

The Sector Bias of International Outsourcing - Implications for Industrialized Economies

Dissertation

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Chapter 1

Introduction

The actual wave of globalization is characterized by some features that turn it into a completely different economic process than the first wave of impressive economic integration one century ago. One of these new attributes is International Outsourcing. As Krugman (1995) mentions, “the ability of producers to slice up the value chain” is one important part of the “new aspects of trade” (p. 332). Within the last years, this newly recovered phenomenon has become one main issue in economic research and political discussion as well. Thus, Grossman and Helpman (2005) recently noticed that “we live in an age of outsourcing” (p. 135). Even if International Outsourcing is meanwhile discussed as a world-wide phenomenon, Kierzkowski (2005) correctly mentions that “it is only the beginning of what seems an inexorable process” (p. 235).

In industrialized economies, discussion is mainly about the implications of International Outsourcing on domestic labor markets. Since Feenstra and Hanson (1996b) empirically showed an increasing effect on relative high skilled wages in the United States, fears emerged that International Outsourcing could accompany skill biased technical change as an additional force harming low skilled labor.

Before deepening the discussion of possible implications of International Outsourcing in industrialized economies, this chapter introduces by describing what is exactly meant when talking about International Outsourcing in this thesis. Furthermore, it provides descriptive statistics showing the magnitude and the development of outsourcing in a variety of countries, describes specific gaps in economic literature, and motivates by establishing several questions of research. Finally, in order to provide an overview of how to contribute to fill some of these gaps, the chapter summarizes the four manuscripts included as main parts in this thesis: It discusses the respective questions of research, the methods used, and the results achieved.

Definition of International Outsourcing

Since the term International Outsourcing has not been standardized yet, it is necessary to describe what is exactly meant when referring to International Outsourcing in this thesis. As Amiti and Wei (2005a) mention, “outsourcing” first occurred in an article in the 1979 issue of the *Journal of Royal Society of Arts*, Vol. CXXVII, 141/1. In this article, an automobile executive stated: “We are so short of professional engineers in the motor industry that we are having to outsource design works to Germany” (p. 313). Meanwhile, International Outsourcing has several synonyms in economic literature. As already mentioned, Krugman (1995) talks about “slicing up the value chain”. Feenstra and Hanson (1999) describe the phenomenon as “disintegration of production” and Arndt (1998b) as “intra-product specialization” or “super specialization”. Deardorff (2001a) or Jones and Kierzkowski (2001) talk about “vertical fragmentation”, Hummels et al. (2001) about “vertical specialization”, whereas Grossman and Rossi-Hansberg (2008) refer to a process called “task trade”. In using the term “International Outsourcing”, this thesis follows recent international trade contributions as e.g. Amiti and Wei (2005a), Egger and Egger (2002, 2003, 2005), or Geishecker and Görg (2008).¹

Therefore, “International Outsourcing”, as used in this thesis, refers to the process of an industry importing intermediate products in order to produce the final commodity at home. Thus, it is not distinguished between different firms’ organizational structures: International Outsourcing in this thesis contains both, intra firm International Outsourcing (by which a firm produces the imported intermediate at a foreign affiliate) and arm’s length International Outsourcing (by which a firm imports an intermediate produced by an independent foreign supplier). Figure 1.1 depicts possible horizontal and vertical integration strategies in order to illuminate the coverage of International Outsourcing as used in this thesis (the two shaded squares below).²

¹For a deeper discussion of different notations and definitions of International Outsourcing see Horgos (2006).

²Actually, the term “offshoring” is also very common to describe the considered phenomenon. As Amiti and Wei (2005a) note, “offshoring” in the means of “moving away from the shore” (p. 314) has a much longer history and can be traced back to 1895. However, using “offshoring” as a synonym for imported inputs, as International Outsourcing is defined here, has a much shorter history.

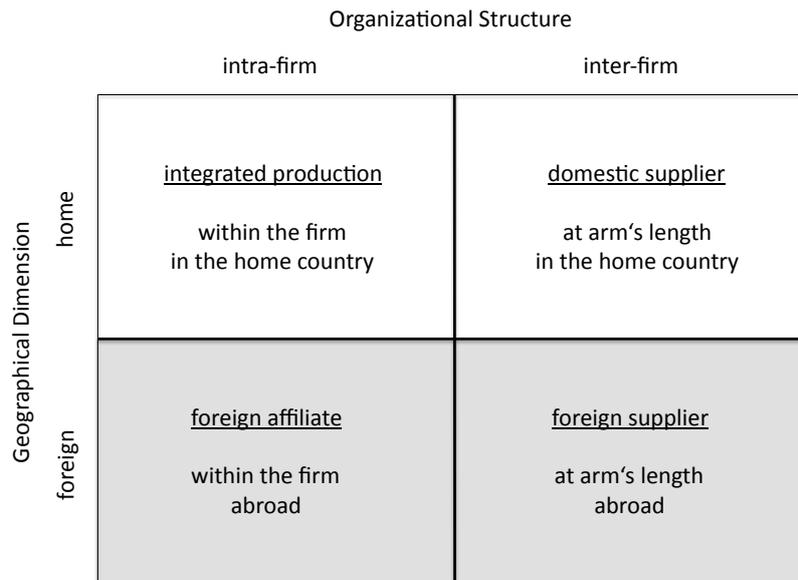


Figure 1.1: Vertical and horizontal firm integration strategies

Descriptive Statistics: Magnitude and Development of International Outsourcing at Country Level

In recent years, a variety of contributions emerged measuring the magnitude and the development of International Outsourcing for several countries. In order to provide an overview of the extent of the phenomenon in different geographical regions, this section summarizes frequently cited empirical findings. Table 1.1 presents numbers for different high-income economies, calculated by Yeats (2001).

Table 1.1: Share of parts and components in total imports (different economies, 1995)

Canada	18.4	Norway	11.5
Singapore	18.1	Finland	11.3
Ireland	15.8	Germany	10.7
Oman	15.2	Austria	10.3
United Kingdom	14.2	France	10.2
Sweden	12.8	Netherlands	9.6
Australia	12.5	Portugal	9.6
United States	12.3	Kuwait	9.6
Spain	11.8	Denmark	9.5
Hong Kong	11.6	Israel	9.3

Source: Yeats (2001, pp. 116-117)

As the table shows, International Outsourcing, measured as the share of parts and components in total imports, reached a magnitude of around 10 - 20 percent in

several high-income countries in 1995. The biggest share of International Outsourcing is calculated with 18.4 percent for Canada, followed by Singapore (18.1 percent) and Ireland (15.8 percent). European economies, as e.g. Germany, Austria, France, or the Netherlands exhibit similar magnitudes around 10 percent. As these numbers show, the extent of International Outsourcing in high-income countries is quite high but still heterogeneous.

Table 1.2 summarizes calculations of Campa and Goldberg (1997). The authors measure International Outsourcing as imported inputs in production and compare the magnitude of International Outsourcing for the manufacturing industry in the United States, Canada, the United Kingdom, and Japan, considering three different years.

Table 1.2: Imported inputs in production (different economies and years)

	1974	1984	1993
Canada	15.86	14.40	20.17
United Kingdom	13.40	18.96	21.64
Japan	8.24	7.31	4.07
United States	4.06 (1975)	6.21 (1985)	8.20 (1995)

Source: Campa and Goldberg (1997), summary of several tables

Compared to the relative high numbers calculated for Canada (15.86 percent in 1974 and 20.17 percent in 1993), International Outsourcing in the United States is still at a relative low level, however, it increased strongly from 4.06 percent in 1975 to 8.2 percent in 1995. The UK also exhibits a high magnitude of International Outsourcing activities. Starting from 13.4 percent in 1974, imported inputs reached a level of 21.64 percent of production in 1993. While in these three economies International Outsourcing increased strongly, it decreased in Japan. Starting at a relative high level of 8.24 percent in 1974, the manufacturing industry reduced its outsourcing activities to a level of 4.07 percent in 1993.

Setting the focus on transition economies, Egger and Egger (2002) investigate International Outsourcing activities in Central and Eastern European Countries. Table 1.3 provides an overview of some of their descriptive results, the magnitude of International Outsourcing in Eastern European economies in 1996.

In measuring outsourcing intensity, the authors use the share of intermediate goods imports in total imports. By contrast to the results presented above, the relative high numbers generally exceed the 50 percent margin. Bulgaria e.g. reaches an outsourcing intensity of 73.72 percent, whereas the Czech Republic exhibits a level of 55.62 percent. On average, the 7 CEEC exhibit a magnitude of outsourcing activities of 59.42 percent in 1996.

Table 1.3: Imports in intermediate goods as percent of total imports (CEECs, 1996)

Bulgaria	73.72	Hungary	59.20
Romania	63.95	Slovenia	55.83
Slovakia	60.64	Czech Republic	55.62
Poland	59.49	7 CEEC	59.42

Source: Egger and Egger (2002, p. 88)

In a companion paper, Egger and Egger (2003) present the change of International Outsourcing for European economies, using the index imported inputs in gross production (from World). The findings are presented in Table 1.4.

As the results show, International Outsourcing in the southern European economies increased relative strong compared to the major European ones. Spain, Portugal, as well as Greece exhibit an annual increase of around 8 - 11 percent. Italy also shows a strong increase of imported inputs in production of 6.54 percent. By contrast, outsourcing activities in Germany increased only at an annual rate of 2.83 percent, slightly beneath the European average of 3.15 percent. By contrast to the increasing rates of the majority of European economies, France and Ireland are characterized by decreasing outsourcing activities.

Summarizing these descriptive numbers, one can note that International Outsourcing is already at a quite high magnitude in numerous economies. Additionally, it gets obvious that numbers differ strongly. This may be due to different measurements and thus, definitions of International Outsourcing. While there is no consensus in the literature on what types of imports should be assigned to International Outsourcing, there is also disagreement on which index to use in order to measure International Outsourcing activities.

Table 1.4: Intermediate goods imports in gross production (European economies, annual change 1990 - 1997)

Spain	10.86	Denmark	2.61
Portugal	9.74	Great Britain	2.35
Greece	8.53	Netherlands	.57
Italy	6.54	France	-.03
Belgium - Luxembourg	4.97	Ireland	-3.93
Germany	2.83	Average	3.15

Source: Egger and Egger (2003, p. 56)

Research Outline: The Sector Bias of International Outsourcing - Implications for Industrialized Economies

Due to the strong increase and thus, the importance of International Outsourcing as an economic process, research in industrialized economies started to investigate possible implications on domestic markets. One main focus is set on labor market issues.

As one of the first contributions presenting significant effects of International Outsourcing, Feenstra and Hanson (1996a,b) show that outsourcing activities induce an increase of relative high skilled wages in the developed (outsourcing) as well as the developing (insourcing) economy. If the manufacturing industry of the relative high skill intensive economy relocates its relative low skill intensive production fragment abroad, demand for the low skilled decreases in both economies (as the outsourced fragment is assumed to be relative high skill intensive with respect to the insourcing economy). Thus, relative wages of the high skilled increase. This so-called factor bias of International Outsourcing induces the fear that outsourcing becomes an additional force, beside pervasive skill biased technical change, harming low skilled labor and thus, serves as theoretical and empirical basis for the majority of research contributions in recent years.

The one-sector model of Feenstra and Hanson is extended by Arndt (1997, 1998a,b) using a traditional 2×2 Heckscher-Ohlin model. With respect to this so-called sector bias of International Outsourcing, results depend on the relative skill intensity of the industry relocating production fragments abroad. With International Outsourcing decreasing unit costs, the outsourcing industry gets the possibility to pay a wage premium as long as world prices are not affected. Provided that International Outsourcing takes place in the relative low skill intensive industry, the wage premium flows to low skilled labor and thus, decreases the wage gap. In general equilibrium, the outsourcing industry expands and increases employment of low as well as high skilled labor. Results are vice versa for outsourcing taking place in the relative high skill intensive industry. With the sector bias of International Outsourcing, Arndt presents a framework that provides the possibility for low skilled labor to gain from International Outsourcing, even if it takes place in industrialized economies. With globalization not harming low skilled labor in general, the implications of the sector bias of International Outsourcing are of high importance for political economy as well.

Whereas a huge amount of theoretical as well as empirical literature investigates the factor bias of International Outsourcing, the sector bias is only less explored.³ Due to the small amount of contributions investigating the sector bias of International Outsourcing, several questions are still unsolved. This thesis, "The Sector Bias of International Outsourcing - Implications for Industrialized Economies" includes four manuscripts that try to contribute to fill some of these gaps.

First, among the huge amount of empirical contributions analyzing labor market effects of International Outsourcing, there is a variety of different indices used to proxy outsourcing activities on a macro-level. Thus, results are not directly comparable. As measurement differences seem to be an important issue in this respect, there is a gap in research investigating how measurement differences affect estimation-results of International Outsourcing. The manuscript "Labor Market Effects of International Outsourcing: How Measurement Matters" (Chapter 2) tries to contribute to fill this gap.

Considering the sector bias of International Outsourcing as illustrated within a traditional 2x2 trade framework in Arndt (1997, 1998a,b), four different outsourcing scenarios are possible. Each industry, the relative high as well as the relative low skill intensive one, can either relocate its high or low skill intensive part of production. Since the implications in general equilibrium depend on various adjustments mechanisms, only two of these four scenarios are solved. In the remaining two scenarios, International Outsourcing leads to ambiguous results. Thus, there is still a gap in research completing the picture of general equilibrium implications of the sector bias of International Outsourcing. The manuscript "The Elasticity of Substitution and the Sector Bias of International Outsourcing: Completing the Puzzle" (Chapter 3) contributes to fill this gap.

Among the various empirical contributions investigating labor market adjustment effects of International Outsourcing, most of them aim to test the factor bias, considering different countries or industries. However, there is no empirical contribution testing the sector bias of International Outsourcing: There is no empirical evidence supporting the result that the wage gap between high and low skilled labor can indeed decrease

³Deardorff (2001a,b) e.g. extends the framework by illuminating the importance of the skill intensity of the relocated production block, Egger and Falkinger (2003) investigate in determining the dominance of the factor or the sector bias of International Outsourcing. While considering different modes of final goods production, they examine several equilibrium situations and show that the sector bias is determining factor price developments in a diversified International Outsourcing equilibrium, where some firms still remain integrated. Kohler (2003) allows for an arbitrary number of industries, factors, and fragments and thus, provides the possibility of different parameter settings to achieve several results, i.a. the sector and the factor bias of International Outsourcing. Beside these International Outsourcing contributions, the discussion if it is the factor or the sector bias that matters most is already known from the literature on technical progress. (cf. Leamer, 1996; Krugman, 2000; Xu, 2001; Jones, 2001)

since outsourcing takes place in relative low skill intensive industries. The manuscript "International Outsourcing and the Sector Bias: New Empirical Evidence" (Chapter 4) tries to contribute to fill this gap.

Both, theoretical as well as empirical contributions investigating International Outsourcing effects typically within a flexible wage economy. With respect to the special characteristics of labor market institutions in major European economies, only few theoretical contributions were published recently, considering some kind of wage stickiness. However, there is no empirical contribution analyzing the implications of wage rigidity for outsourcing effects. The manuscript "International Outsourcing and Wage Rigidity: A Formal Approach and First Empirical Evidence" (Chapter 5) contributes to fill this gap. Chapter 6 concludes by summarizing the major findings of this thesis. Before becoming much more detailed in the following chapters, the next pages summarize the four manuscripts, the literature and methods used, and the main results achieved.

Overview of the Manuscripts

Labor Market Effects of International Outsourcing: How Measurement Matters (Chapter 2)

AUTHOR: DANIEL HORGOS

JOURNAL: INTERNATIONAL REVIEW OF ECONOMICS AND FINANCE

STATUS: ACCEPTED FOR PUBLICATION (OCTOBER 14, 2008)

One challenge emerging when International Outsourcing is empirically investigated on a macroeconomic basis is the lack of a variable observing outsourcing activities. As indicated with the above presented descriptive statistics, several indices exist suiting the above mentioned definition of International Outsourcing. Thus, investigations of International Outsourcing differ not only due to different empirical situations, but also due to the use of different indices.⁴ The measurement problems are even accentuated when trying to estimate labor market effects of International Outsourcing. The manuscript "Labor Market Effects of International Outsourcing: How Measurement Matters" provides an empirical four-step analysis in order to investigate these measurement problems.

⁴See e. g. Feenstra and Hanson (1996b), Campa and Goldberg (1997), Yeats (2001), Egger and Egger (2002), Amiti and Wei (2005b), or Geishecker and Görg (2005).

As first step, four different indices commonly used to measure International Outsourcing are formally defined in order to assess their theoretical differences. Afterward, the indices are used to measure the magnitude and development of International Outsourcing in Germany. The calculations are based on input-output tables provided by the German Federal Statistical Office, covering the period 1991 - 2000, and consider several levels of industry aggregation, the whole economy, the manufacturing industry, high skill intensive and low skill intensive industries, and the service industry. As third step, shift-share analyses are applied to investigate the quality of the indices. Thus, it is analyzed whether the indices are really driven by International Outsourcing activities, or whether there are other forces at work driving their main variance. As fourth step, a macro-econometric panel data analysis investigates the effects of International Outsourcing (measured with the four indices) on the wage gap between low and high skilled labor in Germany.

As the results show, there are huge differences among the various indices. While some of them perform better on more aggregated industry levels, others exhibit a good performance on more disaggregated industry levels. Considering the differences between the indices in hand with the aggregation bias, several important empirical findings can be reconciled.

The Elasticity of Substitution and the Sector Bias of International Outsourcing: Solving the Puzzle (Chapter 3)

AUTHOR: DANIEL HORGOS

JOURNAL: INTERNATIONAL JOURNAL OF ECONOMIC THEORY

STATUS: SUBMITTED (JANUARY 27, 2009)

As already mentioned above, the sector bias of International Outsourcing is discussed in Arndt (1997, 1998a,b), who extends the one-sector model of Feenstra and Hanson (1996b) in order to consider implications on more disaggregated industry levels as well. Using a traditional 2 x 2 Heckscher-Ohlin model, Arndt graphically illustrates International Outsourcing as a process reducing unit costs. In this framework, four different International Outsourcing scenarios exist: International Outsourcing can take place in the relative low skill intensive industry by relocating the low or the high skill intensive production fragment, or in the relative high skill intensive industry, also by relocating the low or the high skill intensive production block. Consequently, results depend on the particular scenario at force. With this so-called sector bias of

International Outsourcing, Arndt shows that, if International Outsourcing takes place in the relative low skill intensive industry, low skilled labor gains by receiving a wage premium. By contrast, if outsourcing takes place in the relative high skill intensive industry, high skilled labor receives the wage markup. When moving from wage to general equilibrium effects, only two of the four scenarios yield unambiguous results. Since a wage-effect works in the opposite direction as an outsourcing-effect, results are ambiguous in the remaining two scenarios. The manuscript "The Elasticity of Substitution and the Sector Bias of International Outsourcing: Solving the Puzzle" contributes to fill this gap.

Therefore, a formal model is set up in order to investigate general equilibrium effects of International Outsourcing. The framework is of a traditional 2×2 Heckscher-Ohlin type and, based on Shephard's Lemma, uses the modern duality approach to general equilibrium. Thus, it follows the line of international trade contributions by Uzawa (1964), Diewert (1971, 1974), Woodland (1977), and Mussa (1979). In this framework, International Outsourcing is introduced, similar to skill biased technical change as in Jones (1965). While examining International Outsourcing as an exogenous shock reducing labor unit requirements of the respective industry, the manuscript aims to specifically address the occurring implications in general equilibrium. Thus, however, determinants of International Outsourcing can not be considered explicitly. Whereas, in terms of technical progress, Jones (1965) focus on investigating the industry vs. the factor bias, the approach adopted in this manuscript explicitly separates all four possible industry and factor specific skill compositions. While formally modeling International Outsourcing the same way as Arndt (1997, 1998a,b) illustrates the sector bias graphically, the manuscript is able to explicitly focus on the ambiguous scenarios of the sector bias of International Outsourcing. After investigating general equilibrium effects of outsourcing formally, a calibration exercise illustrates the findings using German micro-census data.

As the results show, the puzzle can be solved when moving the focus on the elasticity of substitution between low and high skilled labor. Provided that the elasticity exceeds a critical value (the critical value is beneath unity), the wage-effect outperforms the outsourcing-effect confirming the sector bias of International Outsourcing also in general equilibrium. Thus, if outsourcing takes place in the relative low skill intensive industry, relative wages of the low skilled increase and both industries shift production toward more high skilled labor. This result holds even if the industry relocates its low, or its high skill intensive fragment. The industry relocating production fragments abroad expands, while the industry remaining integrated contracts. Since

wages are assumed to be fully flexible, employment effects follow the output pattern: High skilled as well as low skilled labor move from the contracting integrated to the expanding outsourcing industry.

International Outsourcing and the Sector Bias: New Empirical Evidence (Chapter 4)

AUTHOR: DANIEL HORGOS

JOURNAL: REVIEW OF INTERNATIONAL ECONOMICS

STATUS: SUBMITTED (JUNE 30, 2008)

Considering empirical contributions analyzing implications of International Outsourcing on labor markets, most of them aim to test the factor bias stressed in Feenstra and Hanson (1996a,b). Thus, most empirical contributions employ a relatively aggregated industry level to investigate if International Outsourcing significantly harms low skilled labor.⁵ By contrast, there is no contribution investigating the sector bias of International Outsourcing: There is a lack in empirical research showing that International Outsourcing increases the relative wage of the low skilled when it takes place in relative low skill intensive industries. The manuscript "International Outsourcing and the Sector Bias: New Empirical Evidence" contributes to fill this gap.

Therefore, it first provides a part of the formal framework set up in Chapter 3, focusing on how the sector bias of International Outsourcing affects the wage gap between high and low skilled labor. In order to provide some descriptive statistics, a German case-study illuminates the development of International Outsourcing in Germany from 1991-2000. Afterward, a panel data estimation, using input-output tables provided by the German Federal Statistical Office and the SOEP data provided by the DIW in Berlin, investigates if implications of International Outsourcing (measured with one of the indices examined in Chapter 2) on the wage gap significantly differ with respect to the skill intensity of the outsourcing industry.

Results strongly support the wage effect of the sector bias of International Outsourcing. If International Outsourcing takes place in relative high skill intensive industries, it significantly increases the wage gap between low and high skilled labor, whereas the wage gap significantly decreases if International Outsourcing takes place in relative low skill intensive industries. Thus, empirically illuminating the existence of the

⁵See e. g. Egger and Egger (2002), Strauss-Kahn (2003), Amiti and Wei (2005b), or Geishecker and Görg (2005).

sector bias of International Outsourcing in Germany, the manuscript concludes as in Arndt (1997) that concerns about the welfare-reducing implications of International Outsourcing seem to be exaggerated.

International Outsourcing and Wage Rigidity: A Formal Approach and First Empirical Evidence (Chapter 5)

AUTHOR: DANIEL HORGOS

JOURNAL: JOURNAL OF INTERNATIONAL ECONOMICS

STATUS: SUBMITTED (JANUARY 28, 2009)

The effects of International Outsourcing are mostly examined within flexible wage set ups. Only recently, some contributions emerged adopting a rigid wage framework. Egger and Kreickemeier (2008) e.g. model International Outsourcing as in Jones (2000) and Jones and Kierzkowski (2001) and introduce a fair wage approach following Akerlof and Yellen (1990) in order to analyze effects occurring within more inflexible labor markets. Using a novel diagrammatic tool, they show that wage inequality can coexist with unemployment. With home production relative high skill intensive, outsourcing mitigates the unemployment problem and reduces the high skill wage premium. However, with respect to the empirical literature, there is no contribution testing implications of International Outsourcing with labor market rigidities for low skilled labor. The manuscript "International Outsourcing and Wage Rigidity: A Formal Approach and First Empirical Evidence" contributes to fill this gap.

Therefore, the paper extends the framework presented in Chapter 3 by dropping the flexible wage assumption. Inflexible labor markets are introduced in the way that real wages of the low skilled are assumed to be downward rigid along the lines of Brecher (1974a,b). The general equilibrium effects of International Outsourcing occurring when the wage floor is binding are then compared with the effects of the flexible wage benchmark model. Afterward, the theoretical findings are tested empirically. Therefore, a micro-econometric panel data analysis, based on the SOEP data and on input-output tables from the German Federal Statistical office, investigates the effects of an industry's International Outsourcing activity (measured with one of the indices examined in Chapter 2) on individual unemployment. As empirical method, a multiple panel data logit-model is applied. The results where all industries get considered are then compared with the results occurring when industries are characterized by wage rigidity for low skilled labor. In order to proxy low skilled wage rigidity at the in-

dustry level, the analysis follows a statistical method presented e.g. by Holden (2004), Knoppik and Beissinger (2005), Goette et al. (2007), or Bauer et al. (2007).

The empirical results strongly support the theoretical findings. International Outsourcing per se increases the probability of low skilled unemployment, however, not at a significant level in most industries. If, by contrast, International Outsourcing takes place in industries characterized by low skilled wage rigidity, the probability of low skilled labor to get unemployed increases dramatically in magnitude and significance. Thus, the manuscript concludes that, in terms of unemployment, not International Outsourcing but inflexible labor market institutions instead should be blamed for harming low skilled labor.

Chapter 2

Labor Market Effects of International Outsourcing: How Measurement Matters

Abstract

As regards labor market effects of International Outsourcing, empirical results differ strongly. This is not only due to different data, the use of different indices adds to the puzzle. This paper investigates the importance of measurement differences for analyzing labor market effects of International Outsourcing. To this end, several indices are compared with respect to their design, their descriptive properties, their quality in proxying International Outsourcing activities, and their econometrical performance. As the results show, International Outsourcing effects depend strongly on measurement differences and the level of industry aggregation. Considering these results, different empirical findings can be reconciled.

JEL classification: F16; J31; F40

Keywords: International Outsourcing; indices; measurement

2.1 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. Even if International Outsourcing is already seen as a world-wide phenomenon, Kierzkowski (2005, p. 235) correctly mentions that “it is only the beginning of what seems an inexorable process”.

In order to investigate labor market effects of International Outsourcing, a wide area of empirical research emerged.¹ Since it is not possible to directly observe International Outsourcing on an aggregated macro-level, there is a need to proxy it. Thus, several indices were developed and a few of them are very common in use. Within a descriptive analysis, Campa and Goldberg (1997) e.g. measure International Outsourcing using an index called vertical specialization. They show for the period 1974-1993, that International Outsourcing increased strongly in the US, Canada and the UK, but decreased 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 mentions for a variety of countries that International Outsourcing is already at a quite high level.

Even though it is difficult to classify empirical contributions, they can be divided into two broad groups: Some contributions show insignificant effects of International Outsourcing while others support the importance of International Outsourcing for changes on the labor market. Berman et al. (1994) first estimate labor market effects of International Outsourcing using a narrow measure, the parts and components purchased from abroad. 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 show for the US manufacturing sector that International Outsourcing has only small effects while it is the labor saving technical change that turns out to be the main driving force. Amiti and Wei (2005a) investigate the role of service outsourcing

¹For an analysis of the determinants of International Outsourcing, see e.g. Jones et al. (2005) who empirically test the model of Jones and Kierzkowski (1990), and Kimura and Ando (2005) who analyze International Outsourcing activities in East Asia using a huge microeconomic data-set.

for the US and the UK showing that it is on a much lower level 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 result they also present only insignificant effects of service outsourcing on job growth in the UK.² 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.

