

are not well specified with F-Statistics mostly not in the significant range. These results are in line with Geishecker and Görg (2005), showing also insignificant effects of International Outsourcing (measured with *IIGO*) on wages in the overall manufacturing industry in Germany.

In the service industry, by contrast, results are quite different. The wage gap increases with International Outsourcing for all indices, however, statistically significant only for the *IIGO* and the *IITI* index (both at a level of 5 percent). As the t-Statistics show, the *IIGO* index is the most efficient one. Again, the inverse *VAP* index presents a decreasing effect on the wage gap, however, marginally outside the significant range. As can be shown with the F-Statistics, the overall models fit quite well, except the *IITM* index. Thus, like the effects within the whole economy, these results depend strongly on the different International Outsourcing indices and, thus, measurement differences may be one explanation of the low amount of empirical contributions presenting significant effects of International Outsourcing on the wage differential in the service industry.

To empirically test the finding of Arndt (1997, 1998a,b), the effects of International Outsourcing are additionally estimated on the wage gap on a more disaggregated industry level as well, differentiating between high skill intensive and low skill intensive industries of the manufacturing sector. Table 7 presents the results.

As the table shows, estimation results are highly significant, indicating a clearly different pattern for the high skill and the low skill intensive industries. While in

Table 7: Effects of International Outsourcing on the Wage Gap

	High Skill Industries				
	Model 4.1	Model 4.2	Model 4.3	Model 4.4	Model 4.5
	(*IITM*)	(*IITI*)	(*IIGO*)	(*VS*)	(*VAP*)
IO	−0.0600	4.4351*	19.2405***	20.6216***	−12.9968***
	(−0.06)	(1.70)	(2.54)	(4.04)	(−4.00)
Y	9.37*e*-06**	6.20*e*-06	3.34*e*-06	−5.43*e*-06	−3.15*e*-06
	(2.27)	(1.39)	(0.72)	(−1.04)	(−0.64)
Observations	87	87	87	87	87
Groups	10	10	10	10	10
R^2	0.0644	0.0989	0.1384	0.2314	0.2286
Prob > F	0.0825	0.0202	0.0038	0.0001	0.0001
	Low Skill Industries				
	Model 5.1	Model 5.2	Model 5.3	Model 5.4	Model 5.5
	(*IITM*)	(*IITI*)	(*IIGO*)	(*VS*)	(*VAP*)
IO	1.2567	−6.9474***	−24.1515**	−15.9718***	18.8228***
	(0.58)	(−2.59)	(−2.12)	(−2.88)	(3.03)
Y	7.21*e*-07	7.09*e*-06	9.94*e*-06	0.0000	0.0000
	(0.03)	(0.31)	(0.42)	(0.68)	(0.71)
Observations	86	86	86	86	86
Groups	10	10	10	10	10
R^2	0.0056	0.0841	0.0583	0.1017	0.1114
Prob > F	0.8135	0.0387	0.1082	0.0189	0.0127

(t-Statistics in parantheses)

* / ** / *** significant at 10 / 5 / 1 percent

the high skill intensive industries International Outsourcing significantly increases the wage differential between high and low skilled workers, in the low skill intensive industries International Outsourcing significantly reduces this wage gap. By contrast to the results of the more aggregated industry levels, significant effects can be obtained with almost every International Outsourcing index (except the *IITM*), only varying in the level of significance. Thus, these results confirm the theoretical findings of Arndt (1997, 1998a,b) and, since they do not depend as strong on measurement differences as the more aggregated sectors, may be due to the panel data estimation focusing more directly on the within industries wage gap.

Before turning to the concluding remarks, the main findings of the panel data estimation are summarized. Based on the SOEP data, the within industries' wage differential between high and low skilled labor is regressed on the output and the International Outsourcing activity of an industry. Since most of the existing literature estimates the effects of International Outsourcing on the change in wages or unemployment, this form of estimation (considering the wage gap as endogenous variable) differs slightly and focuses more directly on the above mentioned theoretical questions. As it turns out, results confirm several theoretical findings but differ strongly with respect to the different International Outsourcing indices. The *IITM* yields only insignificant results and thus, should not be used to estimate adjustment effects of International Outsourcing. The three indices *IITI*, *IIGO* and *VS* yield quite similar result and show good properties

when being used in econometrical panel data analysis. The *IIGO* index leads to the best performance in more aggregated industries and, thus, can be used to show that the wage gap significantly increases in the whole economy. The results of Arndt (1997, 1998a,b) that the wage gap increases in the high skill intensive industries but decreases in the low skill intensive ones can be shown with almost every index and, thus, is only minor related to measurement differences. Instead, this may be due to the more direct estimation of International Outsourcing on the within industry wage gap. The inverse *VAP* index also yields significant results and, thus, may be used in econometrical analysis as well. Additionally, results show that International Outsourcing also increases the wage gap in the service industries.