By contrast, Feenstra and Hanson (1996a,b, 1999) first present a positive, statistically significant effect of International Outsourcing on the change in the non production wage share of the US manufacturing industry. Using the index imported inputs in total inputs they highlight the importance of International Outsourcing for understanding changes in labor demand and first note that measurement differences can be one crucial point for achieving different results. Egger and Egger (2002) examine the effects of International Outsourcing within the involved low-wage countries. As proxy they use i.a. imported inputs in total imports and find a significantly 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. (1994) and Feenstra and Hanson (1996b, 1997), estimates labor market effects using a cost share equation of a translog function. Hijzen et al. (2005) estimate the effects of International Outsourcing on labor demand in the manufacturing sector in the UK using a very narrow measure, inputs in an industry imported from the same industry. As result they note 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, 2008) show for the German economy that International Outsourcing may have different adjustment effects for different levels of industry aggregation. 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

²In a companion paper Amiti and Wei (2005b) show for the US economy that a negative effect occurs when looking at a more disaggregated industry level, but this effect disappears when considering the aggregate.

Table 2.1: Indices used in empirical contributions

Contribution	Index	Labor Market Implications
<i>Descriptive contributions</i>		
Campa and Goldberg (1997)	Vertical Specialization (VS)	-
Hummels et al. (2001)	Imported Inputs to produce exports	-
Yeats (2001)	Imported Inputs in Total Imports (IITM)	-
<i>Insignificant effects of International Outsourcing</i>		
Berman et al. (1994)	Parts and components purchased from abroad	skill biased technical change as the main driving force
Amiti and Wei (2005a)	Imported Inputs in Total Inputs (ITI)	service outsourcing no effect on aggregated labor markets
<i>Significant effects of International Outsourcing</i>		
Feenstra and Hanson (1996b)	Imported Inputs in Total Inputs (ITI)	increasing relative wages of the high skilled
Egger and Egger (2002)	Imported Inputs in Total Imports (IITM)	increasing wages in low wage countries
Strauss-Kahn (2003)	Vertical Specialization (VS)	decreasing employment of the low skilled in France
Hijzen et al. (2005)	Imported Inputs from the same industry	decreasing demand for low skilled labor
Geishecker and Görg (2005, 2008)	Imported Inputs in Gross Output (IIGO)	wages of low skilled decrease in low skill intensive industries (vice versa for the high skilled)
Hijzen (2007)	two indices (one narrow and one general)	increasing wage inequality (but technical change matters most)

intensive industries. On the other hand, high skilled 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. Hijzen (2007) investigates the effects of International Outsourcing and skill biased technical change on factor prices in the UK for the period 1993-1998. Using two indices, a more general and a narrow one, he shows that International Outsourcing effects are significant, however, technical change is the predominant force behind the change in relative wages. As Egger and Egger (2005) mention, most of the empirical contributions analyzing International Outsourcing do not control for possible spill over effects between industries. When considering these important features, labor market implications of International Outsourcing are expected to get even magnified. Table 2.1 highlights the indices used and the effects achieved by summarizing the existing literature.

As this literature review shows, empirical results differ strongly. Some of them support the importance of International Outsourcing for changes in factor prices, others refuse these effects and show that it is the skill biased technical progress that matters most. The use of different indices to proxy International Outsourcing activities adds to the puzzle. Basic presumptions made on the origin of different empirical results

are that measurement differences may play a crucial role (Feenstra and Hanson, 1996b) and that the level of industry aggregation matters (Geishecker and Görg, 2005; Amiti and Wei, 2005b). This contribution answers both of them. Investigating if measurement differences may be one reason for achieving different empirical results, it turns out that fundamental differences exist between different International Outsourcing indices. While some of them achieve significant results on more aggregated industry levels, others significantly affect labor markets on more disaggregated industry levels. Shedding more light on measurement differences in combination with the aggregation bias, the comparative analysis in this paper reconciles different empirical findings.

The remainder of the paper is structured as follows. Section 2.2 investigates the design of commonly used International Outsourcing indices. They are formally defined and compared with respect to their theoretical compositions. In order to assess the descriptive properties of the indices, International Outsourcing is calculated for Germany within the period 1991-2000 in Section 2.3. Section 2.4 investigates the quality of the indices. Therefore, several shift-share analyses are applied examining whether the indices really capture International Outsourcing activities. Section 2.5 analyzes the performance of the different indices when they are used to estimate labor market adjustment effects. Based on data from the German Socio Economic Panel (GSOEP), several panel data estimations are applied regressing the within industries' wage differential on the different indices and control variables. Section 2.6 concludes by summarizing the major findings.

2.2 Design: First Theoretical Differences

In order to examine measurement differences, the paper considers four International Outsourcing indices very common in use: Imported Inputs in Total Imports (IITM), Imported Inputs in Total Inputs (IITI), Imported Inputs in Gross Output (IIGO), and Vertical Specialization (VS).³ This section investigates the design of the indices and thus, extracts first theoretical differences. Since some of them lack a concrete definition, they first get formally defined.

³All of these indices measure International Outsourcing at an aggregated industry level. They do not distinguish between outsourcing taking place within vertically integrated firms (e.g. multinationals) and International Outsourcing from foreign independent firms. In order to consider these differences it would be necessary to use intra-firm trade data. Since we follow a macroeconomic approach here, this contribution does not provide information on a disaggregated intra-firm level.

Imported Inputs in Total Imports (IITM):

$$IITM_t \equiv \frac{\sum_{j=1}^n \sum_{w=1}^z i_{wjt}}{\sum_{w=1}^z m_{wt}} \quad (2.1)$$

Imported Inputs in Total Inputs (IITI):

$$IITI_t \equiv \frac{\sum_{j=1}^n \sum_{w=1}^z i_{wjt}}{\sum_{j=1}^n \sum_{w=1}^z q_{wjt}} = \frac{\sum_{j=1}^n \sum_{w=1}^z i_{wjt}}{\sum_{j=1}^n \sum_{w=1}^z (i_{wjt} + d_{wjt})} \quad (2.2)$$

Imported Inputs in Gross Output (IIGO):

$$IIGO_t \equiv \frac{\sum_{j=1}^n \sum_{w=1}^z i_{wjt}}{\sum_{j=1}^n o_{jt}} \quad (2.3)$$

Vertical Specialization (VS):⁴

$$VS_t \equiv \sum_{j=1}^n \sum_{w=1}^z \frac{f_{wt} \cdot q_{wjt}}{p_{jt}} = \sum_{j=1}^n \sum_{w=1}^z \frac{m_{wt} \cdot q_{wjt}}{s_{wt} \cdot p_{jt}} \quad (2.4)$$

with i_{wjt} as imported inputs from industry w ($w = 1, \dots, z$) used to produce output in industry j ($j = 1, \dots, n$)⁵ at point of time t , d_{wjt} as domestic inputs of good w used in industry j , q_{wjt} as total inputs ($q = i + d$), m_{wt} as total imports of good w , s_{wt} as domestic

⁴“Vertical Specialization” is sometimes also used as a synonym for International Outsourcing. In this paper, however, it is used throughout to identify one specific index.

⁵It is important to note that we need two different subscripts for the imported intermediates w and the industry where the intermediates are used j . The number of imported intermediates z , however, is the same than the number of domestic industries n ($z = n$). But since this contribution examines only more general indices (not differentiating between which kind of inputs - low or high skill intensive ones - are outsourced), it is necessary to provide the possibility to differently aggregate these two numbers.

use of good w , $f_{wt} \equiv \frac{m_{wt}}{s_{wt}}$ as an estimator of the international component, o_j as gross output, and p_j as production value in industry j .⁶

The IITM index is used e.g. by Yeats (2001), Egger and Egger (2002), or Chen et al. (2005). While IITM-values are often calculated in order to present the magnitude, other indices are more often used to investigate the development of International Outsourcing. Equation (2.1) directly clarifies one problem arising with the IITM index: There is a lack of information on total imports m at the disaggregated industry level j . Imports at the disaggregated industry level j are typically classified as intermediate goods since they are used in industry j 's production. Total imports m , by contrast, additionally include i.a. goods for consumption and thus, can only be distinguished with respect to the imported good w but not with respect to the industries j where they are used as intermediates. This may lead to problems since the IITM relates imported inputs of good w used in industry j to total imports of good w , that are aggregated at the whole economy level. The problem gets magnified when calculating IITM for more disaggregated industry levels. However, all of the mentioned papers recently using the IITM index intuitively considered this problem and calculated the index only for one period t at more aggregated industry levels. Beside this problem, the IITM has also an important advantage over the other indices: It controls for general increases in trade flows. While relating imported inputs to total imports, the index directly focuses on what is specific to intermediate goods trade and thus, can be very welcome to address specific International Outsourcing issues.

The IITI index is used e.g. by Feenstra and Hanson (1996b), Amiti and Wei (2005a), Bardhan and Kroll (2003), or the European Economic Advisory Group (2005).⁷ In contrast to IITM, the IITI index relates imported inputs to total inputs, that are both within industry values. Thus, it is a very direct index of an industry's International Outsourcing activity, not characterized by the above mentioned problems.

A third measure of International Outsourcing is the index IIGO, e.g. used by Egger and Egger (2003) and Geishecker and Görg (2005). The index relates imported inputs to the output of an industry j . Since gross output o_{jt} is an aggregated value at the industry level per definition, there is no need to aggregate different input sources w . Like IITI, the IIGO index relates comparable within industry values. Additionally, it

⁶Even if there exist much more International Outsourcing indices, this contribution stops by investigating four of them. Thus, it presents by no means an exhaustive picture of all the International Outsourcing proxies. A wide range of other indices could also be analyzed. A comparison of these indices with inward or outward processing trade would also be of high interest.

⁷Since Feenstra and Hanson (1996b) and Amiti and Wei (2005a) 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.

controls for production changes of the respective industry. Since industry j 's gross output o is naturally bigger than the industry's total inputs q , the level of International Outsourcing measured with IIGO needs to be smaller than the level measured with IITI.

Another measure for International Outsourcing is the VS index. Campa and Goldberg (1997) present this index as imported inputs into production and Feenstra (1998) summarizes different tables from Campa and Goldberg (1997). Strauss-Kahn (2003) also uses the VS index.⁸ In contrast to the other indices described above, VS is not directly considering imported inputs in the numerator but estimates this value. Therefore, total inputs q_{wjt} are multiplied with an international estimation ratio f_{wt} , relating imported goods m_{wt} to domestically used goods s_{wt} . As imported and domestically used goods, the VS measure in the literature mostly considers final, intermediate as well as capital goods. Like IITI and IIGO, the VS index also compares within industry values. The goodness of the VS index depends on the international estimation ratio f . If the numerator turns out to be a good proxy for imported inputs, the VS index will lead to similar results than the IIGO index and can be assumed to measure International Outsourcing quite well. Since there is no need to directly observe imported intermediates, the calculation of VS does not depend on the availability of input-output tables. This feature makes the index broadly applicable.

2.3 Measurement: Analyzing Descriptive Properties

As the second step, this section investigates descriptive properties of the indices. Within a German case-study, the level as well as the development of International Outsourcing are calculated for several levels of industry aggregation.⁹ The calculations of the different indices base on input-output tables provided by the German Federal Statistical Office.¹⁰

⁸The index used by 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.

⁹Within the whole paper, different levels of industry aggregation are considered: 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. 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 I (p. 34).

¹⁰A lot of empirical papers calculate the indices with the use of input-output tables. 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 the industries abroad from which the inputs get imported and the industries in the home country that use the imported intermediates in production. Thus, they provide the possibility to exactly identify imported inputs at a disaggregated

Table 2.2: Magnitude of International Outsourcing in Germany (different years)

	IITM	IITI	IIGO	VS
<i>1991</i>				
Whole Economy	57%	16%	7%	7%
Manufacturing Industry	52%	24%	12%	11%
Low Skill Industries	61%	25%	13%	13%
High Skill Industries	46%	24%	11%	10%
Service Industry	146%	9%	3%	3%
<i>1995</i>				
Whole Economy	58%	15%	6%	6%
Manufacturing Industry	50%	24%	12%	12%
Low Skill Industries	57%	23%	12%	12%
High Skill Industries	46%	24%	11%	11%
Service Industry	144%	8%	3%	3%
<i>2000</i>				
Whole Economy	55%	19%	8%	9%
Manufacturing Industry	48%	29%	14%	15%
Low Skill Industries	56%	28%	14%	14%
High Skill Industries	44%	29%	14%	15%
Service Industry	133%	11%	4%	5%

Table 2.2 summarizes the magnitude of International Outsourcing in Germany for the years 1991, 1995 and 2000.¹¹ With up to 60 percent, the IITM index measures the highest levels of International Outsourcing in Germany. This confirms the findings of Yeats (2001) and, considering the design of the IITM index discussed in Section 2.2, is a special attribute of the IITM index not indicating an overall high level of International Outsourcing, but a high proportion of International Outsourcing in general trade flows. 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. All three indices exhibit similar between industry structures: As shown in Amiti and Wei (2005a) for the US and the UK, International Outsourcing in the German service industry is still at a low level.

To analyze the development of International Outsourcing in Germany, Table 2.3 presents the percentage change of the indices for different time periods.¹² The IITI, the IIGO, and the VS index show similar patterns of the development of International

industry level. To calculate the indices from input-output tables, the definitions presented in Section 2.2 have to be slightly rearranged into some matrix-algebra. The necessary formulas are presented in Appendix II (p. 35).

¹¹Since the values in the numerator and in the denominator of the indices refer to the same price level, the calculations automatically consider the change in prices.

¹²The development of the different indices is additionally depicted in several figures in Appendix III (p. 36). Since this analysis follows a macroeconomic approach, it only examines International Outsourcing for more aggregated industry levels. For a descriptive examination of the development of International Outsourcing activities in more disaggregated industries in Germany see e.g. Geishecker and Görg (2005).

Table 2.3: Development of International Outsourcing in Germany (1991 - 2000)

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

Outsourcing but, however, with important differences. Considering the whole period, the service industry in Germany is exposed to very high growth rates, also shown in Amiti and Wei (2005a) for the US and the UK. Another noticeable pattern is the stronger increase of International Outsourcing in high skill intensive compared to low skill intensive industries. The VS index generally shows a more volatile pattern of the development of International Outsourcing. While the indices more or less fluctuated in the first years (1991-1995), the big increase of International Outsourcing occurred in the second period (1995-2000). With respect to the IITM index, most of the industries show a decreasing pattern of International Outsourcing. This, however, cannot be interpreted as a decline in International Outsourcing activities. Moreover, it indicates that the fraction of International Outsourcing in general trade flows (measured as total imports) decreased and confirms the results provided by Chen et al. (2005): It is possible for the IITM to decrease even if the International Outsourcing activity of an industry increases.

2.4 Quality: Extracting the Driving Forces

This section investigates the quality of the different indices. With respect to the design of the indices it is possible that they indeed capture International Outsourcing activities but that there are 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, an index is forced to increase even though the outsourcing intensity of the industry has not changed or even declined. Thus, the increase of an index could be due to structural changes as well, what would be an objectionable attribute. Applying several shift-share analysis, the variance of an index is decomposed into one component capturing the International Outsourcing activities (the within component F_j) and another component capturing the structural changes of an industry (the between component θ_j). Therefore,

$$\Delta IO^z = \Delta \sum_{j=1}^n \theta_j F_j = \sum_{j=1}^n \bar{\theta}_j \Delta F_j + \sum_{j=1}^n \bar{F}_j \Delta \theta_j \quad (2.5)$$

is used with IO^z as the value of index z ($z = \text{IITM, IITI, IIGO, VS}$) and Δ indicating absolute changes.¹³ With a bar (denoting the statistical mean of the 1991 and the 2000 value) we fix one component to extract the intrinsic variation of the other component (that is allowed to adjust flexible). Thus, $\sum_{j=1}^n \bar{\theta}_j \Delta F_j$ captures the sole change in International Outsourcing activities while $\sum_{j=1}^n \bar{F}_j \Delta \theta_j$ solely captures structural changes. An index is assumed to be of high quality since the outsourcing-component mainly drives the total change of the index, or in other words, since the fraction of the outsourcing-component relative to the total change of the index is around 100 percent.¹⁴

The results of the shift-share analysis for the period 1991-2000 are summarized in Table 2.4. While the row “within” depicts the variation of the industry’s International Outsourcing activity ($\sum_{j=1}^n \bar{\theta}_j \Delta F_j$), the structural changes are shown in row “between” ($\sum_{j=1}^n \bar{F}_j \Delta \theta_j$). Row “total” presents the overall change of the index (ΔIO^z). The row of main interest “within / total” calculates the contribution of the change in real International Outsourcing activities to the total variation of the index and thus, is used as an indicator of the quality of an index (good quality if “within / total” \approx 100 percent). With respect to the IITM index, the “within / total” ratios are mostly far away from

¹³The 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 captures the variation of the industry’s International Outsourcing activity by focusing on imported inputs.

¹⁴As it depends on the definition of the “quality” of an International Outsourcing index, different quality-tests could be applied. It is e.g. possible to argue that the change of the structural component is also important for the quality of an International Outsourcing index and should thus affect the indices variation. However, several empirical contributions define the quality of an index as the sole change in International Outsourcing activities and provide these kind of shift-share analysis as a framework for quality checks (e.g. Hummels et al., 2001; Strauss-Kahn, 2003). To be in line with the main International Outsourcing literature, this contribution follows their framework and adopts the same definition of quality.

Table 2.4: Outsourcing vs. Industry Structure (1991-2000)

	IITM	IITI	IIGO	VS
	<i>Whole Economy</i>			
Within	-0.0078	0.0378	0.0149	0.0214
Between	-0.0077	-0.0058	-0.0022	-0.0022
Total	-0.0154	0.0320	0.0127	0.0193
Within / Total	50%	118%	117%	111%
	<i>Manufacturing Industry</i>			
Within	-0.0241	0.0533	0.0212	0.0326
Between	-0.0126	-0.0058	0.0002	0.0004
Total	-0.0367	0.0475	0.0214	0.0330
Within / Total	66%	112%	99%	99%
	<i>High Skill Industries</i>			
Within	0.0016	0.0571	0.0257	0.0463
Between	-0.0195	-0.0009	0.0016	0.0024
Total	-0.0179	0.0562	0.0273	0.0487
Within / Total	-9%	102%	94%	95%
	<i>Low Skill Industries</i>			
Within	-0.0720	0.0475	0.0138	0.0100
Between	0.0287	-0.0124	-0.0001	-0.0018
Total	-0.0433	0.0351	0.0137	0.0082
Within / Total	166%	135%	101%	122%
	<i>Service Industry</i>			
Within	0.0957	0.0241	0.0106	0.0137
Between	-0.1666	0.0012	-0.0008	-0.0009
Total	-0.0709	0.0252	0.0098	0.0129
Within / Total	-135%	95%	108%	107%

the aspired 100 percent. This indicates that the bulk of the change in IITM is driven by structural changes, in this particular case the change in general trade flows. Thus, according to the quality definition in this contribution, this result indicates that the IITM is an International Outsourcing index of lower quality. However, the information achieved, that International Outsourcing declined with respect to general trade flows, is quite important for empirical research. The three indices IITI, IIGO and VS are of very high quality. 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, the difference from the 100 percent benchmark is slightly bigger for IITI. With results in a “within / total” share mostly above 100 percent, the IITI index slightly underestimates International Outsourcing activities. With “within / total” ratios smooth by the 100 percent margin, the VS and the IIGO index measure International Outsourcing activities very directly. Thus, as mentioned in Section 2.2, the international estimation ratio of the VS index is quite good and it turns out that the numerator is a good proxy for imported inputs.

2.5 Performance: Estimating Adjustment Effects

In order to investigate the importance of measurement differences for estimating labor market adjustment effects, several panel data analyses are applied in this section. How-

ever, before entering the econometrics, the expected effects of International Outsourcing on the wage differential are discussed from a theoretical point of view.

Among the various theoretical contributions on how International Outsourcing affects domestic labor markets, few of them are well known and regarded as milestones in the economic literature. Feenstra and Hanson (1996a,b) e.g. provide a framework, where in industrialized economies, International Outsourcing induces additional forces toward labor market disruptions. Within a one-sector model, the developed economy relocates its relative low skill intensive production fragment abroad, typically to a less developed economy. This decreases the relative demand for low skilled labor and induces an upward pressure on relative high skilled wages. These effects are known as the so-called factor bias of International Outsourcing. However, results differ when considering more disaggregated industry levels. As Arndt (1997, 1998a,b) shows, a sector bias is at force, leading to different labor market effects if International Outsourcing takes place in different industries. If the relative high skill intensive industry outsources parts of the production chain, production costs decrease, enabling a wage premium for the high skilled. By contrast, if International Outsourcing takes place in the relative low skill intensive industry, the wage markup flows to the low skilled. By contrast to the factor bias of International Outsourcing, the sector bias allows situations where, even in industrialized economies, low skilled labor can benefit from International Outsourcing activities. Recently, several theoretical contributions emerged highlighting different aspects of International Outsourcing effects. Deardorff (2001a,b) e.g. examines the importance of the relative factor intensity of the outsourced production blocks. Egger and Falkinger (2003) consider different equilibrium situations in order to determine the dominance of the factor or the sector bias of International Outsourcing. Ethier (2005) focus on intra-sectoral relations between inputs in order to investigate various main globalization issues, among those i.a. the implications of International Outsourcing on the high skilled wage premium. Egger and Kreickemeier (2008) examine the coexistence of wage inequality and unemployment within a fairness approach to efficiency wages, introduced into a standard International Outsourcing model.¹⁵ Theoretical discussion of labor market effects for less developed economies is, by contrast, rather short.¹⁶

¹⁵Several other valuable theoretical investigations are jointly published within a special issue of the *International Review of Economics and Finance*, 2005, Vol. 14 (3).

¹⁶Feenstra and Hanson (1996a) e.g. show that relative wages of the high skilled also increase in the less developed economy, since the insourced production block is relative high skill intensive from their point of view. By contrast, Deardorff (2001a,b) shows within a Ricardo framework, and Kohler (2001) within a Ricardo-Viner framework, that the wage effects of International Outsourcing on less developed economies may also emerge in opposite direction. However, since the empirical examination focus on

With the empirical analysis below, the paper investigates the effects of International Outsourcing on the wage differential in Germany from 1991-2000, focusing on a comparison of the different results achieved with the use of the different International Outsourcing indices.

Data

The econometric analysis uses data from the German Socio Economic Panel (covering the years 1984-2006) and from input-output tables provided by the Federal Statistical Office in Germany (covering the years 1991-2000). The input-output tables are used to calculate the International Outsourcing indices as well as the output of each industry (according to the two-digit NACE classification). To estimate labor market effects, the wage differential per industry is used as endogenous variable (calculated from the GSOEP waves *H/8* to *Q/17*, 1991-2000). The GSOEP 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 GSOEP data assigns each individual to the two-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 information on the desired aggregation level.¹⁷ To aggregate the individual wages, the mean average within each two-digit NACE industry is calculated, separated for high and low skilled labor.¹⁸ As additional control variable, the high skilled labor utilization per industry is calculated relating high skilled labor *H* to total employment *E*.¹⁹ These variables: the mean wage of high as well as low skilled labor, the output of each industry, the industry's high skilled labor utilization, and the International Outsourcing activity proxied by one of the four indices, are used to examine the importance of measurement differences in the econometric panel data analysis below.

wage effects in an industrialized economy (Germany), these issues are not deepened further.

¹⁷The "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.

¹⁸In line with the ISCED, low skilled 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.

¹⁹For detailed information about the structure and the different variables of the GSOEP see Haisken-DeNew and Frick (2005).

Estimation and Results

In order to investigate labor market effects of International Outsourcing

$$\ln WD_{jt} = \beta_0 + \beta_1 IO_{jt}^z + \beta_2 Y_{jt} + \beta_3 \frac{H_{jt}}{E_{jt}} + u_j + \epsilon_{jt} \quad (2.6)$$

is estimated with WD_{jt} as the wage differential between high and low skilled workers in industry j at time t . The variable of interest is the International Outsourcing activity IO_{jt}^z measured with index z ($z = \text{IITM, IITI, IIGO, VS}$). As control variables, the output of each industry Y_{jt} and the high skilled labor utilization H_{jt}/E_{jt} are 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} . The equation is estimated for the different levels of industry aggregation using the fixed-effects (FE) panel data estimator.²⁰ Since the level of International Outsourcing, the output, and the high skilled labor utilization are expected to vary over the industries and thus, the explanatory variables to be correlated with the industry-level effect u_j , the FE estimator should be used from an economic point of view. However, the Breusch and Pagan test for unobserved heterogeneity as well as the Hausman test are applied to confirm the use of the FE estimator statistically. Highly significant results show unobserved heterogeneity in nearly all the models and, in order to consider heterogeneity, suggest the use of the FE estimator. Additional tests for consistency of the estimated error terms, the modified Wald test for groupwise heteroscedasticity as well as the Wooldridge (2002) test for autocorrelation show that the error terms of some models are characterized by a heteroscedastic error structure as well as autocorrelation. To solve for these problems, to consider possible outliers, and to assure the consistency as well as the comparability of the estimation results, the variances of all the models are estimated using the Huber / White / Sandwich estimator instead of the traditional calculation. While regressing the wage-differential on contemporaneous outsourcing, an interdependent relation could be assumed leading to an endogeneity problem. Thus, several Durbin-Wu-Hausman tests are additionally applied to test whether possible endogeneity could significantly affect the consistency of the estimated coefficients. In most of the regressions, endogeneity does not bias the estimation results. However, in some cases where the test

²⁰This form of industry fixed-effects follows several similar investigations in generally controlling for industry specific characteristics. Due to the special focus on Germany, additionally controlling for union membership of the industries would be of interest. However, due to data constraints, we are not able to adequately perform this exercise here.

Table 2.5: Effects of International Outsourcing on the wage gap (1)

	Whole Economy			
	Model 1.1 (IITM)	Model 1.2 (IITI)	Model 1.3 (IIGO)	Model 1.4 (VS)
IO	0.0801** (2.18)	-0.3303 (-0.16)	9.6474* (1.68)	2.3199 (0.45)
Y	6.56e-06** (2.22)	6.92e-06** (2.36)	5.06e-06* (1.78)	5.95e-06* (1.78)
H/E	0.5289 (0.47)	0.9310 (0.83)	0.4951 (0.44)	0.7299 (0.63)
Observations	341	382	384	384
Groups	42	47	48	48
R ²	0.0247	0.0234	0.0343	0.0248
Prob > F	0.0037	0.0064	0.0012	0.0043

(t-Statistics in parentheses)
* / ** / *** significant at 10 / 5 / 1 percent

showed that endogeneity significantly affects consistency, the lagged versions of the International Outsourcing indices (indicated by “_l”) are used as instruments to avoid possible endogeneity problems.