6 Conclusions

Since the 1990s, labor market adjustment effects of International Outsourcing are in the focus of many theoretical and empirical investigations. While a lot of effects stated by theory could be confirmed with empirical estimations, there exist some important adjustment effects where empirical contributions failed to confirm theory: These are the results that International Outsourcing increases relative wages in labor intensive industries, but decreases relative wages in capital intensive industries (shown by Arndt (1997, 1998a,b)), and that International Outsourcing leads to an increase of the relative wage of high skilled labor at the aggregated whole economy level (shown e.g. by Feenstra and Hanson (1996a,b, 1999)). Since there is a lack of possibilities to observe International Outsourcing on a macro level, several indices got developed and a few of them are very common in use. Thus, empirical results differ strongly what additionally confuses the puzzle. This contribution investigates five different International Outsourcing indices to address the question if the mismatch between theoretical and empirical findings may be due to measurement differences.

With a four-step analysis, the design of the indices, the behavior when they are used as descriptive measurements, the quality in really capturing International Outsourcing activities, and the performance of the indices are examined when it comes to econometrical estimations of labor market adjustment effects. The applied estimation technique differs slightly from other contributions. With a fixed effect panel data estimation using the German SOEP data for the period 1991-2000 the within industries wage gap is regressed on the output and the International Outsourcing activity of an industry. As it turns out, with consideration of the differences of the International Outsourcing indices and with this kind of panel data estimation, results confirm both theoretical findings. The wage differential between high and low skilled labor significantly increases in the whole economy, the service industry, the high skill intensive industries, but not in the low skill intensive industries. There International Outsourcing lowers the wage gap.

As the comparative analysis shows, the *IIGO* index may obtain good results for more aggregated industry levels like the whole economy and the service sector, while the *IITI* and the *VS* index behave quite well for disaggregated industry structures within the manufacturing industry. However, all three indices are defined as very direct proxies of International Outsourcing with a high quality of really capturing International Outsourcing activities and a good performance in econometrical analysis as well. Also the more indirect, inverse measure *VAP* proxies International Outsourcing quite well and turns out to achieve significant results when being used in the panel data estimation. By contrast, with the *IITM* index, difficulties arise within the theoretical design leading to measurement problems and a low quality of the index in capturing International Outsourcing activities. As a result, the econometrical performance of the index is relatively low.

Since significant effects of International Outsourcing on the wage gap within the whole economy can only be obtained with the *IIGO* and the *VAP* index, measurement differences turn out to be crucial to test effects on aggregated industry levels. By contrast, the result of Arndt (1997, 1998a,b) does not depend as strong on the use of different indices. Thus, this result may depend on the more direct way of estimating adjustment effects. With this contribution, the concluding remark of Arndt (1997) is empirically confirmed: the aggregated welfare-reducing effects of International Outsourcing on low-skilled workers may be exaggerated since their relative wages decrease in high skill intensive industries but increase in low skill intensive ones. However, since International Outsourcing increases also the wage gap within the service sector, there may be forces at work worsening low skilled labor in the tertiary sector and, thus, even in the aggregate. Due to the quite low magnitude but the strong increase of International Outsourcing in the service industry, this problem may be magnified soon with Service Outsourcing reaching higher levels.

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Appendix I: Matrix Algebra to calculate the Indices from Input-Output Tables

To calculate the different International Outsourcing indices from input-output tables, the equations shown in section (2) have to be transferred into some matrix algebra. The necessary formulas are presented in this appendix.
For the *IITM* index use

$$IITM_t = u'i[u'm]^{-1} \tag{9}$$

with i as the $z \times 1$ vector of inputs imported by industry j, m as the $n \times 1$ vector of total imports from industry w ($n = z$) and u is the $n \times 1$ vector of 1's. Thus, $IITM_t$ is the industries' j share of imported inputs to total imports at time t.
To calculate *IITI* from input-output tables one can use