Table 2.5 presents the estimation results of the industries’ wage differential for the aggregated whole economy. As the table shows, when estimating International Outsourcing effects for the aggregate, only some indices yield significant results. International Outsourcing measured with IITM increases the wage differential only marginally, however, significant at the 5 percent margin. When using the IIGO index, effects are much stronger and also statistically significant at a level of 10 percent. When using the other two indices IITI or VS, only insignificant results can be obtained, additionally varying in tendency. The R-squares of the FE-estimator are still at a quite low level. However, in panel data analysis the R-squares do not have the OLS-properties and thus, should be handled with care and not be used to assess the main gauge for success.²¹ Thus, the table additionally presents the F-values that are for all models significant at least at the 1 percent level and indicate that the models are fitted well. As these results show, International Outsourcing increases the wage gap between high and low skilled labor on the aggregated whole economy level. However, only significant with the IIGO and the IITM index.

The next series of panel data estimations investigate the effects of International Outsourcing on the wage gap for the manufacturing sector and the service industry. Table 2.6 presents the results. In the manufacturing industry, the IITI index (lagged

²¹The 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. Additional estimations with feasible GLS (not presented here) strongly increase the R-squares in nearly all of the models. However, since heteroscedasticity and autocorrelation varies with the models, the results of the robust FE estimation are presented to guarantee consistency and comparability of the results achieved with the different indices.

Table 2.6: Effects of International Outsourcing on the wage gap (2)

	Manufacturing Industry			
	Model 2.1 (IITM)	Model 2.2 (IITL1)	Model 2.3 (IIGO)	Model 2.4 (VS_1)
IO	0.3822 (0.55)	-7.0802** (-2.11)	-1.4436 (-0.18)	-8.3190 (-1.11)
Y	7.81e-06** (2.18)	11.10e-06** (2.49)	8.15e-06* (1.89)	13.50e-06*** (2.60)
H/E	0.4832 (0.32)	0.4265 (0.30)	0.5089 (0.33)	-0.2537 (-0.16)
Observations	172	159	172	159
Groups	20	20	20	20
R ²	0.0250	0.1351	0.0242	0.0670
Prob > F	0.0202	0.0150	0.0223	0.0306
	Service Industry			
	Model 3.1 (IITM)	Model 3.2 (IITI)	Model 3.3 (IIGO)	Model 3.4 (VS)
IO	0.0789** (2.08)	4.7660 (1.50)	16.3192* (1.75)	7.3991 (1.14)
Y	5.43e-06 (1.11)	4.66e-06 (1.17)	3.61e-06 (0.92)	4.44e-06 (1.01)
H/E	0.6958 (0.39)	0.8552 (0.51)	1.1565 (0.71)	1.2964 (0.79)
Observations	149	189	191	191
Groups	18	22	23	23
R ²	0.0312	0.0488	0.0570	0.0356
Prob > F	0.0834	0.0448	0.0232	0.0287

(t-Statistics in parentheses)

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

by one period due to a possible endogeneity problem) shows a significant decrease of the wage dispersion. However, the results of the other three indices are not within a common level of significance and additionally vary in tendency. These results are in line with Geishecker and Görg (2005), showing also insignificant effects of International Outsourcing (measured with IIGO) on wages in the German manufacturing industry. In the service industry, by contrast, a different picture emerges. As in the aggregate the wage gap increases with International Outsourcing, however, statistically significant only for IIGO and IITM. The effects measured with IITI or VS are insignificant. Thus, also in the service sector, results depend strongly on measurement differences. These measurement differences may be one explanation for the insignificant effects achieved by Amiti and Wei (2005a) for the UK and the US (using the IITI index).

In the next step, the effects of International Outsourcing are estimated on a more disaggregated industry level, differentiating between high skill intensive and low skill intensive industries of the manufacturing sector. Table 2.7 presents the results. With different results of International Outsourcing effects in high skill intensive compared to low skilled intensive industries, the table highlights the sector bias of International Outsourcing described above (see Arndt, 1997, 1998a,b). While International Outsourcing increases the wage gap in the high skill intensive industries, it reduces the differential between high and low skilled wages if it takes place in low skill intensive industries.

Table 2.7: Effects of International Outsourcing on the wage gap (3)

	High Skill Industries			
	Model 4.1 (IITM)	Model 4.2 (IITI)	Model 4.3 (IIGO)	Model 4.4 (VS)
IO	0.1708 (0.37)	1.3875 (0.67)	11.2765* (1.83)	16.6594** (2.36)
Y	1.70e-06 (0.53)	1.18e-06 (0.43)	-8.75e-07 (-0.30)	-6.69e-06* (-1.94)
H/E	4.9866*** (3.25)	4.6888*** (2.80)	4.3760*** (2.65)	2.6455 (1.44)
Observations	86	86	86	86
Groups	10	10	10	10
R ²	0.2065	0.2092	0.2296	0.2861
Prob > F	0.0001	0.0001	0.0000	0.0001
	Low Skill Industries			
	Model 5.1 (IITM)	Model 5.2 (IITI_1)	Model 5.3 (IIGO_1)	Model 5.4 (VS_1)
IO	1.1979 (0.55)	-12.8543*** (-3.77)	-43.3709*** (-3.02)	-24.5521*** (-5.21)
Y	0.0000 (0.96)	0.0000** (2.35)	0.0000** (2.21)	-0.0001*** (2.65)
H / E	-5.9149** (-2.37)	-3.3477* (-1.80)	-4.9598*** (-2.64)	-4.5374** (-2.36)
Observations	86	80	80	80
Groups	10	10	10	10
R ²	0.0938	0.4528	0.3206	0.4084
Prob > F	0.0870	0.0012	0.0118	0.0000

(t-Statistics in parantheses)

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

On these more disaggregated industry levels, the VS index turns out to achieve highly significant results. With respect to the high skill intensive industries, the IIGO and the VS index show significant results, while for the low skill intensive industries, all indices except the IITM find a significant pattern. The overall fit of the models increases dramatically. With R-squares up to 45 percent, there is a huge amount of the variance explained by the models.

As these results show, measurement differences combined with an aggregation bias are of high importance when estimating labor market effects of International Outsourcing. While the IIGO index achieves significant estimation results for most of the aggregation levels, the VS index significantly confirms the importance of International Outsourcing on more disaggregated industry levels. The IITM index shows the tendency to achieve significant results on more aggregated levels. The IITI index, by contrast, leads to significant effects of International Outsourcing on the wage differential in the manufacturing industry.

Considering these findings, different empirical results can be reconciled. For the German manufacturing sector, labor market effects of International Outsourcing are mostly insignificant. This explains the pattern achieved in Geishecker and Görg (2005). With the VS index achieving significant results for more disaggregated industry levels, the index has advantages to highlight the sector bias of International Outsourcing. The

insignificant results of the IITI index for the aggregated service sector may explain the results achieved in Amiti and Wei (2005a) and the overall low amount of contributions providing significant effects for the service industry. By contrast, the significant results of IITI for the manufacturing level can explain the results achieved in Feenstra and Hanson (1996b).²²

2.6 Conclusions

The results of empirical contributions investigating labor market effects of International Outsourcing differ strongly. While some of them significantly support the importance of International Outsourcing to explain changes on the labor market, others yield only insignificant effects. The different results depend on different empirical situations, however, the use of different indices to proxy International Outsourcing activities adds to the puzzle. This paper examines the importance of measurement differences for empirical contributions investigating International Outsourcing effects.

As it turns out, measurement differences may be the reason for the different empirical results. An aggregation bias emerges showing that the performance of different indices strongly depends on the level of industry aggregation. While the IITM index achieves significant results for more aggregated industry levels, the VS index supports significant effects of International Outsourcing within more disaggregated industry levels. The IIGO index, by contrast, shows significant effects for aggregated as well as disaggregated industry levels, while the IITI index confirms the importance of International Outsourcing for affecting the wage differential in the manufacturing industry. While the IITI, the IIGO, and the VS index are very capable of capturing International Outsourcing activities, difficulties with respect to the theoretical design arise for the IITM index. Thus, the IITM also shows a lower quality in emphasizing intrinsic International Outsourcing activities. On the other hand, as IITM measures the fraction of International Outsourcing in general trade flows, the index can be of high interest when examining this special issue.

²²Two very interesting questions of how International Outsourcing affects the wage differential are beyond the scope of this contribution. (i) Effects should differ if an industry relocates the manufacture or the service parts of its production process. This paper, however, does not distinguish between the skill intensity of the inputs procured from abroad. To extent the analysis in this respect would exceed the space available when keeping the focus on comparing the results of different indices. However, to pick out one index and to follow this approach is part of the manuscript presented in Chapter 4. (ii) Another very interesting topic is the consideration of different outsourcing destinations. Different effects could occur if the industry procures its intermediate inputs from a developed or a less developed country. However, since the domestic industry data does not provide bilateral information, this topic can not be addressed here.

Considering these measurement differences in combination with the aggregation bias, several empirical results can be reconciled. While the high levels of International Outsourcing presented in Yeats (2001) depend on the use of the IITM index, the use of IITI may explain the insignificant effects of International Outsourcing in the aggregated service sector shown in Amiti and Wei (2005a) and the significant effects of International Outsourcing for the manufacturing industry in Feenstra and Hanson (1996b). By contrast, the insignificant effects of International Outsourcing within the German manufacturing sector achieved with IIGO and the significant effects with the same index when analyzing more disaggregated industry levels are in line with Geishecker and Görg (2005).

Appendix I: Differentiating between High and Low Skill Intensive Industries

To separate the industries of the German 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 2.8 presents the classification result on the two-digit NACE aggregation level.

Table 2.8: Classification of high and low skill intensive 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
	Pulp, 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 II: Matrix Algebra to Calculate the Indices

To calculate the different International Outsourcing indices from input-output tables, the equations shown in Section 2.2 have to be transferred into some matrix algebra. The necessary formulas are presented in this appendix.

For the *IITM* index use:

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

for *IITI*:

$$IITI_t = u' i [u' x]^{-1} = u' i [u' (i + d)]^{-1}$$

for the *IIGO* index use:

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

with i as the $n \times 1$ vector of inputs imported by industries j , m as the $z \times 1$ vector of total imports of commodities w ($n = z$), d as the $n \times 1$ vector of total inputs used by industries j , the $n \times 1$ vector of total inputs of industries j can be calculated by $x = i + d$, o as the $n \times 1$ vector of gross output of the industries j , and u as an $n \times 1$ vector of 1's.

To obtain the *VS* index from input-output tables,

$$VS_t = (diag(p^{-1})) [diag[diag(m)(s^{-1})] Q]'$$

can be used, with m as the $z \times 1$ vector of imports, s as the $z \times 1$ vector of domestically used goods, Q as the $z \times n$ matrix of all inputs (domestically produced as well as imported) and p as 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 $w = 1, \dots, z$ goods.

Appendix III: Development of the Different International Outsourcing Indices

Figures 2.1 - 2.4 illustrate the development of the different indices for Germany between 1991-2000. The main results are that International Outsourcing fluctuated slightly from 1991 - 1995 and increased strongly from 1995 - 2000. The increase is most pronounced in the service industry and the high skill intensive industries of the manufacturing sector.

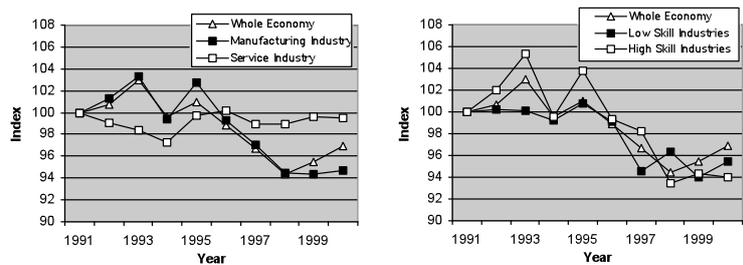


Figure 2.1: Imported Inputs in Total Imports, IITM (Germany, 1991-2000)

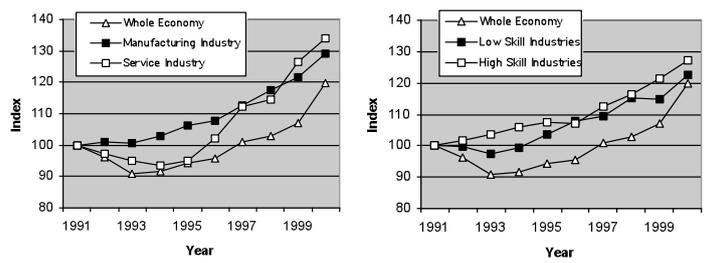


Figure 2.2: Imported Inputs in Total Inputs, IITI (Germany, 1991-2000)

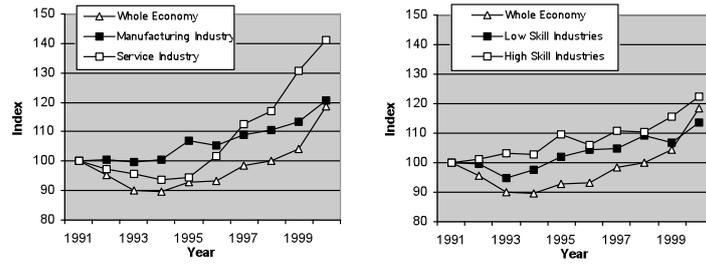


Figure 2.3: Imported Inputs in Gross Output, IIGO (Germany, 1991-2000)

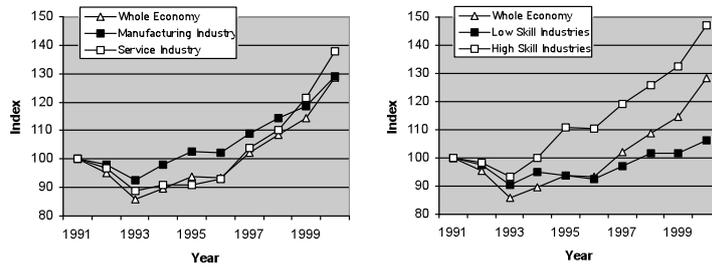


Figure 2.4: Vertical Specialization, VS (Germany, 1991-2000)

Chapter 3

The Elasticity of Substitution and the Sector Bias of International Outsourcing: Solving the Puzzle

Abstract

Considering the sector bias of International Outsourcing within a 2×2 framework, four different scenarios appear. Each industry can either relocate its high or its low skill intensive production fragment. Traditionally, depending on the superiority of a wage vs. an outsourcing-effect, general equilibrium effects of two scenarios are assumed to be ambiguous. Applying a formal duality approach and a calibration exercise for the German economy, this contribution shows that a focus on the elasticity of substitution can solve the puzzle. With the elasticity exceeding a critical value, unambiguous results in all four scenarios appear, supporting the sector bias of International Outsourcing.

JEL classification: F16; F41; E25

Keywords: International Outsourcing; sector bias; elasticity of substitution

3.1 Introduction

Since several years, effects of International Outsourcing are an important issue in economic research and political discussion as well. Grossman and Helpman (2005) recently mentioned that “we live in an age of outsourcing” (p. 135). In industrialized economies, concerns arise on possibly induced labor market disruptions, harming low skilled labor. These concerns base on the so-called factor bias of International Outsourcing, first stressed by Feenstra and Hanson (1996a,b). As Feenstra and Hanson show within a one-sector model, International Outsourcing in industrialized economies decreases relative demand of low skilled labor, if it is the relative low skill intensive production block that gets relocated. Thus, the relative wage of high skilled labor increases. As a consequence, International Outsourcing is seen as beneficial for the high skilled and harmful for low skilled labor, inducing welfare reducing effects in general equilibrium.

However, results differ when extending this one-sector model to more industries and thus, when moving the focus toward more disaggregated industry levels. As Arndt (1997, 1998a,b) shows, different effects occur depending on the relative skill intensity of the industry realizing outsourcing activities. Generally, International Outsourcing decreases production costs of the respective industry and thus, enables a wage premium if the economy faces given world prices. If International Outsourcing takes place in the relative high skill intensive industry, high skilled labor receives this wage markup. On the other hand, if International Outsourcing takes place in the relative low skill intensive industry, low skilled labor benefits in receiving the wage premium. In general equilibrium, the outsourcing industry increases output in tandem with employment. As these results show, low skilled labor can benefit from International Outsourcing even in industrialized economies, if it takes place in the relative low skill intensive industry. Thus, Arndt (1997) concludes that “concerns about the welfare-reducing implications of offshore sourcing appear to be greatly exaggerated” (p. 77).

More recently, a huge amount of theoretical contributions emerged extending these models in order to investigate different aspects of International Outsourcing effects. To mention just a view of them, Deardorff (2001a,b) illuminates the importance of the relative factor intensity of the relocated production blocks. Egger and Falkinger (2003) consider different modes of final goods production and examine several different equilibrium situations in order to determine the dominance of the factor or the sector bias of International Outsourcing. Kohler (2003) also examines distributional effects of International Outsourcing. Allowing for an arbitrary number of goods, factors, and

Table 3.1: Sector Bias of International Outsourcing (overview)

scenario	low skill int. industry		high skill int. industry	
	low skill part	high skill part	low skill part	high skill part
relative wages of the high skilled	↓	↓	↑	↑
relative labor unit requirements of the high skilled	↑	?	?	↓
output	high skill int. industry ↓	?	?	high skill int. industry ↑
	low skill int. industry ↑	?	?	low skill int. industry ↓
employment	high skill int. industry ↓	?	?	high skill int. industry ↑
	low skill int. industry ↑	?	?	low skill int. industry ↓

fragments, he presents a “general principle which is at force” (p. 91) and provides the possibility of different parameter settings to achieve several well known outsourcing results, i.a. those of Feenstra and Hanson as well as Arndt. Burda and Dluhosch (2002) investigate International Outsourcing within an increasing returns to scale framework to focus more on determinants arising with monopolistic competition.

Examining the sector bias of International Outsourcing as presented in Arndt (1997, 1998a,b) in greater detail, four different scenarios appear: International Outsourcing can occur in the relative low skill intensive industry by relocating either its low or its high skill intensive production fragment. The relative high skill intensive industry can also relocate either its low or its high skill intensive production block. In general equilibrium, each of these International Outsourcing scenarios induces effects on relative wages, relative labor unit requirements, output, as well as employment. As Arndt carefully figured out, with respect to the effects on relative wages, results of all four scenarios are unambiguous. However, concerning the effects on relative labor unit requirements, results become ambiguous in two of the four cases. Consequently, effects on output as well as employment are also not clear-cut in these two ambiguous cases. Table 3.1 summarizes the general equilibrium effects of the sector bias of International Outsourcing, highlighting the two ambiguous scenarios.

As the table shows, relative wages of the high skilled increase if International Outsourcing takes place in the relative high skill intensive industry. This effect occurs either if the industry relocates its high or its low skill intensive production fragment.

Table 3.2: Magnitude and development of International Outsourcing in Germany

scenario	low skill int. industries		high skill int. industries	
	low skill parts	high skill parts	low skill parts	high skill parts
1991	6%	3%	2%	8%
1995	6%	3%	2%	9%
2000	6%	4%	2%	12%
1991 – 2000	7%	38%	0%	59%

By contrast, International Outsourcing decreases the relative wage of the high skilled if it takes place in the relative low skill intensive industry. As in the relative high skill intensive industry, this effect occurs either if the industry relocates its high or its low skill intensive production block. The effects on relative wages induce skill shifts in both industries and thus, affect relative labor unit requirements. Thereby, however, two of the four International Outsourcing scenarios yield only ambiguous results (International Outsourcing of the high skill intensive production block in the relative low skill intensive industry and International Outsourcing taking place in the relative high skill intensive industry by relocating its low skill intensive fragment). In general equilibrium, these ambiguity seeps through to the effects on output as well as employment. Thus, general equilibrium effects of the sector bias of International Outsourcing are only determined exhaustively in two of the four possible scenarios, the relative low skill intensive industry relocating its low skill intensive production part and the relative high skill intensive industry its high skill intensive one.

In order to investigate the empirical importance of the four different scenarios, the magnitude and development of International Outsourcing are calculated for Germany. The results are presented in Table 3.2.¹

As the numbers show, International Outsourcing activities in the two ambiguous cases are by no means less important than in the other ones. Considering the relative low skill intensive industries, International Outsourcing of the high skill intensive parts is in average about one half (1991 and 1995) or two third (2000) of the average of relocating the low skill intensive production blocks. Considering the development of International Outsourcing, this scenario is even more important with an increasing rate of around 38 percent. Thus, the two ambiguous scenarios seem to be of high empirical relevance for an overall examination of International Outsourcing activities.

¹The results base on input-output tables provided by the Federal Statistical Office in Germany and are calculated using the Vertical Specialization index, an index often used to proxy International Outsourcing activities. The index relates imported intermediates (estimated) to the output of an industry. For a detailed investigation of the VS index, compared to several other International Outsourcing indices, see Chapter 2.

Since there is a lack in theoretical research investigating general equilibrium effects of these two important International Outsourcing scenarios in an exhaustive manner this contribution tries to fill the gap.

Applying a formal model of general equilibrium effects of International Outsourcing and a calibration exercise for the German economy, the paper shows that results depend strongly on the elasticity of substitution between low and high skilled labor. As it turns out, if the elasticities exceed a critical value, effects are no longer ambiguous and support the sector bias of International Outsourcing: An increase of International Outsourcing in the relative low skill intensive industry unambiguously reduces the relative wage of the high skilled and increases their relative labor unit requirements. As the outsourcing industry gets more productive on world markets, output as well as employment of this industry increase. These effects occur either if the industry relocates its low or its high skill intensive production fragment. Results are similar with the opposite direction when International Outsourcing takes place in the relative high skill intensive industry.

The remainder of the chapter is structured as follows. Section 3.2 discusses the model set up. The framework builds on the modern duality approach to general equilibrium and follows the line of international trade contributions like Uzawa (1964), Diewert (1971, 1974), Woodland (1977), and Mussa (1979). International Outsourcing is introduced similar to skill biased technical progress as in Jones (1965). Section 3.3 examines general equilibrium effects of the four International Outsourcing scenarios, moving the focus especially on the importance of the elasticity of substitution. As the elasticities exceed a critical value, effects on relative labor unit requirements are no longer ambiguous and mainly driven by the relative skill intensity of the industry fragmenting production. However, since effects on output and employment are only clear-cut with the assumption of Cobb Douglas elasticities, Section 3.4 calibrates the model for a wider range of elasticities using data for the German economy in 2005. Section 3.5 concludes by summarizing the major findings.

3.2 Model Set Up

In order to investigate general equilibrium effects of International Outsourcing, the paper uses the modern duality approach, based on Shephard's Lemma, and follows the line of international trade contributions as Uzawa (1964), Diewert (1971, 1974), Woodland (1977), or Mussa (1979). The duality approach in international trade formulates equilibrium conditions in terms of unit cost functions rather than production functions

and minimizes these unit costs in a factor price space.²

Assume an economy that faces given world prices p with two industries, a relative high skill intensive (X) and a relative low skill intensive one (Y).³ Both industries use two primary inputs, low skilled labor (L) and high skilled labor (H) to produce goods of quantity q_i (with $i = X, Y$). Factors are mobile between industries, but internationally immobile. The home economy faces an inelastic supply of factors (\bar{L}, \bar{H}) and remains incompletely specialized ($q_i > 0$) throughout the process. Thus, with goods as well as factor markets perfectly competitive, we achieve

$$c_Y = a_{YL}w_L + a_{YH}w_H = 1 \quad (3.1)$$

$$c_X = a_{XL}w_L + a_{XH}w_H = p \quad (3.2)$$

with c_i as unit costs per industry equaling the price, a_{ij} as unit factor requirements ($j = L, H$), w_j as factor prices and the price of the low skill intensive good (Y) as numeraire. The unit cost functions are positive and linearly homogeneous. According to Shephard's Lemma we can partially differentiate the unit cost functions to solve for the cost minimizing labor unit requirements

$$a_{YL} = \frac{\partial c_Y(w_L, w_H)}{\partial w_L} \quad (3.3)$$

$$a_{YH} = \frac{\partial c_Y(w_L, w_H)}{\partial w_H} \quad (3.4)$$

$$a_{XL} = \frac{\partial c_X(w_L, w_H)}{\partial w_L} \quad (3.5)$$

$$a_{XH} = \frac{\partial c_X(w_L, w_H)}{\partial w_H} \quad (3.6)$$

Considering flexible wages, each factor is either employed in the X or in the Y industry. Thus, we achieve

²Traditional trade theory, by contrast, analyzes equilibrium conditions within a quantity space as introduced by Lerner (1932) and made popular by Chipman (1966). The reason for choosing the duality approach in this paper belongs to several advantages with respect to Shephard's Lemma that will be explained below.

³While assuming that the economy's trade flows do not affect the price ($\hat{p} = 0$) and the price elasticity of demand being unity ($\sigma^D = 1$), we assure that the world market is able to absorb changes in demand. Thus, while setting the focus on the supply side, we are able to abstract from price changes and their effects on the production structure of the two industries.

$$\bar{L} = a_{YL}q_Y + a_{XL}q_X \quad (3.7)$$

$$\bar{H} = a_{YH}q_Y + a_{XH}q_X \quad (3.8)$$

as the labor market clearing conditions and have a system of eight endogenous variables (w_H , w_L , a_{XL} , a_{XH} , a_{YL} , a_{YH} , q_X , and q_Y) in eight equations (3.1) - (3.8) that exactly determine the model.

To introduce International Outsourcing, we define φ_{ij} as the International Outsourcing parameter, similar to skill biased technical change as in Jones (1965). Since International Outsourcing is assumed to reduce labor unit requirements, the percentage change $\hat{\varphi}_{ij} \equiv -\frac{1}{a_{ij}(\partial a_{ij}/\partial IO)}$ shows the alteration in a_{ij} due to International Outsourcing (IO) that would take place at constant wages. Thus, we have to rewrite the unit cost functions (3.1) and (3.2) into

$$c_Y(\vec{w}_L, \vec{w}_H) = \vec{a}_{YL}\vec{w}_L + \vec{a}_{YH}\vec{w}_H \quad (3.9)$$

$$c_X(\vec{w}_L, \vec{w}_H) = \vec{a}_{XL}\vec{w}_L + \vec{a}_{XH}\vec{w}_H \quad (3.10)$$

with $\vec{w}_j \equiv \frac{w_j}{\varphi_{ij}}$ and $\vec{a}_{ij} \equiv \varphi_{ij}a_{ij}$ as wages and labor unit requirements considering International Outsourcing activities.⁴

3.3 General Equilibrium Effects of International Outsourcing

To investigate general equilibrium effects of International Outsourcing, this section first examines the change in relative wages. Afterward, the effects on relative labor unit requirements, output as well as employment are considered.⁵

⁴In order to focus on the effects of International Outsourcing, and to keep the model traceable, determinants of International Outsourcing are not considered explicitly. In this form, International Outsourcing is an exogenous process reducing labor unit requirements. Since the focus is on the ambiguous scenarios as presented in Arndt (1997, 1998a,b), the way of formally modeling International Outsourcing here is the same way as Arndt illustrates the sector bias graphically.

⁵All calculations of this paper are presented in greater detail in the Appendix (p. 62).

Relative Wages

In order to minimize costs, we totally differentiate the unit cost functions (3.9) and (3.10) and achieve

$$\theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H = \theta_{YL}\hat{\phi}_{YL} + \theta_{YH}\hat{\phi}_{YH} \quad (3.11)$$

$$\theta_{XL}\hat{w}_L + \theta_{XH}\hat{w}_H = \theta_{XL}\hat{\phi}_{XL} + \theta_{XH}\hat{\phi}_{XH} \quad (3.12)$$

as equilibrium production costs in both industries with factor income shares $\theta_{ij} \equiv \frac{a_{ij}w_j}{p_i}$ and “hat” denoting percentage changes. Equation (3.11) and (3.12) directly distinguish between the four different International Outsourcing scenarios already mentioned in the introduction:

- (i) International Outsourcing of the low skill intensive production part in the relative low skill intensive industry ($\hat{\phi}_{YL} > 0$ whereas $\hat{\phi}_{YH} = \hat{\phi}_{XL} = \hat{\phi}_{XH} = 0$)
- (ii) International Outsourcing of the high skill intensive production part in the relative low skill intensive industry ($\hat{\phi}_{YH} > 0$ whereas $\hat{\phi}_{YL} = \hat{\phi}_{XL} = \hat{\phi}_{XH} = 0$)
- (iii) International Outsourcing of the low skill intensive production part in the relative high skill intensive industry ($\hat{\phi}_{XL} > 0$ whereas $\hat{\phi}_{YL} = \hat{\phi}_{YH} = \hat{\phi}_{XH} = 0$)
- (iv) International Outsourcing of the high skill intensive production part in the relative high skill intensive industry ($\hat{\phi}_{XH} > 0$ whereas $\hat{\phi}_{YL} = \hat{\phi}_{YH} = \hat{\phi}_{XL} = 0$)

Assuming first scenario (i), equation (3.11) and (3.12) can be solved for the effects of International Outsourcing on the percentage change in real wages

$$\hat{w}_L|_{\hat{\phi}_{YL}>0} = \frac{\theta_{XH}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} \quad (3.13)$$

$$\hat{w}_H|_{\hat{\phi}_{YL}>0} = -\frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} \quad (3.14)$$

with the determinant $\Delta_{\Theta} \equiv \begin{vmatrix} \theta_{XH} & \theta_{XL} \\ \theta_{YH} & \theta_{YL} \end{vmatrix} > 0$. Since the factor income shares are positive per definition ($\theta_{ij} > 0$), low skilled real wages increase (3.13 > 0), whereas wages of the high skilled decrease (3.14 < 0). As we know from the sector bias, International Outsourcing reduces the production costs of the respective industry and

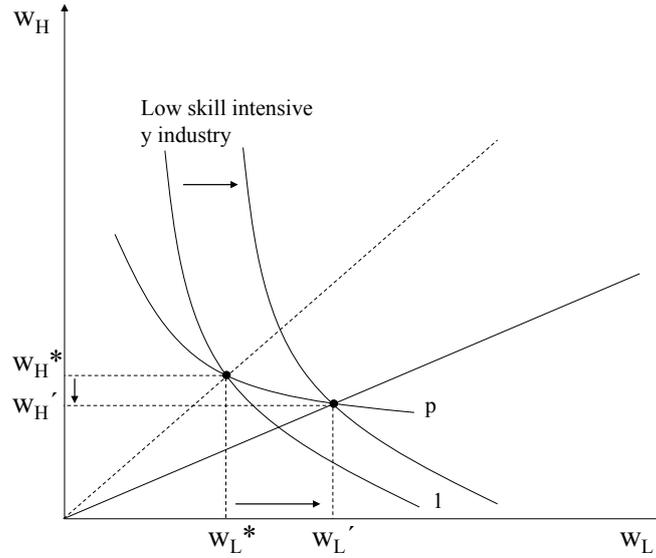


Figure 3.1: Effects of International Outsourcing on wages

thus, since we assume an economy facing given world prices, enables a wage premium for either high or low skilled labor. Since International Outsourcing takes place in the relative low skill intensive industry in this scenario, low skilled labor receives the wage premium, while wages of the high skilled decrease. Equations (3.13) and (3.14) can be rearranged in order to achieve

$$\hat{w}_H - \hat{w}_L |_{\hat{\varphi}_{YL} > 0} = -\frac{\theta_{YL}}{\Delta_{\Theta}} \hat{\varphi}_{YL} \tag{3.15}$$

as the percentage change of the relative wage of high skilled labor. Figure 3.1 illustrates this process within a factor-price space in shifting the unit cost curve of the relative low skill intensive industry (Y) horizontally outward.

Assuming scenario (ii), wage effects are of the same tendency since International Outsourcing occurs in the same industry. Real wages of the high skilled decrease, while low skilled labor again receives the wage premium. Thus, relative wages of the high skilled decrease with

$$\hat{w}_H - \hat{w}_L |_{\hat{\varphi}_{YH} > 0} = -\frac{\theta_{YH}}{\Delta_{\Theta}} \hat{\varphi}_{YH} \tag{3.16}$$

Since, in the relative low skill intensive industry, the factor income shares of the low skilled are bigger than the factor income shares of the high skilled ($\theta_{YL} > \theta_{YH}$), the decrease in relative wages of the high skilled is more intensive if the industry relocates its low skill intensive production patterns ($\hat{w}_H - \hat{w}_L|_{\hat{\phi}_{YL}>0} < \hat{w}_H - \hat{w}_L|_{\hat{\phi}_{YH}>0}$).

Considering International Outsourcing to take place in the relative high skill intensive industry, scenarios (iii) and (iv), results are of opposite direction. For the percentage change in relative high skilled wages we achieve

$$\hat{w}_H - \hat{w}_L|_{\hat{\phi}_{XL}>0} = \frac{\theta_{XL}}{\Delta_{\Theta}} \hat{\phi}_{XL} \quad (3.17)$$

$$\hat{w}_H - \hat{w}_L|_{\hat{\phi}_{XH}>0} = \frac{\theta_{XH}}{\Delta_{\Theta}} \hat{\phi}_{XH} \quad (3.18)$$

with both effects being positive and $\hat{w}_H - \hat{w}_L|_{\hat{\phi}_{XH}>0} > \hat{w}_H - \hat{w}_L|_{\hat{\phi}_{XL}>0}$. Proposition 1 summarizes the effects of International Outsourcing on relative wages, considering the four different International Outsourcing scenarios.

Proposition 1 *The relative wage of high skilled labor decreases if International Outsourcing takes place in the relative low skill intensive industry. If International Outsourcing takes place in the relative high skill intensive industry, relative high skilled wages increase. This pattern occurs regardless of which production block of the respective industry gets relocated.*

Relative Labor Unit Requirements

As we know from Shephard's Lemma, equilibrium labor unit requirements can be achieved by partial differentiating the unit cost functions (see equations 3.3 - 3.6). With log differentiation, we obtain

$$\hat{a}_{YL} = \theta_{YH}\sigma^Y(\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL} - \hat{\phi}_{YH}) - \hat{\phi}_{YL} \quad (3.19)$$

$$\hat{a}_{YH} = -\theta_{YL}\sigma^Y(\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL} - \hat{\phi}_{YH}) - \hat{\phi}_{YH} \quad (3.20)$$

$$\hat{a}_{XL} = \theta_{XH}\sigma^X(\hat{w}_H - \hat{w}_L + \hat{\phi}_{XL} - \hat{\phi}_{XH}) - \hat{\phi}_{XL} \quad (3.21)$$

$$\hat{a}_{XH} = -\theta_{XL}\sigma^X(\hat{w}_H - \hat{w}_L + \hat{\phi}_{XL} - \hat{\phi}_{XH}) - \hat{\phi}_{XH} \quad (3.22)$$

as the percentage change of labor unit requirements with σ^i as elasticity of substitution between low and high skilled labor in industry i ($i = X, Y$). Now, assume again scenario (i: $\hat{\phi}_{YL} > 0$) and substitute for the percentage change of low and high skilled

real wages, we achieve

$$\hat{a}_{YH} - \hat{a}_{YL} |_{\hat{\phi}_{YL} > 0} = \sigma^Y \frac{\theta_{YL}}{\Delta_{\Theta}} \hat{\phi}_{YL} + (1 - \sigma^Y) \hat{\phi}_{YL} \quad (3.23)$$

$$\hat{a}_{XH} - \hat{a}_{XL} |_{\hat{\phi}_{YL} > 0} = \sigma^X \frac{\theta_{YL}}{\Delta_{\Theta}} \hat{\phi}_{YL} \quad (3.24)$$

as the percentage change of relative labor unit requirements of the high skilled in the two industries. In the relative high skill intensive industry (X), the industry that holds to its integrated production process in this scenario, relative labor unit requirements increase solely due to the wage-effect: Since relative wages of the high skilled decrease in both industries (see equation 3.15), the industries substitute high for low skilled labor. By contrast, in the relative low skill intensive industry (Y), the industry performing International Outsourcing activities, the wage-effect gets enriched by an outsourcing-effect: Since the industry relocates its low skill intensive production fragment, additional effects occur for relative labor unit requirements. Depending on the elasticity of substitution between low and high skilled labor, the outsourcing-effect can either increase (if $0 < \sigma^Y < 1$) or reduce relative labor unit requirements of the high skilled (if $\sigma^Y > 1$). With Cobb Douglas elasticities ($\sigma^i = 1$) the outsourcing-effect equally decreases low and high skilled labor unit requirements. However, in the ongoing scenario (i) the wage-effect outperforms the outsourcing-effect anyway, since $\frac{\theta_{YL}}{\Delta_{\Theta}} > 1$. Thus, as illustrated in Arndt (1997), relative labor unit requirements of the high skilled unambiguously increase in both industries, inducing a skill shift toward more high skilled labor.

Considering the first ambiguous case (scenario ii: $\hat{\phi}_{YH} > 0$), we achieve

$$\hat{a}_{YH} - \hat{a}_{YL} |_{\hat{\phi}_{YH} > 0} = \sigma^Y \frac{\theta_{YH}}{\Delta_{\Theta}} \hat{\phi}_{YH} - (1 - \sigma^Y) \hat{\phi}_{YH} \quad (3.25)$$

$$\hat{a}_{XH} - \hat{a}_{XL} |_{\hat{\phi}_{YH} > 0} = \sigma^X \frac{\theta_{YH}}{\Delta_{\Theta}} \hat{\phi}_{YH} \quad (3.26)$$

as the effects of International Outsourcing on relative labor unit requirements of the high skilled. In the relative high skill intensive industry (X), where the production process still remains integrated, relative labor unit requirements of the high skilled increase again solely due to the wage-effect. In the relative low skill intensive industry (Y), the wage-effect gets again accompanied by an outsourcing-effect. In this scenario, when relocating the high skill intensive fragment, the wage-effect is not as strong

as in scenario (i), providing the possibility for the outsourcing-effect to outperform the wage-effect. However, with the elasticity of substitution being big enough, the wage-effect is still dominant, leading to an increase of relative labor unit requirements of the high skilled ($\hat{a}_{YH} - \hat{a}_{YL}|_{\hat{\phi}_{YH}>0} > 0$ if $\sigma^Y > \frac{\Delta_{\Theta}}{\theta_{XH}}$). By contrast, if the elasticity of substitution is beneath this critical value, the wage-effect still increases relative labor unit requirements of the high skilled, but the outsourcing-effect is stronger and turns the change of relative high skilled labor unit requirements negative. Considering the critical value of the elasticity in detail, we can note that $0 < \frac{\Delta_{\Theta}}{\theta_{XH}} < 1$ if $\Delta_{\Theta} < \theta_{XH}$ per definition. Thus, assuming Cobb Douglas elasticities, the wage-effect is anyway stronger than the outsourcing-effect with International Outsourcing increasing relative labor unit requirements of the high skilled, as in the opposite scenario (i).

A similar result occurs when considering the second ambiguous case (scenario iii: $\hat{\phi}_{XL} > 0$). Since the relative high skill intensive industry relocates its low skill intensive production block, the change in relative labor unit requirements of the high skilled can be described with

$$\hat{a}_{YH} - \hat{a}_{YL}|_{\hat{\phi}_{XL}>0} = -\sigma^Y \frac{\theta_{XL}}{\Delta_{\Theta}} \hat{\phi}_{XL} \quad (3.27)$$

$$\hat{a}_{XH} - \hat{a}_{XL}|_{\hat{\phi}_{XL}>0} = -\sigma^X \frac{\theta_{XL}}{\Delta_{\Theta}} \hat{\phi}_{XL} + (1 - \sigma^X) \hat{\phi}_{XL} \quad (3.28)$$

where, in the relative high skill intensive industry (X), it depends on the elasticity of substitution (σ^X) whether the wage-effect outperforms the outsourcing-effect, or vice versa. As can be shown, $\hat{a}_{XH} - \hat{a}_{XL}|_{\hat{\phi}_{XL}>0} < 0$ if $\sigma^X > \frac{\Delta_{\Theta}}{\theta_{YL}}$. Thus, with the elasticity of substitution being big enough, the wage-effect outperforms the outsourcing-effect again, leading to a reduction of relative labor unit requirements of the high skilled. Since $\theta_{YL} > \Delta_{\Theta}$ per definition, $0 < \frac{\Delta_{\Theta}}{\theta_{YL}} < 1$ indicating that, within a Cobb Douglas world, International Outsourcing decreases relative labor unit requirements of the high skilled anyway due to the dominance of the wage-effect.

One scenario, International Outsourcing of the high skill intensive production block in the relative high skill intensive industry (scenario iv: $\hat{\phi}_{XH} > 0$), is still missing. There, we achieve

$$\hat{a}_{YH} - \hat{a}_{YL}|_{\hat{\phi}_{XH}>0} = -\sigma^Y \frac{\theta_{XH}}{\Delta_{\Theta}} \hat{\phi}_{XH} \quad (3.29)$$

$$\hat{a}_{XH} - \hat{a}_{XL}|_{\hat{\phi}_{XH}>0} = -\sigma^X \frac{\theta_{XH}}{\Delta_{\Theta}} \hat{\phi}_{XH} - (1 - \sigma^X) \hat{\phi}_{XH} \quad (3.30)$$

as the percentage change in relative labor unit requirements of the high skilled. If $\frac{\theta_{XH}}{\Delta_{\Theta}} > 1$, results are unambiguous with the wage-effect outperforming the outsourcing-effect anyway, as in scenario (i). Thus, with the relative wage of the high skilled increasing (see equation 3.18), an unambiguous skill shift toward more low skilled labor occurs in both industries. Proposition 2 summarizes the results of this section.

Proposition 2 *The effects of International Outsourcing on relative labor unit requirements of the high skilled are driven by a wage and an outsourcing-effect. While results are unambiguous in two of the four possible scenarios, the outsourcing-effect can outperform the wage-effect in the remaining two scenarios, leading to ambiguous results. The elasticity of substitution between low and high skilled labor is the parameter solving this ambiguity. If the elasticity exceeds a critical value, the wage-effect is stronger than the outsourcing-effect, leading to unambiguous results that substantiate the sector bias of International Outsourcing: Relative labor unit requirements of the high skilled increase if International Outsourcing takes place in the relative low skill intensive industry and decrease if it takes place in the relative high skill intensive industry. Which production block gets relocated is only of minor importance.*

Output

In order to examine the effects of International Outsourcing on the output of the industries, remember the full employment conditions (3.7) and (3.8), take the total differential and substitute for the change in relative wages and relative labor unit requirements. For scenario (i: $\hat{\varphi}_{YL} > 0$), we achieve

$$\hat{q}_Y|_{\hat{\varphi}_{YL}>0} = \frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{YL}\hat{\varphi}_{YL} + \frac{(1 - \sigma^Y)\lambda_{XH}\lambda_{YL}}{\Delta_{\Lambda}}\hat{\varphi}_{YL} + \sigma^Y\theta_{YL}\hat{\varphi}_{YL} \quad (3.31)$$

$$\hat{q}_X|_{\hat{\varphi}_{YL}>0} = -\frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{YL}\hat{\varphi}_{YL} - \frac{(1 - \sigma^Y)\lambda_{YH}\lambda_{YL}}{\Delta_{\Lambda}}\hat{\varphi}_{YL} \quad (3.32)$$

as the percentage change of the industries' output with λ as labor shares ($\lambda_{ij} = \frac{L_i}{L}$, or $\frac{H_i}{H}$ respectively), $\delta_L \equiv \lambda_{XL}\theta_{XH}\sigma^X + \lambda_{YL}\theta_{YH}\sigma^Y$, and $\delta_H \equiv \lambda_{XH}\theta_{XL}\sigma^X + \lambda_{YH}\theta_{YL}\sigma^Y$. With respect to output, results depend on too many parameters for getting solved endogenously: The θ 's and λ 's are implicitly driven by low and high skilled wages, the four labor unit requirements, labor endowments in both industries, and the two elasticities of substitution. Thus, in order to achieve unambiguous results, we need to assume Cobb Douglas elasticities at first. With these assumptions, we are able to reduce equations (3.31) and (3.32) to

$$\hat{q}_Y|_{\hat{\phi}_{YL}>0} = \frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} + \theta_{YL}\hat{\phi}_{YL} \quad (3.33)$$

$$\hat{q}_X|_{\hat{\phi}_{YL}>0} = -\frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} \quad (3.34)$$

with the δ 's > 0 , the λ 's > 0 , as well as the two determinants $\Delta_\Theta > 0$ and $\Delta_\Lambda > 0$. As the result shows, the relative low skill intensive industry (Y), where International Outsourcing takes place in this scenario, expands, whereas the relative high skill intensive industry (X), where production remains integrated, reduces output.⁶

Holding to the Cobb Douglas assumption, even in the cases where the effects on output are traditionally assumed to be ambiguous, unambiguous results can be obtained. When the low skill intensive industry relocates its high skill intensive production fragment (scenario ii: $\hat{\phi}_{YH} > 0$), we achieve

$$\hat{q}_Y|_{\hat{\phi}_{YH}>0} = \frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda}\theta_{YH}\hat{\phi}_{YH} + \theta_{YH}\hat{\phi}_{YH} \quad (3.35)$$

$$\hat{q}_X|_{\hat{\phi}_{YH}>0} = -\frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_\Theta\Delta_\Lambda}\theta_{YH}\hat{\phi}_{YH} \quad (3.36)$$

and

$$\hat{q}_Y|_{\hat{\phi}_{XL}>0} = -\frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XL}\hat{\phi}_{XL} \quad (3.37)$$

$$\hat{q}_X|_{\hat{\phi}_{XL}>0} = \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XL}\hat{\phi}_{XL} + \theta_{XL}\hat{\phi}_{XL} \quad (3.38)$$

if International Outsourcing takes place in the relative high skill intensive industry by relocating its low skill intensive production block (scenario iii: $\hat{\phi}_{XL} > 0$). As the results show, also in these two cases the industry relocating production unambiguously increases output.

Turning to scenario (iv), we achieve

$$\hat{q}_Y|_{\hat{\phi}_{XH}>0} = -\frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XH}\hat{\phi}_{XH} \quad (3.39)$$

$$\hat{q}_X|_{\hat{\phi}_{XH}>0} = \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XH}\hat{\phi}_{XH} + \theta_{XH}\hat{\phi}_{XH} \quad (3.40)$$

⁶We relax the Cobb Douglas assumption of this paragraph in the calibration exercise in Section 3.4.

Again, the relative high skill intensive industry (X), where International Outsourcing takes place, expands while the relative low skill intensive industry decreases output. Proposition 3 summarizes the effects of International Outsourcing on the output of the industries.

Proposition 3 *Considering the effects of International Outsourcing on the output of the industries, results again depend strongly on the elasticities of substitution. With Cobb Douglas elasticities, the effects are unambiguous for all four International Outsourcing scenarios. The industry where International Outsourcing takes place expands, while the industry remaining integrated reduces output. This result occurs no matter whether the industries relocate their high or their low skill intensive production fragment.*

Employment

Since we assume a flexible wage economy, the effects of International Outsourcing on employment are straightforward. Low as well as high skilled labor are fully employed, either in the relative low, or in the relative high skill intensive industry. With overall fixed supply of labor, changes on employment are in line with the contraction and expansion of the two industries. In order to achieve percentage changes of the different employment constellations within industries, consider the full employment conditions (3.7) and (3.8) and log differentiate. Substituting for the change in relative wages, relative labor unit requirements and output, and holding to the Cobb Douglas assumption again, we achieve

$$\hat{L}_X|_{\hat{\varphi}_{YL}>0} = -\frac{\theta_{XH}\theta_{YL}}{\Delta_{\Theta}}\hat{\varphi}_{YL} - \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{YL}\hat{\varphi}_{YL} \quad (3.41)$$

$$\hat{L}_Y|_{\hat{\varphi}_{YL}>0} = -\frac{\theta_{YH}\theta_{YL}}{\Delta_{\Theta}}\hat{\varphi}_{YL} + \frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{YL}\hat{\varphi}_{YL} \quad (3.42)$$

$$\hat{H}_X|_{\hat{\varphi}_{YL}>0} = \frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}}\hat{\varphi}_{YL} - \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{YL}\hat{\varphi}_{YL} \quad (3.43)$$

$$\hat{H}_Y|_{\hat{\varphi}_{YL}>0} = \frac{\theta_{YL}\theta_{YL}}{\Delta_{\Theta}}\hat{\varphi}_{YL} + \frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{YL}\hat{\varphi}_{YL} \quad (3.44)$$

as the percentage change of high and low skilled labor in the two industries since International Outsourcing occurs in the relative low skill intensive industry by relocating the low skill intensive production block (scenario i: $\hat{\varphi}_{YL} > 0$). The first part of the equations belongs to the change in relative wages. As the relative wage of the

low skilled increases in this scenario, employment of the low skilled is reduced. The second component belongs to the change in output of the industries (including the change in relative labor unit requirements and relative wages as well): Low and high skilled employment expand in the industry where International Outsourcing takes place (Y) since this industry increases output. As these results show, the relative high skill intensive industry decreases employment of the low skilled ($\hat{L}_X|_{\hat{\phi}_{YL}>0} < 0$). Thus, due to the flexible wage set up, the freed low skilled move to the low skill intensive industry (Y), the industry performing outsourcing activities and expanding output, to find employment. Thus, $\hat{L}_Y|_{\hat{\phi}_{YL}>0}$ needs to be positive. Simultaneously, the relative low skill intensive industry (Y) increases high skill intensive employment ($\hat{H}_Y|_{\hat{\phi}_{YL}>0} > 0$). As long as we assume an inelastic supply of labor, the high skilled are withdrawn from the relative high skill intensive industry. Thus, $\hat{H}_X|_{\hat{\phi}_{YL}>0}$ needs to be negative.

As in the previous section on output, effects on employment are unambiguous in all four scenarios since Cobb Douglas elasticities are assumed. Consider e.g. scenario (ii: $\hat{\phi}_{YH} > 0$), International Outsourcing taking place in the relative low skill intensive industry by relocating its high skill intensive production fragment, we obtain

$$\hat{L}_X|_{\hat{\phi}_{YH}>0} = -\frac{\theta_{XH}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} - \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{YH}\hat{\phi}_{YH} \quad (3.45)$$

$$\hat{L}_Y|_{\hat{\phi}_{YH}>0} = -\frac{\theta_{YH}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} + \frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{YH}\hat{\phi}_{YH} \quad (3.46)$$

$$\hat{H}_X|_{\hat{\phi}_{YH}>0} = \frac{\theta_{XL}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} - \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{YH}\hat{\phi}_{YH} \quad (3.47)$$

$$\hat{H}_Y|_{\hat{\phi}_{YH}>0} = \frac{\theta_{YL}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} + \frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{YH}\hat{\phi}_{YH} \quad (3.48)$$

as the percentage change of high and low skilled employment in both industries. Again, if International Outsourcing takes place in the relative low skill intensive industry, employment in this industry unambiguously increases for high as well as for low skilled labor. If International Outsourcing takes place in the relative high skill intensive industry, similar results occur. Proposition 4 summarizes the effects of International Outsourcing on employment.

Proposition 4 *With Cobb Douglas elasticities of substitution, effects on employment of all four International Outsourcing scenarios are unambiguous and in line with the change in output. Since International Outsourcing takes place, the outsourcing industry increases employment of low as well as high skilled labor. The industry that remains integrated reduces employment*

of both skill groups. This result supports the sector bias of International Outsourcing since it depends on the relative skill intensity of the industry relocating production and not on the fragment being outsourced.

3.4 Calibration Exercise

While investigating the importance of the elasticity of substitution between low and high skilled labor for International Outsourcing effects theoretically, results showed that, for output and employment, too many parameters have been at stake, squeezing us into a Cobb Douglas world. Thus, using data for the German economy in 2005 (provided by the German micro-census and the Genesis database of the German Federal Statistical office) in order to constrain some parameter values, this section calibrates the model for a wider range of elasticities. To illustrate the effects on relative wages, relative labor unit requirements, output, and employment, a one percentage increase of International Outsourcing is assumed.

To perform the calibration exercise, assumptions on the wages of high and low skilled labor, on the economy's high and low skilled labor endowment, and on the industries' skill intensity are needed. Information on the gross wages for the high as well as the low skilled can be found in the Genesis database offered by the Federal Statistical Office in Germany (Chapter 6.2 "wages and labor costs"). The data provides information on the gross wage per month for the German manufacturing and service industry in October 2005, disaggregated by skill level. Aggregating the skill groups into either high or low skilled labor and relating the monthly wage to the hours worked per month, we obtain for low skilled workers an average gross wage of 20 euro per hour (w_L) and 32 euro as gross wage per hour for the high skilled (w_H).⁷

To obtain the overall labor endowment we use data from the German micro-census 2005, offering information about the labor force grouped by age and education. Using the same aggregation procedure as above we obtain an economy endowed with 25.3 million low skilled workers and 10.9 million workers educated at a higher skill level.

⁷To aggregate the different skill groups, the definition of the internationally comparable "International Standard Classification of Education" (ISCED) from UNESCO (1997) is used. There, graduations of elementary school, of secondary school or of junior high school (comparable with the German "Realschule") are regarded as low skill education, whereas all higher education (grammar school, high school or university) are regarded as high skilled. We also calculated the numbers with respect to vocational training instead. However, results differ only marginally. To obtain the wage per hour we assume 140 hours work per month.

Table 3.3: Percentage change of relative high skilled wages

International Outsourcing Scenario	Percentage Change in Relative High Skilled Wages
$\hat{\phi}_{YL} > 0$	$\hat{w}_H - \hat{w}_L = -2.03$
$\hat{\phi}_{YH} > 0$	$\hat{w}_H - \hat{w}_L = -.65$
$\hat{\phi}_{XL} > 0$	$\hat{w}_H - \hat{w}_L = 1.03$
$\hat{\phi}_{XH} > 0$	$\hat{w}_H - \hat{w}_L = 1.65$

Finally, parameters indicating the skill intensity of the two industries under consideration are needed. In these kind of models, the industries' skill intensity is defined by the respective labor unit requirements. Since the requirement of low and high skilled labor depends on the production technology of each industry, they are only provided rarely by the empirical literature. Krugman (1995) e.g. calibrates a trade model focusing on a Northern economy and therefore, assumes 50 percent skilled workers in the relative high skill intensive industry and 20 percent in the relative low skill intensive industry.⁸ In this contribution, we follow Krugman (1995) and assume that firms in the low skill intensive industry require 1 hour of low skilled (a_{YL}) and .2 hours of high skilled workers (a_{YH}) to produce one unit of commodity Y . The high skill intensive X industry needs 2 hours of low skilled (a_{XL}) and the same amount of high skilled workers ($a_{XH} = 2$) to produce one unit. However, remember that only relative numbers matter.