$$IITI_t \equiv u'i[u'x]^{-1} \hat{=} u'i[u'(i+d)]^{-1} \tag{10}$$

with i as the $n \times 1$ vector of imported inputs used by industries j, d as the $n \times 1$ vector of total inputs used by industries j and u as a $n \times 1$ vector of 1's. The $n \times 1$ vector of total inputs in industries j can be calculated by $x = i + d$.
For the *IIGO* index use

$$IIGO_t = u'i[u'o]^{-1} \tag{11}$$

with i as the $n \times 1$ vector of imported inputs used by industries j, o as the $n \times 1$ vector of gross output of the industries j and u as $n \times 1$ vector of 1's.
To obtain the *VS* index from input-output tables,

$$VS_t = (diag(p^{-1}))[diag[diag(m)(d^{-1})]Q]' \tag{12}$$

can be used, with m as the $(z \times 1)$ vector of imports, d as the $(z \times 1)$ vector of domestically used goods, Q the $(z \times n)$ matrix of all inputs (domestically produced as well as imported) and p the $(n \times 1)$ vector of total production. The single elements of the resulting $(n \times z)$

matrix VS_t reflect the imported inputs from industry w embodied in the production of industry j and thus need to get additionally aggregated over the $w = 1 \ldots z$ goods. Finally, VAP can be calculated from input-output tables using

$$VAP_t = u'v[u'p]^{-1} \tag{13}$$

with v as the $n \times 1$ vector of value added, p as the $n \times 1$ vector containing the values of production and u as a $n \times 1$ vector of 1's.

Appendix II: Differentiating between High and Low Skill Intensive Industries

To separate the industries of the manufacturing sector into high skill intensive and low skill intensive ones, the paper refers to a cluster analysis done by Geishecker and Görg (2005). Following a k-means cluster analysis technique (with the use of a standard Euclidean distance measure) they group industries with respect to the education of the workers within a specific industry. Table 8 presents the classification result on the 2-digit NACE aggregation level.

Table 8: Classification of high Skill and Low Skill Industries

Source: Geishecker and Görg (2005)

	Industry	NACE
Low Skill Industries	Food products and beverages/tobacco	15
	Textiles	17
	Wearing apparel	18
	Tanning, dressing of leather	19
	Wood products, except furniture	20
	Pups, paper and paper products	21
	Coke, refined petroleum	23
	Rubber and plastic products	25
	Other non metallic mineral products	26
	Fabricated metal products	28
	Furniture; manufacturing n.e.c.	36
High Skill Industries	Publishing, printing and reproduction	22
	Chemicals and chemical products	24
	Basic metals	27
	Machinery and equipment	29
	Office machinery and computer	30
	Electrical machinery and apparatus	31
	Radio, television and communication	32
	Medical, precision and optical instrum.	33
	Motor vehicles, trailer	34
	Other transport equipment	35

Appendix III: The Inversity of the $IITM$ Index

Considering the whole economy, the *IITM* index is defined as i/m with i as imported inputs and m as total imports. To calculate the percentage change of *IITM* from 1991 to 2000, one can use the index formula $\frac{IITM_{2000}}{IITM_{1991}}$. The index will decrease if $IITM_{2000} < IITM_{1991}$.

$$\begin{aligned}
IITM_{2000} &< IITM_{1991} \\
\frac{i_{2000}}{m_{2000}} &< \frac{i_{1991}}{m_{1991}} \\
\frac{i_{2000}}{i_{1991}} &< \frac{m_{2000}}{m_{1991}} \\
\frac{i_{2000} - i_{1991}}{i_{1991}} &< \frac{m_{2000} - m_{1991}}{m_{1991}} \\
\frac{di}{i_{1991}} &< \frac{dm}{m_{1991}} \\
\hat{i} &< \hat{m}
\end{aligned}$$

Thus, if the percentage change of i ($\hat{i}$) is smaller than the percentage change of m ($\hat{m}$), the percentage change of the *IITM* index is negative ($\hat{IITM} < 0$) though International Outsourcing (as imported inputs i) is still positive. This was exactly the case for the considered time period in the German economy.

As an example, one can focus on the raw data for the German economy from 1991-2000: The amount of International Outsourcing i in 1991 was 206,789 (in Mill. EUR) and it increased with $di = 137,971$ to an amount of 344,760 leading to an percentage change of $\hat{i} = 0.67$. Total imports m in 1991 were observed with 362,020 and increases with $dm = 260,780$ to an amount of 622,800, leading to an percentage change of $\hat{m} = 0.72$. Thus, $\hat{m} > \hat{i}$ leading to a decrease of the *IITM* index though International Outsourcing i increased.

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