Based on these assumptions we can calculate the price structure of the economy with $p = 6.36$ as the relative price of the X good, in terms of Y .

Relative Wages

As shown in the theoretical section, effects of International Outsourcing on relative wages are driven by the industry relocating production fragments. Calibrating the model with data for the German economy we can support this sector bias of International Outsourcing. Table 3.3 summarizes the results.

Recall that if International Outsourcing takes place in the relative low skill intensive industry (Y), relative wages of the high skilled decrease. If this industry increases outsourcing of its low skill intensive production block by one percent, relative wages of the high skilled decrease by 2.03 percent. If the industry increases outsourcing of its high skill intensive production part by one percent, relative wages of the high skilled decrease by .65 percent. By contrast, if International Outsourcing takes place in the

⁸Krugman (1995) bases his assumptions on Wood (1994) and Balassa (1979) who compute these numbers.

relative high skill intensive industry, the wage premium flows to the high skilled and increases their relative wages. If the high skill intensive industry expands outsourcing activities of its low skill intensive production block by one percent, relative wages of the high skilled increase by 1.03 percent. If the industry increases outsourcing of its high skill intensive fragment, the relative wage of the high skilled increases by 1.65 percent.

Relative Labor Unit Requirements

Considering the effects of a one percentage increase in International Outsourcing activities on relative labor unit requirements of the high skilled, Figure 3.2 depicts the findings.

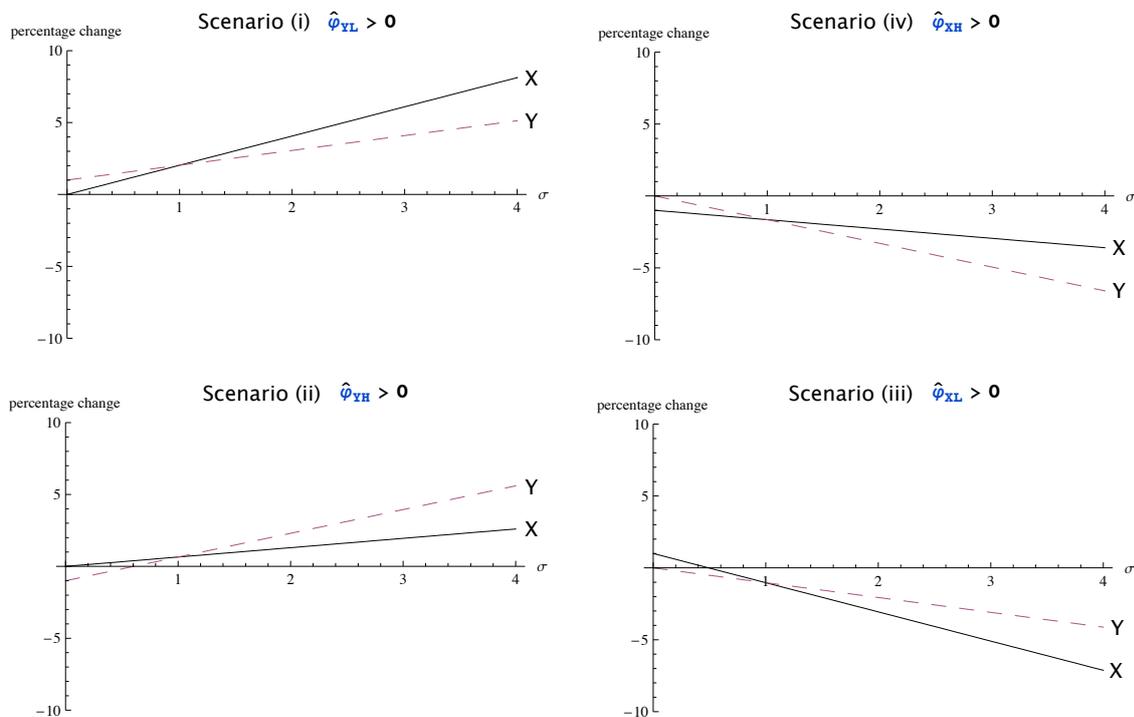


Figure 3.2: Effects on Relative Labor Unit Requirements of the High Skilled

As the figure shows, if International Outsourcing occurs in the relative low skill intensive industry by relocating its low skill intensive production block (scenario i: $\hat{\varphi}_{YL} > 0$), relative labor unit requirements of the high skilled increase unambiguously in both industries, for each level of elasticity of substitution. A similar result occurs

if International Outsourcing takes place in the relative high skill intensive industry by relocating its high skill intensive production fragment (scenario iv: $\hat{\phi}_{XH} > 0$). There, relative labor unit requirements of the high skilled unambiguously decrease in both industries. These results occur since the wage-effect outperforms the outsourcing-effect in both cases. However, when turning to the two ambiguous scenarios (the two charts below), the outsourcing-effect outperforms the wage-effect for small values of the elasticity of substitution. If $\hat{\phi}_{YH} > 0$ (scenario ii), relative labor unit requirements of the high skilled increase unambiguously in the X industry, the industry that remains integrated, due to the decrease in relative high skilled wages. In the relative low skill intensive industry, where the high skill intensive production block gets outsourced, the outsourcing-effect outperforms the wage-effect if the elasticity of substitution is below the critical value of .61, leading to a decrease of relative high skilled labor unit requirements. Thus, as shown with the theoretical results above, within a Cobb Douglas world, relative labor unit requirements of the high skilled increase anyway. In scenario (iii: $\hat{\phi}_{XL} > 0$), a similar process occurs with the opposite direction and a critical value for the elasticity of substitution of .49.

Output

Turning to the effects of a one percentage increase in International Outsourcing activities on the output of the industries, Figure 3.3 depicts the results.

In the theoretical examination above, Cobb Douglas elasticities need to be assumed to handle the model. As German parameter values are assumed in this calibration exercise, we do not need to fix the elasticity and thus, are able to achieve further insights. Similar to the effects on relative labor unit requirements, the effects on output are unambiguous in scenarios (i: $\hat{\phi}_{YL} > 0$) and (iv: $\hat{\phi}_{XH} > 0$). The industry facing International Outsourcing activities increases its output while the industry holding to its integrated process decreases production. For the two ambiguous scenarios (ii: $\hat{\phi}_{YH} > 0$) and (iii: $\hat{\phi}_{XL} > 0$) we obtain again that the industries' elasticity of substitution between high and low skilled labor has to exceed a critical value. The critical value (scenario ii: .43 and scenario iii: .34) is in both cases smaller than unity. Thus, exceeding these values, unambiguous results occur, confirming the sector bias of International Outsourcing. The industry where International Outsourcing takes place expands production while the industry remaining integrated contracts.

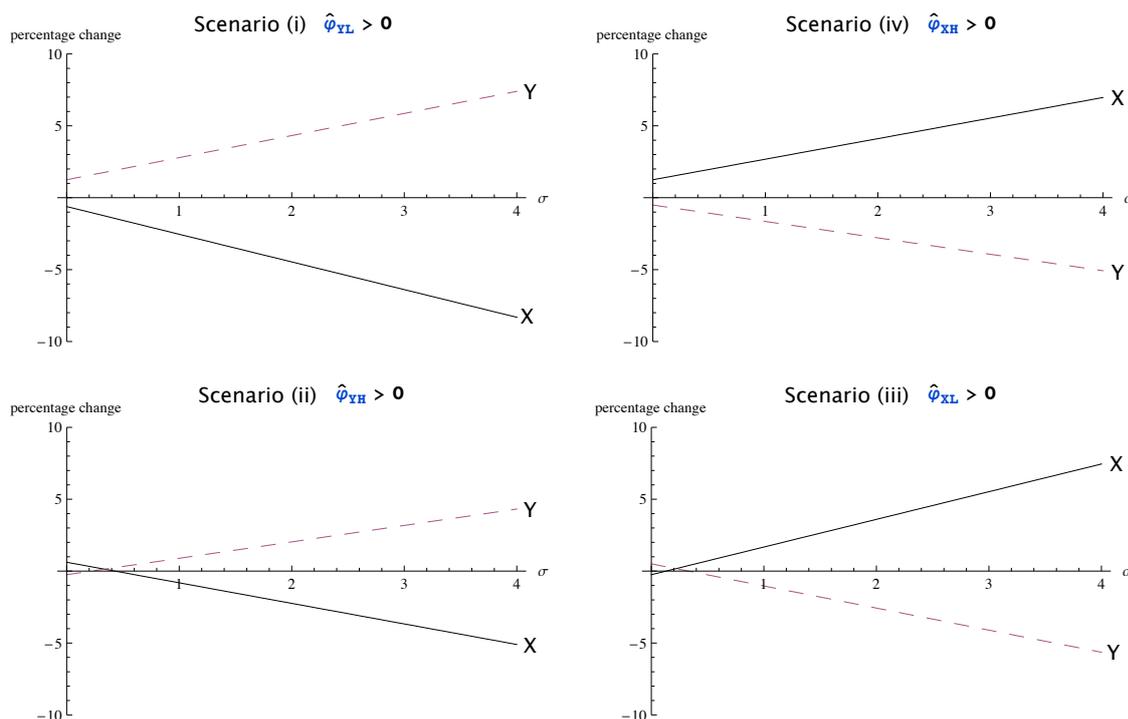


Figure 3.3: Effects on Output

Employment

A similar picture emerges for the effects of International Outsourcing on employment. Figure 3.4 depicts the results.

Since we examine employment of low and high skilled labor in each of the two industries, four lines need to be considered in each chart of this figure. Again, in the two scenarios (i: $\hat{\phi}_{YL} > 0$) and (iv: $\hat{\phi}_{XH} > 0$), unambiguous results occur. The industry relocating production abroad increases employment of both skill groups, low as well as high skilled labor. By contrast, the industry holding to its integrated production pattern has to reduce employment of both skill groups. Considering the two ambiguous scenarios, again, unambiguous results can only be achieved for elasticities of substitution above a critical value (scenario ii: .52 and scenario iii: .39). The critical value, however, is in both scenarios beneath unity. With elasticities exceeding these values, the sector bias of International Outsourcing can also be confirmed with respect to employment effects: The skill intensity of the industry relocating production matters, rather than which production block gets outsourced.⁹

⁹With respect to the implications on employment, one has to consider, that the results would depend crucially on specific labor market institutions. Especially in major European economies, like Germany,

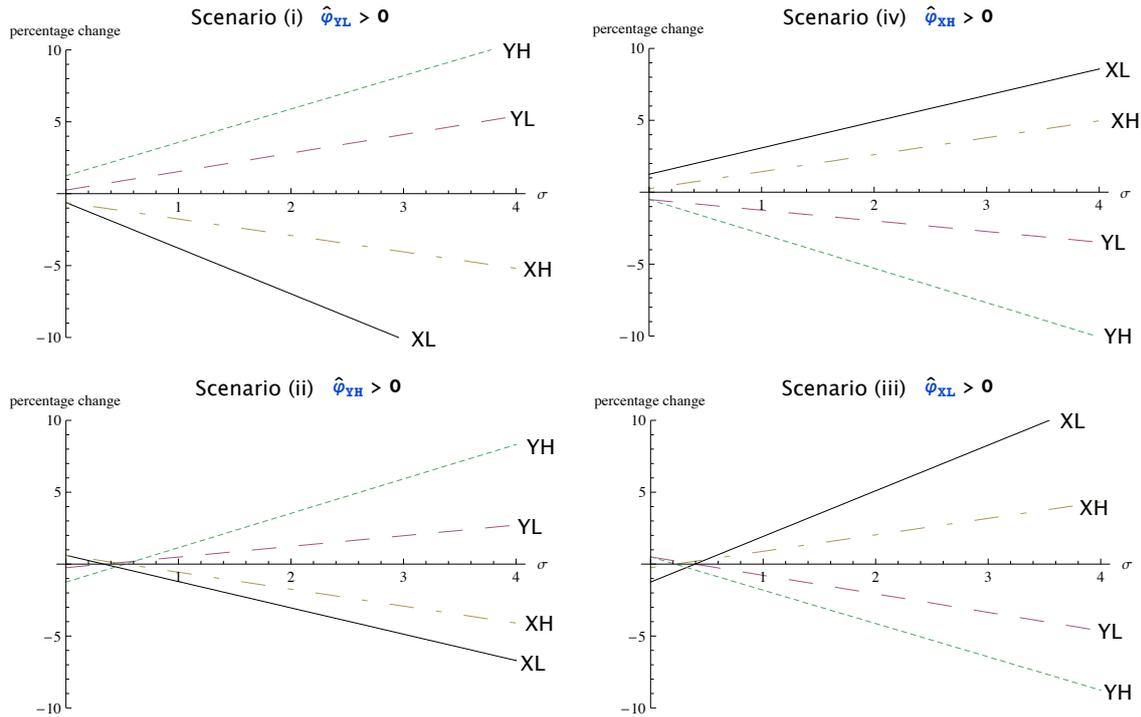


Figure 3.4: Effects on Employment

3.5 Conclusion

As the sector bias of International Outsourcing shows, low skilled labor receives a wage premium and thus, benefits, if outsourcing takes place in the relative low skill intensive industry. If International Outsourcing takes place in the relative high skill intensive industry, the high skilled benefit in receiving the wage markup. In general equilibrium, when examining the effects on labor unit requirements, output and employment, this wage-effect gets accompanied by an outsourcing-effect. Since the outsourcing-effect can work in the opposite direction and even outperform the wage-effect, results are only clear-cut in two of four possible scenarios: either if the relative low skill intensive industry relocates its low skill intensive production fragment, or if the relative high skill intensive industry relocates its high skill intensive one. By contrast, if the relative low skill intensive industry relocates its high skill intensive production block, or the relative high skill intensive industry its low skill intensive one, International Outsourcing effects are ambiguous.

low skilled unemployment is supposed to occur. For an examination of how low skilled wage rigidity affects International Outsourcing implications, see Chapter (5). This exercise, however, aims in calibrating the formal model shown above, and not in providing any empirical evidence for the German economy.

Table 3.4: Sector Bias of International Outsourcing (theoretical results)

scenario	low skill int. industry		high skill int. industry	
	low skill part	high skill part	low skill part	high skill part
relative wages of the high skilled	↓	↓	↑	↑
relative labor unit requirements of the high skilled	↑	$(\sigma^Y > \frac{\Delta e}{\theta_{XH}})$ ↑	$(\sigma^X > \frac{\Delta e}{\theta_{YL}})$ ↓	↓
		$(\sigma^Y = 1)$	$(\sigma^X = 1)$	
output	high skill int. industry ↓	high skill int. industry ↓	high skill int. industry ↑	high skill int. industry ↑
	low skill int. industry ↑	low skill int. industry ↑	low skill int. industry ↓	low skill int. industry ↓
		$(\sigma^Y = 1)$	$(\sigma^X = 1)$	
employment	high skill int. industry ↓	high skill int. industry ↓	high skill int. industry ↑	high skill int. industry ↑
	low skill int. industry ↑	low skill int. industry ↑	low skill int. industry ↓	low skill int. industry ↓

In this paper, general equilibrium effects of International Outsourcing are analyzed within a formal model, using the modern duality approach in international trade theory, and calibrated assuming German micro-census data. As the results show, the elasticity of substitution between low and high skilled labor is the parameter at force solving the puzzle. With the elasticity exceeding a critical value (the value is beneath unity), the results on relative labor unit requirements, output and employment can be solved unambiguously, confirming the sector bias of International Outsourcing: Provided that International Outsourcing takes place in the relative low skill intensive industry, relative wages of the low skilled increase. In general equilibrium, this wage-effect outperforms the outsourcing-effect. Thus, both industries substitute high for low skilled labor. As the relative low skill intensive industry gets more competitive on world markets, relative output of this industry increases. This expansion induces labor flows of both skill groups toward the outsourcing industry. Reverse effects occur if International Outsourcing takes place in the relative high skill intensive industry. In both cases, the effects occur either if the respective industry relocates its low or its high skill intensive production fragment. Table 3.4 summarizes the formal results.

The findings are of high political relevance as well. As illuminated in the introduction, the two scenarios where International Outsourcing has ambiguous results are empirically quite important. Concerning policy issues, it is necessary to consider the complete picture of International Outsourcing effects. With the results achieved above, this contribution tries to fill this gap. If the elasticity of substitution exceeds a critical value (that is beneath unity), all four scenarios of the sector bias of International Outsourcing can be solved unambiguously. Thus, this pattern illuminates the importance of the sector bias of International Outsourcing and shows, that several cases exist where International Outsourcing can be beneficial for low skilled labor, even if it takes place in an industrialized economy.

For future research, it would be worth investigating the empirical importance of the sector bias of International Outsourcing as well. Since most empirical work bases on the factor bias of International Outsourcing and thus, on more aggregated industry levels, evidence on the implications if International Outsourcing occurring in industries differing with respect to their skill intensity would be of high interest.

Appendix: Calculations

Assumptions

The calculations in this contribution follow the modern duality approach to general equilibrium and build on a traditional 2 x 2 Heckscher-Ohlin model. Assume an economy facing given world prices ($\hat{p} = 0$), with two industries i ($i = X, Y$), producing two goods with quantities q_i . The economy is endowed with two primary inputs, high and low skilled labor (H_i, L_i). The factors as well as the good markets are perfectly competitive with factors mobile between sectors but internationally immobile ($\hat{w}_{Xj} = \hat{w}_{Yj} = \hat{w}_j$, with $j = L, H$). The economy faces an inelastic supply of factors (\bar{H} and \bar{L}) and remains incompletely specialized ($q_i > 0$).

Model Set-Up

The industries produce commodities using the production function

$$q_i = F_i(H_i, L_i)$$

with both inputs necessary for positive production. Costs can be described as $C_i = w_L L_i + w_H H_i$ and thus, the unit cost functions are $c_i(w_j) = \frac{C_i(q_i; w_j)}{q_i}$. In competitive equilibrium, unit costs equal the price

$$c_Y(w_L, w_H) = a_{YL}w_L + a_{YH}w_H = 1 \quad (3.49)$$

$$c_X(w_L, w_H) = a_{XL}w_L + a_{XH}w_H = p \quad (3.50)$$

with p as relative price of the high skill intensive product and the price of good Y as numeraire.¹⁰ Following Shephard's Lemma, we can solve for the labor unit requirements in partially differentiating the unit cost functions (3.49) and (3.50)

$$a_{YL} = \frac{\partial c_Y(w_L, w_H)}{\partial w_L} \quad (3.51)$$

$$a_{YH} = \frac{\partial c_Y(w_L, w_H)}{\partial w_H} \quad (3.52)$$

$$a_{XL} = \frac{\partial c_X(w_L, w_H)}{\partial w_L} \quad (3.53)$$

$$a_{XH} = \frac{\partial c_X(w_L, w_H)}{\partial w_H} \quad (3.54)$$

The factor market equilibrium conditions (assuming inelastic labor supply, full employment, and positive factor prices $w_j > 0$) can be described as

$$\bar{L} = a_{YL}q_Y + a_{XL}q_X \quad (3.55)$$

$$\bar{H} = a_{YH}q_Y + a_{XH}q_X \quad (3.56)$$

In order to introduce International Outsourcing, we define $\hat{\varphi}_{ij} \equiv -\frac{1}{a_{ij}(\partial a_{ij}/\partial IO)}$ similar to skill biased technical change as in Jones (1965). To obtain labor unit requirements as well as wages considering International Outsourcing activities, we need to relate $\vec{a}_{ij} = \varphi_{ij}a_{ij}$ as well as $\vec{w}_i = \frac{w_i}{\varphi_{ij}}$. Thus, the unit cost functions (3.49) and (3.50) change to

$$c_Y(\vec{w}_L, \vec{w}_H) = \vec{a}_{YL}\vec{w}_L + \vec{a}_{YH}\vec{w}_H = \varphi_{YL}a_{YL}\frac{w_L}{\varphi_{YL}} + \varphi_{YH}a_{YH}\frac{w_H}{\varphi_{YH}} \quad (3.57)$$

$$c_X(\vec{w}_L, \vec{w}_H) = \vec{a}_{XL}\vec{w}_L + \vec{a}_{XH}\vec{w}_H = \varphi_{XL}a_{XL}\frac{w_L}{\varphi_{XL}} + \varphi_{XH}a_{XH}\frac{w_H}{\varphi_{XH}} \quad (3.58)$$

¹⁰Numbers of equations are those in the text.

General Equilibrium Effects of International Outsourcing

For equilibrium, minimize unit costs by taking the total differential, first in the relative high skill intensive industry (X). Facing given world prices, changes in effective factor endowments have no effect on factor prices. Thus, as we effectively change factor endowments, the \vec{a}_{XH} and \vec{a}_{XL} do not change.

$$\begin{aligned}
c_X &= \varphi_{XL} a_{XL} \frac{w_L}{\varphi_{XL}} + \varphi_{XH} a_{XH} \frac{w_H}{\varphi_{XH}} \\
dc_X &= \frac{dw_L}{\varphi_{XL}} (\varphi_{XL} a_{XL}) + \frac{dw_H}{\varphi_{XH}} (\varphi_{XH} a_{XH}) \\
&\quad - \frac{w_L}{(\varphi_{XL})^2} (\varphi_{XL} a_{XL}) d\varphi_{XL} - \frac{w_H}{(\varphi_{XH})^2} (\varphi_{XH} a_{XH}) d\varphi_{XH} \\
dc_X &= w_L a_{XL} \hat{w}_L + w_H a_{XH} \hat{w}_H - w_L a_{XL} \hat{\varphi}_{XL} - w_H a_{XH} \hat{\varphi}_{XH} = 0 \\
0 &= \theta_{XL} \hat{w}_L + \theta_{XH} \hat{w}_H - \theta_{XL} \hat{\varphi}_{XL} - \theta_{XH} \hat{\varphi}_{XH}
\end{aligned}$$

with $\theta_{ij} \equiv \frac{a_{ij} w_j}{p_i}$ and “hat” denoting percentage changes. For the relative low skill intensive industry (Y) we obtain

$$\begin{aligned}
c_Y &= \varphi_{YL} a_{YL} \frac{w_L}{\varphi_{YL}} + \varphi_{YH} a_{YH} \frac{w_H}{\varphi_{YH}} \\
dc_Y &= \frac{dw_L}{\varphi_{YL}} (\varphi_{YL} a_{YL}) + \frac{dw_H}{\varphi_{YH}} (\varphi_{YH} a_{YH}) \\
&\quad - \frac{w_L}{(\varphi_{YL})^2} (\varphi_{YL} a_{YL}) d\varphi_{YL} - \frac{w_H}{(\varphi_{YH})^2} (\varphi_{YH} a_{YH}) d\varphi_{YH} \\
dc_Y &= w_L a_{YL} \hat{w}_L + w_H a_{YH} \hat{w}_H - w_L a_{YL} \hat{\varphi}_{YL} - w_H a_{YH} \hat{\varphi}_{YH} = 0 \\
0 &= \theta_{YL} \hat{w}_L + \theta_{YH} \hat{w}_H - \theta_{YL} \hat{\varphi}_{YL} - \theta_{YH} \hat{\varphi}_{YH}
\end{aligned}$$

Relative Wages

Slightly rearranging this result, we achieve

$$\theta_{YL} \hat{w}_L + \theta_{YH} \hat{w}_H = \theta_{YL} \hat{\varphi}_{YL} + \theta_{YH} \hat{\varphi}_{YH} \quad (3.59)$$

$$\theta_{XL} \hat{w}_L + \theta_{XH} \hat{w}_H = \theta_{XL} \hat{\varphi}_{XL} + \theta_{XH} \hat{\varphi}_{XH} \quad (3.60)$$

as equilibrium production in both industries. As (3.59) and (3.60) illuminate, four different International Outsourcing scenarios emerge:

- (i) International Outsourcing of the low skill intensive production part in the relative low skill intensive industry ($\hat{\phi}_{YL} > 0$ whereas $\hat{\phi}_{YH} = \hat{\phi}_{XL} = \hat{\phi}_{XH} = 0$)
- (ii) International Outsourcing of the high skill intensive production part in the relative low skill intensive industry ($\hat{\phi}_{YH} > 0$ whereas $\hat{\phi}_{YL} = \hat{\phi}_{XL} = \hat{\phi}_{XH} = 0$)
- (iii) International Outsourcing of the low skill intensive production part in the relative high skill intensive industry ($\hat{\phi}_{XL} > 0$ whereas $\hat{\phi}_{YL} = \hat{\phi}_{YH} = \hat{\phi}_{XH} = 0$)
- (iv) International Outsourcing of the high skill intensive production part in the relative high skill intensive industry ($\hat{\phi}_{XH} > 0$ whereas $\hat{\phi}_{YL} = \hat{\phi}_{YH} = \hat{\phi}_{XL} = 0$)

We can now solve (3.59) and (3.60) for changes in wages (\hat{w}_L, \hat{w}_H) due to exogenous changes in International Outsourcing activities.

Consider first scenario (i), the relative low skill intensive industry (Y) outsourcing its low skill intensive production fragment. Thus, (3.59) and (3.60) changes to:

$$\begin{aligned}\theta_{YH}\hat{w}_H + \theta_{YL}\hat{w}_L &= \theta_{YL}\hat{\phi}_{YL} \\ \theta_{XH}\hat{w}_H + \theta_{XL}\hat{w}_L &= 0\end{aligned}$$

Applying some matrix algebra

$$\begin{pmatrix} \theta_{XH} & \theta_{XL} \\ \theta_{YH} & \theta_{YL} \end{pmatrix} \begin{pmatrix} \hat{w}_H \\ \hat{w}_L \end{pmatrix} = \begin{pmatrix} 0 \\ \theta_{YL}\hat{\phi}_{YL} \end{pmatrix}$$

and solving for the change in factor prices with the use of cramer's rule, we achieve

$$\begin{aligned}\hat{w}_L|_{\hat{\phi}_{YL}>0} &= \frac{\begin{vmatrix} \theta_{XH} & 0 \\ \theta_{YH} & \theta_{YL}\hat{\phi}_{YL} \end{vmatrix}}{\Delta_{\Theta}} = \frac{\theta_{XH}\theta_{YL}\hat{\phi}_{YL}}{\Delta_{\Theta}} \\ &= \frac{\theta_{XH}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL}\end{aligned}\tag{3.61}$$

$$\begin{aligned}\hat{w}_H|_{\hat{\phi}_{YL}>0} &= \frac{\begin{vmatrix} 0 & \theta_{XL} \\ \theta_{YL}\hat{\phi}_{YL} & \theta_{YL} \end{vmatrix}}{\Delta_{\Theta}} = \frac{-\theta_{XL}\theta_{YL}\hat{\phi}_{YL}}{\Delta_{\Theta}} \\ &= -\frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL}\end{aligned}\tag{3.62}$$

with $\Delta_{\Theta} > 0$ the determinant of the matrix Θ .

Proof for the determinant $\Delta_{\Theta} > 0$:

$$\begin{aligned}
 \Delta_{\Theta} &= \begin{vmatrix} \theta_{XH} & \theta_{XL} \\ \theta_{YH} & \theta_{YL} \end{vmatrix} \\
 &= \theta_{XH}\theta_{YL} - \theta_{XL}\theta_{YH} \\
 &= \theta_{XH}(1 - \theta_{YH}) - (1 - \theta_{XH})\theta_{YH} \\
 &= \theta_{XH} - \theta_{XH}\theta_{YH} - \theta_{YH} + \theta_{XH}\theta_{YH} \\
 &= \theta_{XH} - \theta_{YH} > 0
 \end{aligned}$$

For the change in relative high skill wages, we achieve

$$\begin{aligned}
 \hat{w}_H - \hat{w}_L|_{\hat{\phi}_{YL} > 0} &= \frac{-\theta_{XL}\theta_{YL}\hat{\phi}_{YL} - \theta_{XH}\theta_{YL}\hat{\phi}_{YL}}{\Delta_{\Theta}} \\
 &= \frac{-(1 - \theta_{XH})\theta_{YL} - \theta_{XH}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} \\
 &= \frac{-\theta_{YL} + \theta_{XH}\theta_{YL} - \theta_{XH}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} \\
 &= -\frac{\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} < 0
 \end{aligned} \tag{3.63}$$

Now assume scenario (ii), the relative low skill intensive industry outsourcing its high skill intensive production fragment, ($\hat{\phi}_{YH} > 0$, whereas $\hat{\phi}_{YL} = \hat{\phi}_{XL} = \hat{\phi}_{XH} = 0$). Thus, (3.59) and (3.60) change to

$$\begin{aligned}
 \theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H &= \theta_{YH}\hat{\phi}_{YH} \\
 \theta_{XL}\hat{w}_L + \theta_{XH}\hat{w}_H &= 0
 \end{aligned}$$

Again, we can solve this for the change in relative high skill wages

$$\hat{w}_H - \hat{w}_L|_{\hat{\phi}_{YH} > 0} = -\frac{\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} < 0 \tag{3.64}$$

For scenario (iii: $\hat{\phi}_{XL} > 0$) and (iv: $\hat{\phi}_{XH} > 0$), we obtain

$$\hat{w}_H - \hat{w}_L|_{\hat{\varphi}_{XL}>0} = \frac{\theta_{XL}}{\Delta_{\Theta}} \hat{\varphi}_{XL} > 0 \quad (3.65)$$

$$\hat{w}_H - \hat{w}_L|_{\hat{\varphi}_{XH}>0} = \frac{\theta_{XH}}{\Delta_{\Theta}} \hat{\varphi}_{XH} > 0 \quad (3.66)$$

for the change in relative high skill wages.

Relative Labor Unit Requirements

As we know from Shephard's Lemma (3.51), (3.52), (3.53), and (3.54)

$$\begin{aligned} c_{\vec{w}_L}^Y &= \vec{a}_{YL} = a_{YL} \varphi_{YL} \\ a_{YL} &= \frac{c_{\vec{w}_L}^Y}{\varphi_{YL}} \end{aligned}$$

Using some log differentiation, we achieve

$$\begin{aligned} \ln a_{YL} &= \ln c_{\vec{w}_L}^Y - \ln \varphi_{YL} \\ \frac{da_{YL}}{a_{YL}} &= \frac{c_{\vec{w}_L \vec{w}_L}^Y d\vec{w}_L + c_{\vec{w}_L \vec{w}_H}^Y d\vec{w}_H}{c_{\vec{w}_L}^Y} - \frac{d\varphi_{YL}}{\varphi_{YL}} \\ \hat{a}_{YL} &= \frac{\vec{w}_L c_{\vec{w}_L \vec{w}_L}^Y}{c_{\vec{w}_L}^Y} \hat{w}_L + \frac{\vec{w}_H c_{\vec{w}_L \vec{w}_H}^Y}{c_{\vec{w}_L}^Y} \hat{w}_H - \hat{\varphi}_{YL} \end{aligned}$$

Since c^Y is linear homogeneous, $c_{\vec{w}_L}^Y$ is homogeneous of the degree of 0. Thus, recall Euler

$$\frac{\vec{w}_L c_{\vec{w}_L \vec{w}_L}^Y}{c_{\vec{w}_L}^Y} + \frac{\vec{w}_H c_{\vec{w}_L \vec{w}_H}^Y}{c_{\vec{w}_L}^Y} = 0$$

$$\frac{\vec{w}_L c_{\vec{w}_L \vec{w}_L}^Y}{c_{\vec{w}_L}^Y} = - \frac{\vec{w}_H c_{\vec{w}_L \vec{w}_H}^Y}{c_{\vec{w}_L}^Y}$$

in order to obtain

$$\hat{a}_{YL} = \frac{\vec{w}_H c_{\vec{w}_L \vec{w}_H}^Y}{c_{\vec{w}_L}^Y} (\hat{w}_H - \hat{w}_L) - \hat{\varphi}_{YL}$$

Now, consider the elasticity of substitution between high and low skilled labor in the Y industry, $\sigma^Y \equiv \frac{c^Y c^Y_{\vec{w}_L \vec{w}_H}}{c^Y_{\vec{w}_H} c^Y_{\vec{w}_L}}$ and expand

$$\begin{aligned}\hat{a}_{YL} &= \frac{\vec{w}_H c^Y_{\vec{w}_L \vec{w}_H} c^Y_{\vec{w}_H} c^Y}{c^Y_{\vec{w}_L} c^Y_{\vec{w}_H} c^Y} (\hat{\vec{w}}_H - \hat{\vec{w}}_L) - \hat{\phi}_{YL} \\ \hat{a}_{YL} &= \frac{\vec{w}_H c^Y_{\vec{w}_H}}{c^Y} \sigma^Y (\hat{\vec{w}}_H - \hat{\vec{w}}_L) - \hat{\phi}_{YL} \\ \hat{a}_{YL} &= \frac{\vec{w}_H a_{YH}}{p} \sigma^Y (\hat{\vec{w}}_H - \hat{\vec{w}}_L) - \hat{\phi}_{YL}\end{aligned}$$

Now, recall the change of high skilled wages in the relative low skill intensive industry,

$$\begin{aligned}\vec{w}_H &= \frac{w_H}{\varphi_{YH}} \\ \ln \vec{w}_H &= \ln w_H - \ln \varphi_{YH} \\ \hat{\vec{w}}_H &= \hat{w}_H - \hat{\phi}_{YH}\end{aligned}$$

and similar for low skilled wages. Thus, we achieve

$$\hat{a}_{YL} = \theta_{YH} \sigma^Y (\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL} - \hat{\phi}_{YH}) - \hat{\phi}_{YL} \quad (3.67)$$

and

$$\hat{a}_{YH} = -\theta_{YL} \sigma^Y (\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL} - \hat{\phi}_{YH}) - \hat{\phi}_{YH} \quad (3.68)$$

$$\hat{a}_{XL} = \theta_{XH} \sigma^X (\hat{w}_H - \hat{w}_L + \hat{\phi}_{XL} - \hat{\phi}_{XH}) - \hat{\phi}_{XL} \quad (3.69)$$

$$\hat{a}_{XH} = -\theta_{XL} \sigma^X (\hat{w}_H - \hat{w}_L + \hat{\phi}_{XL} - \hat{\phi}_{XH}) - \hat{\phi}_{XH} \quad (3.70)$$

For the changes of labor unit requirements in scenario (i: $\hat{\phi}_{YL} > 0$), we obtain

$$\begin{aligned}\hat{a}_{XL} |_{\hat{\phi}_{YL} > 0} &= \theta_{XH} \sigma^X (\hat{w}_H - \hat{w}_L) \\ \hat{a}_{XH} |_{\hat{\phi}_{YL} > 0} &= -\theta_{XL} \sigma^X (\hat{w}_H - \hat{w}_L) \\ \hat{a}_{YL} |_{\hat{\phi}_{YL} > 0} &= \theta_{YH} \sigma^Y (\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL}) - \hat{\phi}_{YL} \\ \hat{a}_{YH} |_{\hat{\phi}_{YL} > 0} &= -\theta_{YL} \sigma^Y (\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL})\end{aligned}$$

Now, solve for the change in relative labor unit requirements in the relative low skill intensive industry (Y)

$$\begin{aligned}
\hat{a}_{YH} - \hat{a}_{YL}|_{\hat{\phi}_{YL}>0} &= -\theta_{YL}\sigma^Y(\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL}) - \theta_{YH}\sigma^Y(\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL}) + \hat{\phi}_{YL} \\
&= -\sigma^Y[(\theta_{YL} + \theta_{YH})(\hat{w}_H - \hat{w}_L)] \\
&\quad -\sigma^Y(\theta_{YL} + \theta_{YH})\hat{\phi}_{YL} + \hat{\phi}_{YL} \\
&= -\sigma^Y(\hat{w}_H - \hat{w}_L) + (1 - \sigma^Y)\hat{\phi}_{YL} \\
&= \sigma^Y\frac{\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} + (1 - \sigma^Y)\hat{\phi}_{YL}
\end{aligned} \tag{3.71}$$

For the relative high skill intensive industry (X), we achieve

$$\begin{aligned}
\hat{a}_{XH} - \hat{a}_{XL}|_{\hat{\phi}_{YL}>0} &= -\theta_{XL}\sigma^X(\hat{w}_H - \hat{w}_L) - \theta_{XH}\sigma^X(\hat{w}_H - \hat{w}_L) \\
&= -\sigma^X[(\theta_{XL} + \theta_{XH})(\hat{w}_H - \hat{w}_L)] \\
&= -\sigma^X(\hat{w}_H - \hat{w}_L) \\
&= -\sigma^X\left(-\frac{\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL}\right) \\
&= \sigma^X\frac{\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL}
\end{aligned} \tag{3.72}$$

Since $\sigma^i > 0$, $\hat{a}_{XH} - \hat{a}_{XL}|_{\hat{\phi}_{YL}>0} > 0$ and

$$\begin{aligned}
\hat{a}_{YH} - \hat{a}_{YL}|_{\hat{\phi}_{YL}>0} &= \sigma^Y\left(\frac{\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL}\right) + (1 - \sigma^Y)\hat{\phi}_{YL} \\
&= \hat{\phi}_{YL}\left(\frac{\theta_{YL}}{\Delta_{\Theta}}\sigma^Y + 1 - \sigma^Y\right) \\
&= \hat{\phi}_{YL}\left(\sigma^Y\left(\frac{\theta_{YL}}{\Delta_{\Theta}} - 1\right) + 1\right) > 0
\end{aligned}$$

if $\theta_{YL} > \Delta_{\Theta}$.

Considering scenario (ii), similar calculations yield

$$\hat{a}_{YH} - \hat{a}_{YL}|_{\hat{\phi}_{YH}>0} = \sigma^Y\frac{\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} - (1 - \sigma^Y)\hat{\phi}_{YH} \tag{3.73}$$

$$\hat{a}_{XH} - \hat{a}_{XL}|_{\hat{\phi}_{YH}>0} = \sigma^X\frac{\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} > 0 \tag{3.74}$$

In this scenario, the result for the relative low skill intensive industry (Y) depends crucially on the elasticity of substitution:

$$\begin{aligned}
 \hat{a}_{YH} - \hat{a}_{YL}|_{\hat{\phi}_{YH}>0} &= \frac{\theta_{YH}\sigma^Y}{\Delta_{\Theta}}\hat{\phi}_{YH} + (\sigma^Y - 1)\hat{\phi}_{YH} \\
 &= \hat{\phi}_{YH}\left(\frac{\theta_{YH}}{\Delta_{\Theta}}\sigma^Y + \sigma^Y - 1\right) \\
 &= \hat{\phi}_{YH}\left(\sigma^Y\left(\frac{\theta_{YH}}{\Delta_{\Theta}} + 1\right) - 1\right) > 0
 \end{aligned}$$

since

$$\begin{aligned}
 \sigma^Y\left(\frac{\theta_{YH}}{\Delta_{\Theta}} + 1\right) &> 1 \\
 \sigma^Y &> \frac{1}{\frac{\theta_{YH}}{\Delta_{\Theta}} + 1} \\
 &> \frac{1}{\frac{\theta_{YH}\theta_{XH} - \theta_{YH}}{\theta_{XH} - \theta_{YH}}} \\
 &> \frac{\theta_{XH} - \theta_{YH}}{\theta_{XH}} \\
 &> \frac{\Delta_{\Theta}}{\theta_{XH}}
 \end{aligned}$$

Thus, for $\theta_{XH} > \Delta_{\Theta}$, the critical value of the elasticity of substitution is beneath unity.

Considering scenario (iii), we achieve a similar result for the percentage change in labor unit requirements

$$\hat{a}_{YH} - \hat{a}_{YL}|_{\hat{\phi}_{XL}>0} = -\sigma^Y \frac{\theta_{XL}}{\Delta_{\Theta}} \hat{\phi}_{XL} < 0 \quad (3.75)$$

$$\hat{a}_{XH} - \hat{a}_{XL}|_{\hat{\phi}_{XL}>0} = -\sigma^X \frac{\theta_{XL}}{\Delta_{\Theta}} \hat{\phi}_{XL} + (1 - \sigma^X) \hat{\phi}_{XL} \quad (3.76)$$

Thus, for the relative high skill intensive industry (X), results again depend on the elasticity of substitution

$$\begin{aligned}
\hat{a}_{XH} - \hat{a}_{XL} |_{\hat{\phi}_{XL} > 0} &= -\frac{\theta_{XL}\sigma^X}{\Delta_{\Theta}}\hat{\phi}_{XL} + (1 - \sigma^X)\hat{\phi}_{XL} \\
&= -\hat{\phi}_{XL}\left(\frac{\theta_{XL}\sigma^X}{\Delta_{\Theta}} + (\sigma^X - 1)\right) \\
&= -\hat{\phi}_{XL}\left(\sigma^Y\left(\frac{\theta_{XL}}{\Delta_{\Theta}} + 1\right) - 1\right) < 0
\end{aligned}$$

since

$$\begin{aligned}
\sigma^Y\left(\frac{\theta_{XL}}{\Delta_{\Theta}} + 1\right) &> 1 \\
\sigma^X &> \frac{1}{\frac{\theta_{XL}}{\Delta_{\Theta}} + 1} \\
&> \frac{1}{\frac{\theta_{XL} + \theta_{YL} - \theta_{XL}}{\theta_{YL} - \theta_{XL}}} \\
&> \frac{\theta_{YL} - \theta_{XL}}{\theta_{YL}}
\end{aligned}$$

Thus, again, the critical value is smaller unity.

Considering scenario (iv), results are similar to scenario (i). As the percentage change of relative labor unit requirements, we achieve

$$\hat{a}_{YH} - \hat{a}_{YL} |_{\hat{\phi}_{XH} > 0} = -\sigma^Y \frac{\theta_{XH}}{\Delta_{\Theta}} \hat{\phi}_{XH} < 0 \quad (3.77)$$

$$\hat{a}_{XH} - \hat{a}_{XL} |_{\hat{\phi}_{XH} > 0} = -\sigma^X \frac{\theta_{XH}}{\Delta_{\Theta}} \hat{\phi}_{XH} - (1 - \sigma^X) \hat{\phi}_{XH} < 0 \quad (3.78)$$

Thus, in both cases, results are unambiguously smaller 0, independent on the elasticity of substitution:

$$\begin{aligned}
\hat{a}_{XH} - \hat{a}_{XL} |_{\hat{\phi}_{XH} > 0} &= -\frac{\theta_{XH}\sigma^X}{\Delta_{\Theta}} \hat{\phi}_{XH} - \hat{\phi}_{XH}(1 - \sigma^X) < 0 \\
\hat{\phi}_{XH} \left(-\frac{\theta_{XH}\sigma^X}{\Delta_{\Theta}} - (1 - \sigma^X) \right) &< 0 \\
-\frac{\theta_{XH}\sigma^X}{\Delta_{\Theta}} - (1 - \sigma^X) &< 0 \\
\sigma^X \left(-\frac{\theta_{XH}}{\Delta_{\Theta}} + 1 \right) - 1 &< 0 \\
\sigma^X &> \underbrace{\frac{1}{1 - \frac{\theta_{XH}}{\Delta_{\Theta}}}}_{< 0, \text{ since } \theta_{XH} > \Delta_{\Theta}}
\end{aligned}$$

Output

To examine the effects of International Outsourcing on the output of the industries, take the total differential of the full employment conditions (3.55) and (3.56). With flexible wages, high and low skilled labor are at any time fully employed ($\hat{H} = \hat{L} = 0$).

$$\begin{aligned}
da_{XL}q_X + da_{YL}q_Y + a_{XL}dq_X + a_{YL}dq_Y &= 0 \\
a_{XL} \frac{da_{XL}}{a_{XL}} q_X + a_{YL} \frac{da_{YL}}{a_{YL}} q_Y + q_X a_{XL} \frac{dq_X}{q_X} + q_Y a_{YL} \frac{dq_Y}{q_Y} &= 0 \\
\hat{a}_{XL} \frac{L_X}{L} + \hat{a}_{YL} \frac{L_Y}{L} + \hat{q}_X \frac{L_X}{L} + \hat{q}_Y \frac{L_Y}{L} &= 0 \\
\hat{a}_{XL} \lambda_{XL} + \hat{a}_{YL} \lambda_{YL} + \hat{q}_X \lambda_{XL} + \hat{q}_Y \lambda_{YL} &= 0 \\
\hat{q}_X \lambda_{XL} + \hat{q}_Y \lambda_{YL} &= -(\hat{a}_{XL} \lambda_{XL} + \hat{a}_{YL} \lambda_{YL})
\end{aligned}$$

with λ_{ij} as labor shares of skill group j in industry i . By analogy, we obtain for the high skilled:

$$\begin{aligned}
da_{XH}q_X + da_{YH}q_Y + a_{XH}dq_X + a_{YH}dq_Y &= 0 \\
a_{XH} \frac{da_{XH}}{a_{XH}} q_X + a_{YH} \frac{da_{YH}}{a_{YH}} q_Y + q_X a_{XH} \frac{dq_X}{q_X} + q_Y a_{YH} \frac{dq_Y}{q_Y} &= 0 \\
\hat{a}_{XH} \frac{H_X}{H} + \hat{a}_{YH} \frac{H_Y}{H} + \hat{q}_X \frac{H_X}{H} + \hat{q}_Y \frac{H_Y}{H} &= 0 \\
\hat{a}_{XH} \lambda_{XH} + \hat{a}_{YH} \lambda_{YH} + \hat{q}_X \lambda_{XH} + \hat{q}_Y \lambda_{YH} &= 0 \\
\hat{q}_X \lambda_{XH} + \hat{q}_Y \lambda_{YH} &= -(\hat{a}_{XH} \lambda_{XH} + \hat{a}_{YH} \lambda_{YH})
\end{aligned}$$

Now, consider scenario (i), substitute for the change in relative wages (3.63) and the change in labor unit requirements (3.67, 3.68, 3.69, 3.70) in order to obtain

$$\begin{aligned}\hat{q}_X\lambda_{XL} + \hat{q}_Y\lambda_{YL} &= -\left\{\left(\theta_{XH}\sigma^X\left(-\frac{\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL}\right)\right)\lambda_{XL} + \left(\theta_{YH}\sigma^Y\left(-\frac{\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} + \hat{\phi}_{YL}\right) - \hat{\phi}_{YL}\right)\lambda_{YL}\right\} \\ \hat{q}_X\lambda_{XH} + \hat{q}_Y\lambda_{YH} &= -\left\{\left(-\theta_{XL}\sigma^X\left(-\frac{\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL}\right)\right)\lambda_{XH} + \left(-\theta_{YL}\sigma^Y\left(-\frac{\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} + \hat{\phi}_{YL}\right)\right)\lambda_{YH}\right\}\end{aligned}$$

Rearranging yields

$$\begin{aligned}\hat{q}_X\lambda_{XL} + \hat{q}_Y\lambda_{YL} &= -\left\{\frac{-\theta_{XH}\sigma^X\theta_{YL}\lambda_{XL}\hat{\phi}_{YL}}{\Delta_\Theta} + \frac{-\theta_{YH}\sigma^Y\theta_{YL}\hat{\phi}_{YL}\lambda_{YL}}{\Delta_\Theta} + \theta_{YH}\sigma^Y\hat{\phi}_{YL}\lambda_{YL} - \hat{\phi}_{YL}\lambda_{YL}\right\} \\ &= -\left\{\frac{-\theta_{XH}\sigma^X\theta_{YL}\lambda_{XL}\hat{\phi}_{YL}}{\Delta_\Theta} + \frac{-\theta_{YH}\sigma^Y\theta_{YL}\hat{\phi}_{YL}\lambda_{YL}}{\Delta_\Theta} - (1 - \sigma^Y\theta_{YH})\hat{\phi}_{YL}\lambda_{YL}\right\} \\ &= \frac{\sigma^Y}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL} + (1 - \sigma^Y\theta_{YH})\lambda_{YL}\hat{\phi}_{YL}\end{aligned}$$

and

$$\begin{aligned}\hat{q}_X\lambda_{XH} + \hat{q}_Y\lambda_{YH} &= -\left\{\frac{\theta_{XL}\sigma^X\theta_{YL}\lambda_{XH}\hat{\phi}_{YL}}{\Delta_\Theta} + \frac{\theta_{YL}\sigma^Y\theta_{YL}\hat{\phi}_{YL}\lambda_{YH}}{\Delta_\Theta} - \theta_{YL}\sigma^Y\hat{\phi}_{YL}\lambda_{YH}\right\} \\ &= -\left\{\frac{\delta_H}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL} - \theta_{YL}\sigma^Y\lambda_{YH}\hat{\phi}_{YL}\right\} \\ &= -\frac{\delta_H}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL} + \theta_{YL}\sigma^Y\lambda_{YH}\hat{\phi}_{YL}\end{aligned}$$

with $\delta_H \equiv \lambda_{XH}\theta_{XL}\sigma^X + \lambda_{YH}\theta_{YL}\sigma^Y$ and $\delta_L \equiv \lambda_{XL}\theta_{XH}\sigma^X + \lambda_{YL}\theta_{YH}\sigma^Y$. Now, apply some matrix algebra

$$\begin{pmatrix} \lambda_{XH} & \lambda_{YH} \\ \lambda_{XL} & \lambda_{YL} \end{pmatrix} \begin{pmatrix} \hat{q}_X \\ \hat{q}_Y \end{pmatrix} = \begin{pmatrix} -\frac{\delta_H}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL} + \theta_{YL}\sigma^Y\hat{\phi}_{YL}\lambda_{YH} \\ \frac{\delta_L}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL} + (1 - \sigma^Y\theta_{YH})\lambda_{YL}\hat{\phi}_{YL} \end{pmatrix}$$

Using Cramer's rule, we can solve this equation for \hat{q}_X and \hat{q}_Y

$$\begin{aligned}
\hat{q}_Y|_{\hat{\phi}_{YL}>0} &= \frac{\begin{vmatrix} \lambda_{XH} & -\frac{\delta_H}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL} + \theta_{YL}\sigma^Y\hat{\phi}_{YL}\lambda_{YH} \\ \lambda_{XL} & \frac{\delta_L}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL} + (1 - \sigma^Y\theta_{YH})\theta_{YL}\lambda_{YL} \end{vmatrix} \hat{\phi}_{YL}}{\Delta_\Lambda} \\
&= \frac{\frac{\delta_L}{\Delta_\Theta}\theta_{YL}\lambda_{XH}\hat{\phi}_{YL} + (1 - \sigma^Y\theta_{YH})\lambda_{YL}\lambda_{XH}\hat{\phi}_{YL} + \frac{\delta_H}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL}\lambda_{XL} - \theta_{YL}\lambda_{YH}\lambda_{XL}\hat{\phi}_{YL}}{\Delta_\Lambda} \\
&= \frac{\frac{\delta_L\lambda_{XH} + \delta_H\lambda_{XL}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} + \frac{\lambda_{YL}\lambda_{XH}}{\Delta_\Lambda}\hat{\phi}_{YL} - \frac{\sigma^Y\theta_{YL}\lambda_{YH}\lambda_{YH}}{\Delta_\Lambda}\hat{\phi}_{YL} - \frac{\delta^Y\theta_{YL}\lambda_{YH}\lambda_{XL}}{\Delta_\Lambda}\hat{\phi}_{YL}}{\Delta_\Lambda} \\
&= \frac{\frac{\delta_L\lambda_{XH} + \delta_H\lambda_{XL}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} + \frac{\lambda_{YL}\lambda_{XH}}{\Delta_\Lambda}\hat{\phi}_{YL}}{\Delta_\Lambda} \\
&\quad - \frac{(1 - \theta_{YL})\sigma^Y\lambda_{YH}\lambda_{XH}}{\Delta_\Lambda}\hat{\phi}_{YL} - \frac{\delta^Y\theta_{YL}\lambda_{YH}\lambda_{XL}}{\Delta_\Lambda}\hat{\phi}_{YL} \\
&= \frac{\frac{\delta_L\lambda_{XH} + \delta_H\lambda_{XL}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} + \frac{\lambda_{YL}\lambda_{XH}}{\Delta_\Lambda}\hat{\phi}_{YL} - \frac{\sigma^Y\lambda_{YH}\lambda_{XH}}{\Delta_\Lambda}\hat{\phi}_{YL} +}{\Delta_\Lambda} \\
&\quad \frac{\theta_{YL}\sigma^Y\lambda_{YH}\lambda_{XH}}{\Delta_\Lambda}\hat{\phi}_{YL} - \frac{\delta^Y\theta_{YL}\lambda_{YH}\lambda_{XL}}{\Delta_\Lambda}\hat{\phi}_{YL}}{\Delta_\Lambda} \\
&= \frac{\frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} + \frac{(1 - \sigma^Y)\lambda_{XH}\lambda_{YL}}{\Delta_\Lambda}\hat{\phi}_{YL} + \sigma^Y\theta_{YL}\hat{\phi}_{YL}}{\Delta_\Lambda} \tag{3.79}
\end{aligned}$$

with the determinant $\Delta_\Lambda > 0$

$$\begin{aligned}
\Lambda &= \begin{vmatrix} \lambda_{XH} & \lambda_{YH} \\ \lambda_{XL} & \lambda_{YL} \end{vmatrix} \\
\Delta_\Lambda &= \lambda_{XH}\lambda_{YL} - \lambda_{YH}\lambda_{XL} \\
&= \lambda_{XH}\lambda_{YL} - \lambda_{YH}\lambda_{XL} \\
&= \lambda_{XH}(1 - \lambda_{XL}) - (1 - \lambda_{XH})\lambda_{XL} \\
&= \lambda_{XH} - \lambda_{XH}\lambda_{XL} - \lambda_{XL} + \lambda_{XH}\lambda_{XL} \\
&= \lambda_{XH} - \lambda_{XL} \\
&= \frac{a_{XHx}}{H} - \frac{a_{XLx}}{L} > 0 \\
&\quad \frac{a_{XHx}}{H} > \frac{a_{XLx}}{L} \\
&\quad \frac{a_{XH}}{a_{XL}} > \frac{H}{L}
\end{aligned}$$

In an empirical way this is true, because the low skilled labor force exceeds the high skilled one.

For output in the relative high skill intensive industry (X), we obtain

$$\begin{aligned}
\hat{q}_X|_{\hat{\phi}_{YL}>0} &= \frac{\begin{vmatrix} -\frac{\delta_H}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL} + \theta_{YL}\sigma^Y\hat{\phi}_{YL}\lambda_{YH} & \lambda_{YH} \\ \frac{\delta_L}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL} + (1 - \sigma^Y)\theta_{YH}\lambda_{YL}\hat{\phi}_{YL} & \lambda_{YL} \end{vmatrix}}{\Delta_\Lambda} \\
&= \frac{-\frac{\delta_H}{\Delta_\Theta}\theta_{YL}\hat{\phi}_{YL}\lambda_{YL} + (1 - \sigma^Y)\theta_{YH}\lambda_{YL}\hat{\phi}_{XH}\lambda_{YH} - \frac{\delta_L}{\Delta_\Theta}\theta_{YH}\hat{\phi}_{YL}\lambda_{XL} - \theta_{YH}\sigma^Y\hat{\phi}_{YL}\lambda_{YH}\lambda_{XL}}{\Delta_\Lambda} \\
&= -\frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} + \frac{\theta_{YL}\sigma^Y\hat{\phi}_{YL}\lambda_{YH}(1 - \sigma^Y)\theta_{YH}\hat{\phi}_{YL}\lambda_{YH}\lambda_{YL}}{\Delta_\Lambda} + \\
&\quad (\theta_{YL}\sigma^Y - 1 + \theta_{YH}\sigma^Y)\hat{\phi}_{YL}\lambda_{YH}\lambda_{YL} - \frac{(1 - \sigma^Y)\hat{\phi}_{YL}\lambda_{YH}\lambda_{YL}}{\Delta_\Lambda} \\
&= -\frac{\delta_H\lambda_{YL} + \delta_L\lambda_{YH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} - \frac{(1 - \sigma^Y)\lambda_{YH}\lambda_{YL}}{\Delta_\Lambda}\hat{\phi}_{YL} \tag{3.80}
\end{aligned}$$

Now, consider the Cobb Douglas case of $\sigma^i = 1$, the system reduces to

$$\hat{q}_Y|_{\hat{\phi}_{YL}>0} = \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} + \theta_{YL}\hat{\phi}_{YL} \tag{3.81}$$

$$\hat{q}_X|_{\hat{\phi}_{YL}>0} = -\frac{\delta_H\lambda_{YL} + \delta_L\lambda_{YH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} \tag{3.82}$$

Using similar calculations, we obtain for scenario (ii),

$$\hat{q}_Y|_{\hat{\phi}_{YH}>0} = \frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda}\theta_{YH}\hat{\phi}_{YH} + \theta_{YH}\hat{\phi}_{YH} \tag{3.83}$$

$$\hat{q}_X|_{\hat{\phi}_{YH}>0} = -\frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_\Theta\Delta_\Lambda}\theta_{YH}\hat{\phi}_{YH} \tag{3.84}$$

For scenario (iii), we achieve

$$\hat{q}_Y|_{\hat{\phi}_{XL}>0} = -\frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XL}\hat{\phi}_{XL} \tag{3.85}$$

$$\hat{q}_X|_{\hat{\phi}_{XL}>0} = \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XL}\hat{\phi}_{XL} + \theta_{XL}\hat{\phi}_{XL} \tag{3.86}$$

and for scenario (iv),

$$\hat{q}_Y|_{\hat{\phi}_{XH}>0} = -\frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XH}\hat{\phi}_{XH} \quad (3.87)$$

$$\hat{q}_X|_{\hat{\phi}_{XH}>0} = \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XH}\hat{\phi}_{XH} + \theta_{XH}\hat{\phi}_{XH} \quad (3.88)$$

Employment

To focus on the change of employment within industries, consider the full employment conditions (3.55) and (3.56)

$$\begin{aligned} \bar{L} &= L_X + L_Y \\ &= a_{XL}q_X + a_{YL}q_Y \end{aligned}$$

$$\begin{aligned} \bar{H} &= H_X + H_Y \\ &= a_{XH}q_X + a_{YH}q_Y \end{aligned}$$

and concentrate on the change of one specific skill group within the industries (L_X, L_Y, H_X, H_Y). With log differentiation, we achieve

$$\begin{aligned} L_X &= a_{XL}q_X \\ \ln L_X &= \ln a_{XL} + \ln q_X \\ \hat{L}_X &= \hat{a}_{XL} + \hat{q}_X \end{aligned}$$

Thus, with respect to each skill level in both industries, we obtain four equations

$$\begin{aligned} \hat{L}_X &= \hat{a}_{XL} + \hat{q}_X \\ \hat{L}_Y &= \hat{a}_{YL} + \hat{q}_Y \\ \hat{H}_X &= \hat{a}_{XH} + \hat{q}_X \\ \hat{H}_Y &= \hat{a}_{YH} + \hat{q}_Y \end{aligned}$$

Assuming scenario (i) and substituting for the change in labor unit requirements (3.67, 3.68, 3.69, 3.70), yields

$$\begin{aligned}\hat{L}_X|_{\hat{\phi}_{YL}>0} &= \theta_{XH}\sigma^X(\hat{w}_H - \hat{w}_L) + \hat{q}_X < 0 \\ \hat{L}_Y|_{\hat{\phi}_{YL}>0} &= \theta_{XH}\sigma^Y(\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL}) - \hat{\phi}_{YL} + \hat{q}_Y \\ \hat{H}_X|_{\hat{\phi}_{YL}>0} &= -\theta_{XL}\sigma^X(\hat{w}_H - \hat{w}_L) + \hat{q}_X \\ \hat{H}_Y|_{\hat{\phi}_{YL}>0} &= -\theta_{YL}\sigma^Y(\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL}) + \hat{q}_Y > 0\end{aligned}$$

Finally, substitute for the change in relative wages

$$\begin{aligned}\hat{L}_X|_{\hat{\phi}_{YL}>0} &= \theta_{XH}\sigma^X\left(-\frac{\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL}\right) - \frac{\delta_H\lambda_{YL} + \delta_L\lambda_{YH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} - \frac{(1-\sigma^Y)\lambda_{YH}\lambda_{YL}}{\Delta_\Lambda}\hat{\phi}_{YL} \\ &= -\frac{\theta_{XH}\sigma^X\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} - \frac{\delta_H\lambda_{YL} + \delta_L\lambda_{YH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} - \frac{(1-\sigma^Y)\lambda_{YH}\lambda_{YL}}{\Delta_\Lambda}\hat{\phi}_{YL} \\ \hat{L}_Y|_{\hat{\phi}_{YL}>0} &= \theta_{XH}\sigma^Y\left(-\frac{\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} + \hat{\phi}_{YL}\right) - \hat{\phi}_{YL} \\ &\quad + \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} + \frac{(1-\sigma^Y)\lambda_{YL}\lambda_{XH}}{\Delta_\Lambda}\hat{\phi}_{YL} + \theta_{YL}\sigma^Y\hat{\phi}_{YL} \\ &= -\frac{\theta_{XH}\sigma^Y\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} + \hat{\phi}_{YL} - \hat{\phi}_{YL} + \\ &\quad \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} + \frac{(1-\sigma^Y)\lambda_{YL}\lambda_{XH}}{\Delta_\Lambda}\hat{\phi}_{YL} + \theta_{YL}\sigma^Y\hat{\phi}_{YL} \\ \hat{H}_X|_{\hat{\phi}_{YL}>0} &= -\theta_{XL}\sigma^X\left(-\frac{\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL}\right) - \frac{\delta_H\lambda_{YL} + \delta_L\lambda_{YH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} - \frac{(1-\sigma^Y)\lambda_{YH}\lambda_{YL}}{\Delta_\Lambda}\hat{\phi}_{YL} \\ &= \frac{\theta_{XL}\sigma^X\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} - \frac{\delta_H\lambda_{YL} + \delta_L\lambda_{YH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} - \frac{(1-\sigma^Y)\lambda_{YH}\lambda_{YL}}{\Delta_\Lambda}\hat{\phi}_{YL} \\ \hat{H}_Y|_{\hat{\phi}_{YL}>0} &= -\theta_{YL}\sigma^Y\left(-\frac{\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} + \hat{\phi}_{YL}\right) + \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} \\ &\quad + \frac{(1-\sigma^Y)\lambda_{YL}\lambda_{XH}}{\Delta_\Lambda}\hat{\phi}_{YL} + \theta_{YL}\sigma^Y\hat{\phi}_{YL} \\ &= \frac{\theta_{YL}\sigma^Y\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} - \theta_{YL}\sigma^Y\hat{\phi}_{YL} + \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} \\ &\quad + \frac{(1-\sigma^Y)\lambda_{YL}\lambda_{XH}}{\Delta_\Lambda}\hat{\phi}_{YL} + \theta_{YL}\sigma^Y\hat{\phi}_{YL}\end{aligned}$$

With Cobb Douglas elasticities, these equations reduce to

$$\hat{L}_X|_{\hat{\phi}_{YL}>0} = -\frac{\theta_{XH}\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} - \frac{\delta_H\lambda_{YL} + \delta_L\lambda_{YH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} < 0 \quad (3.89)$$

$$\begin{aligned} \hat{L}_Y|_{\hat{\phi}_{YL}>0} &= -\frac{\theta_{YH}\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} + \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} \\ &= -\frac{\theta_{YH}\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} + \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} \end{aligned} \quad (3.90)$$

$$\hat{H}_X|_{\hat{\phi}_{YL}>0} = \frac{\theta_{XL}\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} - \frac{\delta_H\lambda_{YL} + \delta_L\lambda_{YH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} \quad (3.91)$$

$$\begin{aligned} \hat{H}_Y|_{\hat{\phi}_{YL}>0} &= \frac{\theta_{YL}\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} + \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} \\ &= \frac{\theta_{YL}\theta_{YL}}{\Delta_\Theta}\hat{\phi}_{YL} + \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YL}\hat{\phi}_{YL} > 0 \end{aligned} \quad (3.92)$$

For scenario (ii), we obtain

$$\hat{L}_X|_{\hat{\phi}_{YH}>0} = -\frac{\theta_{XH}\theta_{YH}}{\Delta_\Theta}\hat{\phi}_{YH} - \frac{\delta_H\lambda_{YL} + \delta_L\lambda_{YH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YH}\hat{\phi}_{YH} < 0 \quad (3.93)$$

$$\hat{L}_Y|_{\hat{\phi}_{YH}>0} = -\frac{\theta_{YH}\theta_{YH}}{\Delta_\Theta}\hat{\phi}_{YH} + \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YH}\hat{\phi}_{YH} \quad (3.94)$$

$$\hat{H}_X|_{\hat{\phi}_{YH}>0} = \frac{\theta_{XL}\theta_{YH}}{\Delta_\Theta}\hat{\phi}_{YH} - \frac{\delta_H\lambda_{YL} + \delta_L\lambda_{YH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YH}\hat{\phi}_{YH} \quad (3.95)$$

$$\hat{H}_Y|_{\hat{\phi}_{YH}>0} = \frac{\theta_{YL}\theta_{YH}}{\Delta_\Theta}\hat{\phi}_{YH} + \frac{\delta_H\lambda_{XL} + \delta_L\lambda_{XH}}{\Delta_\Theta\Delta_\Lambda}\theta_{YH}\hat{\phi}_{YH} > 0 \quad (3.96)$$

Chapter 4

International Outsourcing and the Sector Bias: New Empirical Evidence

Abstract

Considering labor market effects of International Outsourcing on more disaggregated industry levels, a sector bias appears showing that low skilled labor receives a wage premium when International Outsourcing takes place in low skill intensive industries. Empirical contributions, however, fail to test this pattern. This paper formally illuminates the sector bias of International Outsourcing and provides new empirical evidence for Germany. Applying a panel data analysis, significant results confirm the decreasing wage gap if International Outsourcing takes place in low skill intensive industries. Thus, harmful effects of International Outsourcing for low skilled labor seem to be exaggerated.

JEL classification: F16; J31; F40

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Keywords: International Outsourcing; sector bias; wage effects

4.1 Introduction

Within the last decades, International Outsourcing gained increasing importance in political discussion as well as in economic research. Thus, Grossman and Helpman (2005) recently noticed that “we live in an age of outsourcing” (p. 135). In industrialized countries, International Outsourcing is seen as an additional force toward labor market disruptions. If an economy relocates its relative low skill intensive production blocks abroad, relative demand for low skilled labor decreases, inducing an upward pressure on the relative wage for the high skilled. This beneficial effect for high skilled labor is harmful for the low skilled and induces welfare reducing effects in general equilibrium. These effects are known as the so-called factor bias of International Outsourcing, theoretically and empirically stressed in Feenstra and Hanson (1996a,b).

When moving the focus toward more disaggregated industry levels, results may differ. As Arndt (1997, 1998a,b) theoretically shows, a sector bias is at force, inducing different labor market effects if International Outsourcing takes place in different industries.¹ If the relative high skill intensive industry relocates production fragments abroad, the reduced production costs induce an additional gain enabling a wage premium for high skilled labor. By contrast, if International Outsourcing takes place in the relative low skill intensive industry, relative wages of the low skilled increase. Thus, by contrast to the factor bias of International Outsourcing, the sector bias allows situations where low skilled labor benefits from International Outsourcing in receiving a wage premium. In general equilibrium, this pattern decreases the welfare reducing effects of International Outsourcing. Thus, Arndt (1997) concludes that “concerns about the welfare-reducing implications of offshore sourcing appear to be greatly exaggerated” (p. 77).²

In the empirical literature, most contributions consider more aggregated industry levels (typically the manufacturing industry) and thus, directly aim to test the factor bias of the one-sector model of Feenstra and Hanson (1996b) and not the sector bias of International Outsourcing. Feenstra and Hanson (1996a,b, 1999) first highlight the importance of International Outsourcing for understanding changes in labor demand. With statistically significant results supporting the factor bias, they present

¹The discussion if it is the sector or the factor bias that matters most is well known from the literature on technical progress (cf. Leamer, 1996; Krugman, 2000).

²Egger and Falkinger (2003) theoretically show that the dominance of the factor or the sector bias in International Outsourcing models depends on different equilibrium situations. Within a diversified International Outsourcing equilibrium, it is the sector bias that determines the factor price developments. However, if there remain firms with integrated production patterns even in the outsourcing sector, it is the factor bias that matters.

positive effects of International Outsourcing on relative wages of the high skilled in the US manufacturing industry. Investigating 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. Hijzen et al. (2005) estimate the effects of International Outsourcing within the manufacturing sector in the UK and also note that International Outsourcing has a strong negative effect on the demand of low skilled workers. For Germany, Falk and Koebel (2002) estimate a factor demand system based on the Box-Cox cost function. As results they note that output and capital growth are more important than International Outsourcing for explaining changes in labor demand. Since these contributions consider more aggregated industry levels, they build on the one-sector model of Feenstra and Hanson (1996b) and thus, are not capable (and even not designed) to examine the importance of the sector bias of International Outsourcing. In order to investigate this pattern, analysis has to move the focus toward more disaggregated industry levels. To this end, only few contributions provide empirical evidence.

Hijzen (2007) investigates the effects of International Outsourcing and skill biased technical change on factor prices in the UK for the period 1993-1998. He shows that International Outsourcing effects are significant, however, technical change is the predominant force behind the change in relative wages. Additionally, he mentions the importance of the sector bias for International Outsourcing effects on labor markets. Based on a huge micro-econometric analysis, Geishecker and Görg (2005, 2008) show for the German economy that International Outsourcing significantly reduces the real wage of low skilled workers employed in low skill intensive industries, whereas effects on low skilled workers in high skill intensive industries are not as significant. On the other hand, high skilled workers significantly gain from international fragmentation only if they are employed in high skill intensive industries. Since these results base on a micro-econometric analysis and are not in a relative form, they can not be directly assigned to the factor or the sector bias of International Outsourcing.

Since the few empirical papers investigating International Outsourcing effects on more disaggregated industry levels do not aim to examine the theoretically mentioned sector bias, there is a lack of research showing that low skilled labor receives a wage premium and thus, benefits from International Outsourcing as it takes place in low skill intensive industries. This paper tries to contribute to fill this gap.

Therefore, Section 4.2 provides a theoretical framework, illuminating the sector bias of International Outsourcing in examining especially the effects on the wage differential. The model follows the duality approach in line with Uzawa (1964), Diewert (1971,

1974), Woodland (1977), and Mussa (1979) and introduces International Outsourcing similar to skill biased technical progress as in Jones (1965). In order to test the sector bias empirically, Section 4.3 describes the index used to measure International Outsourcing activities and provides first descriptive results. The index used is characterized by good properties for measuring International Outsourcing on more disaggregated industry levels. In order to provide some descriptive statistics, the level as well as the development of International Outsourcing is measured for the period 1991 - 2000 within a German case-study, considering different levels of industry aggregation. In Section 4.4, a panel data analysis is applied supporting the sector bias of International Outsourcing empirically. Using data from the German Socio Economic Panel (GSOEP) and the Federal Statistical Office in Germany, the within industries' wage differential is regressed on the International Outsourcing activity, as well as the output and the high to low skilled labor ratio as control variables. As it turns out, highly significant results confirm the theoretical findings. If International Outsourcing takes place in relative high skill intensive industries, it significantly increases the wage gap between high and low skilled labor. By contrast, if relative low skill intensive industries relocate their production fragments, the wage differential significantly decreases. These results empirically support the sector bias of International Outsourcing: There indeed exist cases where low skilled labor benefits in receiving a wage premium. Section 4.5 concludes by summarizing the main findings.

Two aspects are beyond the aim of this contribution. Even though theoretical research mostly examines the sector bias within general equilibrium, the analysis in this paper follows a partial equilibrium approach, focusing solely on labor market implications. Second, the paper investigates the sector bias and does not aim to examine whether it is the factor or the sector bias that is more important for International Outsourcing effects.

4.2 Formal Duality Approach of the Sector Bias

The sector bias of International Outsourcing is illuminated in Arndt (1997, 1998a,b). Examining International Outsourcing on more disaggregated industry levels, Arndt shows that labor market effects crucially depend on the relative skill intensity of the industry relocating its production fragments. Based on a traditional 2 x 2 Heckscher-Ohlin model he shows that, if International Outsourcing takes place in the relative low skill intensive industry, relative wages of the low skilled increase. By contrast,

if International Outsourcing takes place in the relative high skill intensive industry, relative wages of the high skilled increase. These effects occur either if the industries relocate their high or their low skill intensive production blocks. Thus, low skilled labor can benefit from International Outsourcing as it takes place in the relative low skill intensive industry.

In order to base the empirical analysis below on a theoretical model, this section provides a formal examination of the sector bias of International Outsourcing. The model uses the dual approach, based on Shephard's Lemma, and follows the line of theoretical trade contributions by Uzawa (1964), Diewert (1971, 1974), Woodland (1977), and Mussa (1979). The modern duality approach in international trade theory formulates equilibrium conditions in terms of unit cost functions rather than production functions. As Shephard's Lemma shows, with unit cost functions differentiable at the factor price vector w^* , the cost minimizing input-output-coefficients can simply be obtained by formulating the partial derivatives of the unit cost functions.

Thus, assume an economy facing given world prices p with two industries, a relative high skill intensive (X) and a relative low skill intensive one (Y). Both industries use two primary inputs, low skilled labor L and high skilled labor H , to produce goods of quantity q_i (with $i = X, Y$). Factors are mobile between industries, but internationally immobile. The home economy faces an inelastic supply of factors (\bar{L}, \bar{H}) and remains incompletely specialized ($q_i > 0$) throughout the process. Additionally, in order to abstract from the demand side, we assume the elasticity of demand being unity ($\sigma^D = 1$). Thus, with $\hat{p} = 0$ and $\sigma^D = 1$, the world market absorbs changes in demand and we are able to focus explicitly on the supply side, which mainly drives the results. Thus, with goods as well as factor markets perfectly competitive, unit costs of both industries equal the price

$$c_X(w_L, w_H) = a_{XL}w_L + a_{XH}w_H = p \quad (4.1)$$

$$c_Y(w_L, w_H) = a_{YL}w_L + a_{YH}w_H = 1 \quad (4.2)$$

with c_i as unit costs, a_{ij} as unit factor requirements ($j = L, H$), w_j as factor prices and the price of the low skill intensive good Y as numeraire. The unit cost functions are positive, linearly homogeneous and concave of $w > 0$.

In order to introduce International Outsourcing activities, we define φ_{ij} as an International Outsourcing parameter, similar to skill biased technical change in Jones (1965). Since International Outsourcing is assumed to reduce labor unit requirements,

the percentage change $\hat{\varphi}_{ij} \equiv -\frac{1}{a_{ij} \cdot (\partial a_{ij} / \partial IO)}$ is a measure showing the alteration in a_{ij} due to International Outsourcing (*IO*) that would take place at constant wages. Thus, we can rewrite the unit cost functions (4.1) and (4.2) as

$$c_X(\vec{w}_L, \vec{w}_H) = \vec{a}_{XL}\vec{w}_L + \vec{a}_{XH}\vec{w}_H \quad (4.3)$$

$$c_Y(\vec{w}_L, \vec{w}_H) = \vec{a}_{YL}\vec{w}_L + \vec{a}_{YH}\vec{w}_H \quad (4.4)$$

with $\vec{w}_j \equiv \frac{w_j}{\varphi_{ij}}$ and $\vec{a}_{ij} \equiv \varphi_{ij}a_{ij}$ as wages and labor unit requirements including International Outsourcing activities.³ When totally differentiating the unit cost functions in order to minimize production costs, we achieve equilibrium production in both industries

$$\theta_{XL}\hat{w}_L + \theta_{XH}\hat{w}_H = \theta_{XL}\hat{\varphi}_{XL} + \theta_{XH}\hat{\varphi}_{XH} \quad (4.5)$$

$$\theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H = \theta_{YL}\hat{\varphi}_{YL} + \theta_{YH}\hat{\varphi}_{YH} \quad (4.6)$$

with factor income shares $\theta_{ij} \equiv \frac{a_{ij}w_j}{p_i}$ and a “hat” over variables denoting percentage changes. As equations (4.5) and (4.6) illuminate, there are four International Outsourcing scenarios possible: (i) International Outsourcing of the low skill intensive production block in the relative high skill intensive industry ($\hat{\varphi}_{XL} > 0$), (ii) the relative high skill intensive industry relocating its high skill intensive production block ($\hat{\varphi}_{XH} > 0$), (iii) International Outsourcing of the low skill intensive block of the relative low skill intensive industry ($\hat{\varphi}_{YL} > 0$), and (iv) the relative low skill intensive industry relocating its high skill intensive production fragments ($\hat{\varphi}_{YH} > 0$).

As we know from Arndt (1997), International Outsourcing activities in the relative high skill intensive industry increase the relative wage of the high skilled, either if the industry relocates its low skill intensive (scenario i) or its high skill intensive production block (ii). By contrast, if International Outsourcing takes place in the relative low skill intensive industry, the relative wage of the low skilled increases. Again, either if the industry relocates its low skill intensive (iii), or its high skill intensive part of production (iv).

³Modeling International Outsourcing in this way does not consider its determinants. Endogenizing International Outsourcing is beyond the scope of the contribution, however, with this kind of modeling International Outsourcing, the paper is in line with the framework presented in Arndt (1997, 1998a,b) and thus, directly relates to the sector bias of International Outsourcing.

In order to examine these wage effects formally, consider first International Outsourcing occurring in the relative high skill intensive industry (scenarios i and ii). Thus, only $\hat{\phi}_{XL} > 0$ and / or $\hat{\phi}_{XH} > 0$ whereas $\hat{\phi}_{YL} = \hat{\phi}_{YH} = 0$ so that (4.5) and (4.6) change to

$$\theta_{XL}\hat{w}_L + \theta_{XH}\hat{w}_H|_{(\hat{\phi}_{YL}=\hat{\phi}_{YH}=0)} = \theta_{XL}\hat{\phi}_{XL} + \theta_{XH}\hat{\phi}_{XH} \quad (4.7)$$

$$\theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H|_{(\hat{\phi}_{YL}=\hat{\phi}_{YH}=0)} = 0 \quad (4.8)$$

Now, (4.7) and (4.8) can easily be solved for the percentage change in low and high skilled real wages

$$\hat{w}_L|_{(\hat{\phi}_{YL}=\hat{\phi}_{YH}=0)} = -\frac{\theta_{XL}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{XL} - \frac{\theta_{XH}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{XH} \quad (4.9)$$

$$\hat{w}_H|_{(\hat{\phi}_{YL}=\hat{\phi}_{YH}=0)} = \frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{XL} + \frac{\theta_{XH}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{XH} \quad (4.10)$$

with Δ_{Θ} as the determinant of the matrix of factor income shares $\Theta \equiv \begin{pmatrix} \theta_{XH} & \theta_{XL} \\ \theta_{YH} & \theta_{YL} \end{pmatrix}$.

Thus, we obtain

$$\hat{w}_H - \hat{w}_L|_{(\hat{\phi}_{YL}=\hat{\phi}_{YH}=0)} = \frac{\theta_{XL}}{\Delta_{\Theta}}\hat{\phi}_{XL} + \frac{\theta_{XH}}{\Delta_{\Theta}}\hat{\phi}_{XH} \quad (4.11)$$

as the change in relative high skilled wages. Since $\Delta_{\Theta} > 0$, International Outsourcing in the relative high skill intensive industry increases relative wages of the high skilled ($\hat{w}_H - \hat{w}_L|_{(\hat{\phi}_{YL}=\hat{\phi}_{YH}=0)} > 0$).⁴

On the other hand, if International Outsourcing takes place in the relative low skill intensive industry (scenarios iii and iv), only $\hat{\phi}_{YL} > 0$ and / or $\hat{\phi}_{YH} > 0$ whereas $\hat{\phi}_{XL} = \hat{\phi}_{XH} = 0$. In this case, (4.5) and (4.6) change to

$$\theta_{XL}\hat{w}_L + \theta_{XH}\hat{w}_H|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} = 0 \quad (4.12)$$

$$\theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} = \theta_{YL}\hat{\phi}_{YL} + \theta_{YH}\hat{\phi}_{YH} \quad (4.13)$$

Now, (4.12) and (4.13) can be solved for the percentage change in low and high skilled real wages

⁴All the calculations of this paper are presented in greater detail in the Appendix (p. 95).

$$\hat{w}_L|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} = \frac{\theta_{XH}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} + \frac{\theta_{XH}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} \quad (4.14)$$

$$\hat{w}_H|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} = -\frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} - \frac{\theta_{XL}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} \quad (4.15)$$

Thus, the effect of International Outsourcing on the wage differential can be described as

$$\hat{w}_H - \hat{w}_L|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} = -\frac{\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} - \frac{\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} \quad (4.16)$$

International Outsourcing decreases the wage differential between high and low skilled labor if it takes place in the relative low skill intensive industry ($\hat{w}_H - \hat{w}_L|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} < 0$). These effects formally describe the labor market implications of the sector bias of International Outsourcing as illuminated in Arndt (1997) and provide the theoretical basis to be tested in the empirical analysis below.⁵

4.3 German Case-Study: First Descriptive Results

In order to examine the development of International Outsourcing in Germany, this section first introduces the index used to measure International Outsourcing. Afterward it applies a descriptive case-study calculating the magnitude as well as the development of International Outsourcing for the period 1991-2000. The examination focuses especially on the sector bias of International Outsourcing and thus, on the four different International Outsourcing scenarios described above.

Since International Outsourcing can not be observed on a macroeconomic level, there is a need to proxy it. Therefore, research developed several International Outsourcing indices with a few of them very common in use.⁶ To measure International Outsourcing activities, this paper uses one of these indices called Vertical Specialization (VS). As shown in Chapter 2, the VS-index is characterized by good properties for more disaggregated industry levels as well. These properties are welcome when examining

⁵Since the empirical analysis focuses on labor market effects of International Outsourcing, this section does not discuss general equilibrium effects. Rather, it only addresses the first step: the effects of International Outsourcing on the wage differential. For the whole picture of general equilibrium effects in this model see Chapter 3.

⁶For a discussion of recently used International Outsourcing indices and an empirical analysis of their impact on labor market estimations see Chapter 2.

the sector bias of International Outsourcing within the panel data analysis below.⁷ The VS-index can be calculated using

$$VS_t = \sum_{j=1}^n \sum_{w=1}^z \frac{\frac{m_{wt}}{s_{wt}} \cdot q_{wjt}}{p_{jt}} \quad (4.17)$$

with q_{wjt} as total inputs from industry w ($w = 1, \dots, z$) used to produce output in industry j ($j = 1, \dots, n$) at point of time t , and p_{jt} as production value in industry j . With m_{wt} as total imports and s_{wt} as the domestic use of good w , $\frac{m_{wt}}{s_{wt}}$ is a fraction estimating the international component of intermediates. Thus, since there is no need to directly observe imported inputs, the index is quite popular and often used in recent empirical examinations.

Campa and Goldberg (1997) present this index as “Imported Inputs into Production” and descriptively calculate International Outsourcing shares for the US, Canada, the UK, and Japan. Considering different input-output tables since 1974 they show that International Outsourcing increased strongly in the US, Canada, and the UK, but decreased in Japan. Feenstra (1998) summarizes different tables from Campa and Goldberg (1997) and additionally presents calculations for some politically important disaggregated industries as well. Strauss-Kahn (2003) also uses the VS-index and presents results for France showing that International Outsourcing increases, however, illuminating heterogeneous patterns for more disaggregated industries.⁸

To examine International Outsourcing activities in Germany the VS-index is used to calculate the magnitude as well as the development for several levels of industry aggregation: the whole economy, the manufacturing industry, low skill intensive industries of the manufacturing industry, high skill intensive industries of the manufacturing industry, as well as the service sector. In order to illuminate the sector bias, the indices are additionally calculated for outsourcing low and high skill intensive parts in the relative low and high skill intensive industries.⁹ As data, the calculations base on input-output tables from the German Federal Statistical Office. Figure 4.1 provides a first impression of the development of International Outsourcing in Germany from 1991-2000.

⁷Note that “Vertical Specialization” is sometimes also used as a synonym for International Outsourcing. In this paper, however, it is used throughout to identify one specific index.

⁸The 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.

⁹To differ between high and low skill intensive industries of the manufacturing sector, the paper refers to a cluster analysis provided by Geishecker and Görg (2005). The results of this cluster analysis are presented in the Appendix of Chapter 2 (p. 34).

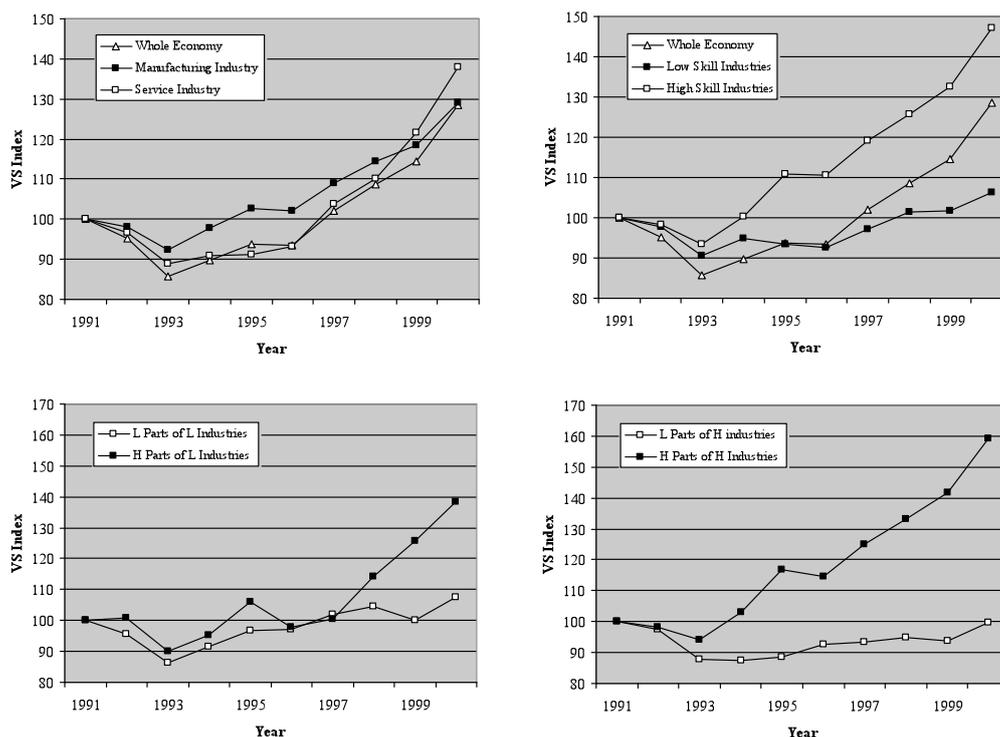


Figure 4.1: Development of International Outsourcing in Germany

The upper part of the figure shows the change for different levels of industry aggregation. Generally, International Outsourcing fluctuated slightly in the first years from 1991 - 1995, before the main boost occurred in the second half of the time period. Table 4.1 presents the corresponding magnitudes of International Outsourcing in 1991, 1995, and 2000. Considering more disaggregated industry levels, there are several patterns of the level and the development of International Outsourcing that are worth being mentioned. In the service industry, International Outsourcing is still at a quite low level (3 percent in 1991, 5 percent in 2000), however, with a very strong increase of nearly 40 percent over the considered time period (upper left part of the figure). This result for the German economy is similar to the patterns in the UK and the US, as shown in Amiti and Wei (2005a). In order to focus on the above described sector bias of International Outsourcing, the activities in the disaggregated high skill intensive and low skill intensive industries are of special interest. As the calculations show, both industries experience different patterns of International Outsourcing activities. In the high skill intensive industries, International Outsourcing started at a lower level in 1991 (10 percent vs. 13 percent) and, due to an enormous increase of nearly 50 percent (upper right part of the figure), reached a higher level in 2000 (15 percent vs. 14 percent). Thus, the biggest increase of International Outsourcing activities in Germany occurred in the

Table 4.1: Magnitude of International Outsourcing in Germany

	1991	1995	2000
Whole Economy	7%	6%	9%
Manufacturing Industry	11%	12%	15%
Low Skill Industries	13%	12%	14%
High Skill Industries	10%	11%	15%
Service Industry	3%	3%	5%
Low Skill Parts of Low Skill Industries	6%	6%	6%
High Skill Parts of Low Skill Industries	3%	3%	4%
Low Skill Parts of High Skill Industries	2%	2%	2%
High Skill Parts of High Skill Industries	8%	9%	12%

high skill intensive industries and in the service sector.

Another interesting picture emerges when distinguishing between the different International Outsourcing scenarios crucial for the sector bias, relocating low or high skill intensive parts of either the relative low or high skill intensive industries. As the lower part of Figure 4.1 shows, the high as well as the low skill intensive industries' main International Outsourcing activity was relocating the high skill intensive production blocks. Whereas outsourcing of the low skill intensive parts was nearly stable in both industries. By contrast to this similar pattern of development, the magnitude of International Outsourcing activities strongly differs between the two industries. As can be seen in the lower part of Table 4.1, International Outsourcing of the high skill intensive production parts is at a relative high level in the high skill intensive industries. By contrast, the low skill intensive industries experience a relative high level of International Outsourcing in their low skill intensive parts of production.

This picture conflicts with the common sentiment policy makers and the public have on International Outsourcing activities in industrialized economies. First, International Outsourcing in high skill intensive industries is already at a high level, and still increasing strongly. Second, the main bulk of International Outsourcing was not relocating low skill intensive production blocks (to gain e.g. from wage differentials to low skill abundant economies). By contrast, the strongest increase occurred by International Outsourcing of the high skill intensive parts of production. This, however, is not due to a small level of International Outsourcing of these production fragments. They are already at a very high level in high skill intensive industries. Thus, with respect to determinants of International Outsourcing, there seem to be several different forces at work, providing plenty of room for research.¹⁰

¹⁰However, as mentioned above, investigating the determinants of International Outsourcing is beyond the scope of this contribution.

4.4 Empirical Evidence on the Sector Bias

After examining International Outsourcing descriptively, this section applies several panel data analyses testing labor market effects of the sector bias of International Outsourcing.

Data

The analysis builds on the GSOEP (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 VS-index and (ii) the output of each industry, according to the two-digit NACE classification. To estimate labor market effects, the wage differential per industry is calculated using the GSOEP data considering the waves *H/8* to *Q/17* (1991-2000). The GSOEP includes information on the wages of around 40,000 individuals. In the sample, wages are observed as average wages per hour, including additional payments like e.g. 13th or 14th month pay, holiday or Christmas bonuses.¹¹ Since the GSOEP assigns each individual to the two-digit NACE industry where she works and observes the education of each individual with respect to the international comparable ISCED classification,¹² additional information is provided to aggregate the individual data in order to obtain the desired information on a macro-level. To aggregate the individual wages, the mean average within each two-digit NACE industry is calculated, separated for high skilled and low skilled labor.¹³ Additionally, the industries' utilization of high skilled labor is calculated as a ratio of high to low skilled labor. Thus, with the mean wage of high skilled and low skilled labor in each two-digit NACE industry, with the output as well as the high to low skilled labor ratio of each industry and with the International Outsourcing activity measured with the VS-index, we have the necessary data at hand and are able to move forward to test the sector bias of International Outsourcing empirically.

¹¹For detailed information about the structure and the different variables of the GSOEP see Haisken-DeNew and Frick (2005).

¹²The "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.

¹³In 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 workers are individuals with some form of post secondary education.

Estimation and Results

In order to examine the effects of International Outsourcing on the within industries' wage differential,

$$\ln WD_{jt} = \beta_0 + \beta_1 VS_{jt} + \beta_2 Y_{jt} + \beta_3 \frac{H_{jt}}{L_{jt}} + u_j + \epsilon_{jt} \quad (4.18)$$

is estimated with WD_{jt} as the wage differential between high and low skilled labor in industry j at time t . The explanatory variable of interest is the level of International Outsourcing activity measured with the Vertical Specialization index VS_{jt} . As control variables, the output of each industry Y_{jt} as well as the industries' high to low skilled labor ratio $\frac{H_{jt}}{L_{jt}}$, with H_j as high and L_j as low skilled labor in industry j , are 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} .¹⁴ The equation is estimated for the different levels of industry aggregation using the fixed-effects (FE) panel data estimator. Since the level of International Outsourcing, output, as well as high to low skilled labor ratio are 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. To additionally confirm the use of the FE estimator from a statistical point of view, two test statistics are applied. First, the Breusch and Pagan test for unobserved heterogeneity. Highly significant results confirm the presence of unobserved heterogeneity in most of the models. To proof which estimator should be used to capture the unobserved heterogeneity, Hausman tests are applied testing the rejection of the null hypothesis (H_0) assuming orthogonality of the u_j . As results show, H_0 can be mostly rejected indicating the use of the consistent and efficient FE estimator. Several additional tests for consistency of the estimated error terms, the modified Wald test for groupwise heteroscedasticity as well as the Wooldridge test for autocorrelation show that the error terms of some models are characterized by a heteroscedastic error structure as well as autocorrelation. To solve for these problems, and to consider possible outliers, the variances of all the models

¹⁴Equation (4.18) is similar to a typical wage equation often used in empirical analysis (cf. Feenstra and Hanson, 1996b), however, with a small difference: As endogenous variable the equation includes the wage differential within an industry, instead of mean wages. This allows us to focus more directly on distributional effects of International Outsourcing and on the sector bias mentioned above. Due to data constraints, the regression does not control for capital utilization, instead, it contains the industries' high to low skilled labor ratio as control variable. We additionally estimated the equation while including the ratio of high skilled labor to total employment (as done in Chapter 2). The results, however, are overall robust and do not differ.

Table 4.2: Effects of International Outsourcing on the Wage Gap (1)

	Whole Economy	Manufacturing Industry	Service Industry	Low Skill Industries	High Skill Industries
VS	2.1137 (0.33)	-10.1789 (-1.01)	7.4625 (1.32)	-22.2749*** (-5.26)	15.5984* (2.07)
Y	5.76e-06* (1.38)	12.00e-06 (1.58)	4.96e-06 (0.94)	42.00e-06** (2.84)	-7.11e-06* (-2.11)
H / L	0.0743** (2.33)	0.1187 (0.68)	0.0642* (2.02)	-0.4930 (-1.48)	0.3082*** (3.55)
Observations	384	159	191	80	86
Groups	48	20	23	10	10
R ²	0.0340	0.0744	0.0448	0.3911	0.3356
Prob > F	0.0030	0.1484	0.0009	0.0031	0.0022

(t-Statistics in parantheses)

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

are estimated using the robust Huber / White / Sandwich estimator instead of the traditional calculation. Thus, the consistency and the comparability of the estimation results can be assured. In order to account for possible endogeneity problems, several Durbin-Wu-Hausman tests are applied, testing if endogeneity could significantly affect the consistency of the estimated coefficients. The tests indicate that, considering the regressions for the manufacturing sector, for the low skill intensive industries, and for the low skill intensive parts of the low skill intensive industries, endogeneity could bias results. Thus, the lagged versions of the VS-index (VS_1) are used in these cases. Table 4.2 presents the estimation results.

As the table shows, International Outsourcing increases the wage differential between high and low skilled workers within the aggregated whole economy. However, not at a statistically significant level. As expected for the aggregate, the R-squares are still at a quite low level. Since in longitudinal analysis much variances influence the error term, the R-squares of the FE-estimator do not have the properties of the OLS R-squares and thus, can be misleading when used as the main gauge for success. As an additional proof of the goodness of the estimated model, the table presents the F-value being significant at the 1 percent level. Thus, the model is fitted quite well. In the manufacturing industry, International Outsourcing decreases the wage differential between low and high skilled labor. Again, the effect is not within the common level of statistical significance. This result is in line with the results presented by Geishecker and Görg (2005) showing also insignificant effects of International Outsourcing (measured with another index: imported inputs in gross production) on wages in the overall manufacturing industry. In the service industry, the estimation results show a positive effect of International Outsourcing on the wage differential, however, the estimated

Table 4.3: Effects of International Outsourcing on the Wage Gap (2)

	low skill parts of low skill int. industries	high skill parts of low skill int. industries	low skill parts of high skill int. industries	high skill parts of high skill int. industries
VS	-24.3925*** (-5.05)	16.8478 (1.15)	-59.5542 (-1.62)	14.9593* (1.96)
Y	36.50e-06** (2.42)	9.39e-06 (0.33)	3.57e-06 (1.28)	-5.81e-06* (-1.93)
H/L	-0.5047 (-1.62)	-0.8420 (-1.68)	0.4240*** (5.23)	0.3167*** (3.71)
Observations	80	86	86	86
Groups	10	10	10	10
R ²	0.4174	0.1323	0.2889	0.3361
Prob > F	0.0030	0.2049	0.0016	0.0017

(t-Statistics in parantheses)

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

coefficient is still not significant.

In order to investigate the sector bias, the analysis has to be applied to more disaggregated industry levels. As the table shows, when considering low skill intensive and high skill intensive industries, results differ strongly. International Outsourcing increases the wage gap between high and low skilled labor when taking place in high skill intensive industries. By contrast, when the low skill intensive industries relocate production fragments, the wage gap decreases. Both estimation results are highly statistically significant. Also, the R-squares increase up to a level of around 40 percent for the low skill intensive industries. With this clearly differing pattern between high and low skill intensive industries, the empirical results emphasize the importance of the sector bias of International Outsourcing and support the theoretical findings mentioned above.¹⁵ Since the highly statistically significant effects in low and high skill intensive industries outperform each other, insignificant effects occur in the aggregated manufacturing sector. However, adding the positive effect of International Outsourcing on the wage gap in the service industry (even if not within the significant range), a positive pattern can also be achieved for the aggregated whole economy.

Another interesting picture emerges when analyzing the different International Outsourcing scenarios crucial for the sector bias. As Table 4.3 shows, the wage gap

¹⁵ Assuming incomplete specialization and labor to be perfectly mobile between industries, the theoretical results on relative wages are valid for the whole economy: Relative wages and their change needs to be the same in all industries to achieve positive production patterns. However, this assumption can only hold in theory but not in empirical contributions. Since labor can not be assumed to be perfectly mobile between industries, different industries need to get the possibility of achieving different relative wages and wage changes. To take account for this empirical feature, the panel data estimation allows for effects of International Outsourcing on the wage gap at the industry level. However, ceteris paribus, a change of the within industries' wage gap is in line with the change of the wage gap in the aggregate.

increases when the industries relocate their high skill intensive production patterns. By contrast, the wage gap decreases when the low skill intensive parts are relocated abroad. With respect to the high skill intensive industries, results are only significant when relocating the high skill intensive production parts. Considering the low skill intensive industries instead, implications are only significant for the relocation of the low skill intensive production blocks. This pattern additionally supports the sector bias of International Outsourcing.

4.5 Conclusions

For several years, labor market 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 important adjustment effects where empirical contributions failed to support theory. As e.g. Arndt (1997, 1998a,b) shows, if International Outsourcing takes place in the relative low skill intensive industry, relative wages of the low skilled increase. By contrast, relative wages of the high skilled increase if International Outsourcing takes place in the relative high skill intensive industry. This contribution empirically examines the importance of this so-called sector bias of International Outsourcing. As can be shown within a panel data analysis, the sector bias is an important feature of International Outsourcing implications on the German labor market (considering the period 1991-2000). Showing that the wage gap between high and low skilled labor increases significantly when International Outsourcing takes place in high skill intensive industries but decreases significantly if the low skill intensive industries relocate their production fragments, the empirical results directly confirm the theoretical findings.

Thus, the paper concludes as in Arndt (1997) that there indeed exist cases, even in industrialized economies, where low skilled labor benefits from International Outsourcing in receiving a wage premium. However, since the increase of International Outsourcing activities in the low skill intensive industries is only small compared to the increase in the high skill intensive ones, the beneficial effects may get outperformed by the harmful ones occurring in the high skill intensive industries.

With the panel data analysis presented above, this contribution does not aim to explain or extract the major forces of International Outsourcing on factor price changes. Therefore, it would be necessary to include a variety of explanatory variables and also to test the effects occurring within general equilibrium as e.g. in Harrigan and Balaban

(1999) or Tombazos (2003). Instead, this paper empirically investigates the importance of the skill intensity of an industry for labor market effects of International Outsourcing. The examination of the sector bias of International Outsourcing still leaves enough space for future research: The consideration of situations where only some firms of the sector outsource would e.g. allow deeper insights for a comparison of the importance of the sector vs. the factor bias of International Outsourcing.

Appendix: Calculations

The formal calculations of this chapter are part of the whole model presented in Chapter 3, however, appear slightly different in order to illuminate the relative wage effects of the sector bias of International Outsourcing. The numbered equations correspond to those in the text.

Starting from the same assumption, we again obtain the unit cost framework considering the outsourcing parameter φ (see equation 3.57 and 3.58)

$$c_X(\vec{w}_L, \vec{w}_H) = \vec{a}_{XL}\vec{w}_L + \vec{a}_{XH}\vec{w}_H = \varphi_{XL}a_{XL}\frac{w_L}{\varphi_{XL}} + \varphi_{XH}a_{XH}\frac{w_H}{\varphi_{XH}} \quad (4.19)$$

$$c_Y(\vec{w}_L, \vec{w}_H) = \vec{a}_{YL}\vec{w}_L + \vec{a}_{YH}\vec{w}_H = \varphi_{YL}a_{YL}\frac{w_L}{\varphi_{YL}} + \varphi_{YH}a_{YH}\frac{w_H}{\varphi_{YH}} \quad (4.20)$$

Taking the total differential and recalling that, due to the given world prices, changes in factor endowments have no effect on factor prices,

$$\begin{aligned} c_X &= \varphi_{XL}a_{XL}\frac{w_L}{\varphi_{XL}} + \varphi_{XH}a_{XH}\frac{w_H}{\varphi_{XH}} \\ dc_X &= \frac{dw_L}{\varphi_{XL}}(\varphi_{XL}a_{XL}) + \frac{dw_H}{\varphi_{XH}}(\varphi_{XH}a_{XH}) \\ &\quad - \frac{w_L}{(\varphi_{XL})^2}(\varphi_{XL}a_{XL})d\varphi_{XL} - \frac{w_H}{(\varphi_{XH})^2}(\varphi_{XH}a_{XH})d\varphi_{XH} \\ dc_X &= w_L a_{XL} \hat{w}_L + w_H a_{XH} \hat{w}_H - w_L a_{XL} \hat{\varphi}_{XL} - w_H a_{XH} \hat{\varphi}_{XH} = 0 \\ 0 &= \theta_{XL} \hat{w}_L + \theta_{XH} \hat{w}_H - \theta_{XL} \hat{\varphi}_{XL} - \theta_{XH} \hat{\varphi}_{XH} \end{aligned}$$

with $\theta_{ij} \equiv \frac{a_{ij}w_j}{p_i}$ and "hat" denoting percentage changes. For the relative low skill intensive industry (Y), we achieve

$$\begin{aligned}
c_Y &= \varphi_{YL}a_{YL}\frac{w_L}{\varphi_{YL}} + \varphi_{YH}a_{YH}\frac{w_H}{\varphi_{YH}} \\
dc_Y &= \frac{dw_L}{\varphi_{YL}}(\varphi_{YL}a_{YL}) + \frac{dw_H}{\varphi_{YH}}(\varphi_{YH}a_{YH}) \\
&\quad - \frac{w_L}{(\varphi_{YL})^2}(\varphi_{YL}a_{YL})d\varphi_{YL} - \frac{w_H}{(\varphi_{YH})^2}(\varphi_{YH}a_{YH})d\varphi_{YH} \\
dc_Y &= w_La_{YL}\hat{w}_L + w_Ha_{YH}\hat{w}_H - w_La_{YL}\hat{\varphi}_{YL} - w_Ha_{YH}\hat{\varphi}_{YH} = 0 \\
0 &= \theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H - \theta_{YL}\hat{\varphi}_{YL} - \theta_{YH}\hat{\varphi}_{YH}
\end{aligned}$$

Slightly rearranging, we achieve

$$\theta_{XL}\hat{w}_L + \theta_{XH}\hat{w}_H = \theta_{XL}\hat{\varphi}_{XL} + \theta_{XH}\hat{\varphi}_{XH} \quad (4.21)$$

$$\theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H = \theta_{YL}\hat{\varphi}_{YL} + \theta_{YH}\hat{\varphi}_{YH} \quad (4.22)$$

We can solve these two equations for changes in low and high skilled wages (\hat{w}_L, \hat{w}_H) due to exogenous changes in different International Outsourcing activities ($\hat{\varphi}_{ij}$).

Effects of International Outsourcing on Relative High Skill Wages

Assume that International Outsourcing takes place in the relative high skill intensive industry (X). Thus, $\hat{\varphi}_{XL} > 0$ and / or $\hat{\varphi}_{XH} > 0$, whereas $\hat{\varphi}_{YL} = \hat{\varphi}_{YH} = 0$. In this scenario, (4.21) and (4.22) change to

$$\theta_{XL}\hat{w}_L + \theta_{XH}\hat{w}_H|_{(\hat{\varphi}_{YL}=\hat{\varphi}_{YH}=0)} = \theta_{XL}\hat{\varphi}_{XL} + \theta_{XH}\hat{\varphi}_{XH} \quad (4.23)$$

$$\theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H|_{(\hat{\varphi}_{YL}=\hat{\varphi}_{YH}=0)} = 0 \quad (4.24)$$

These two equations can be solved for the percentage changes of low and high skilled wages. Therefore, applying some matrix algebra yields

$$\begin{pmatrix} \theta_{XH} & \theta_{XL} \\ \theta_{YH} & \theta_{YL} \end{pmatrix} \begin{pmatrix} \hat{w}_H \\ \hat{w}_L \end{pmatrix} = \begin{pmatrix} \theta_{XL}\hat{\varphi}_{XL} + \theta_{XH}\hat{\varphi}_{XH} \\ 0 \end{pmatrix}$$

and solve with the use of Cramer's rule

$$\begin{aligned}
\hat{w}_L|_{(\hat{\phi}_{YL}=\hat{\phi}_{YH}=0)} &= \frac{\begin{vmatrix} \theta_{XH} & \theta_{XL}\hat{\phi}_{XL} + \theta_{XH}\hat{\phi}_{XH} \\ \theta_{YH} & 0 \end{vmatrix}}{\Delta_{\Theta}} \\
&= -\frac{\theta_{XL}\theta_{YH}\hat{\phi}_{XL} + \theta_{XH}\theta_{YH}\hat{\phi}_{XH}}{\Delta_{\Theta}} \\
&= -\frac{\theta_{XL}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{XL} - \frac{\theta_{XH}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{XH}
\end{aligned} \tag{4.25}$$

$$\begin{aligned}
\hat{w}_H|_{(\hat{\phi}_{YL}=\hat{\phi}_{YH}=0)} &= \frac{\begin{vmatrix} \theta_{XL}\hat{\phi}_{XL} + \theta_{XH}\hat{\phi}_{XH} & \theta_{XL} \\ 0 & \theta_{YL} \end{vmatrix}}{\Delta_{\Theta}} \\
&= \frac{\theta_{XL}\theta_{YL}\hat{\phi}_{XL} + \theta_{XH}\theta_{YL}\hat{\phi}_{XH}}{\Delta_{\Theta}} \\
&= \frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{XL} + \frac{\theta_{XH}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{XH}
\end{aligned} \tag{4.26}$$

with $\Delta_{\Theta} \equiv \begin{vmatrix} \theta_{XH} & \theta_{XL} \\ \theta_{YH} & \theta_{YL} \end{vmatrix} > 0$.

For the change in relative high skill wages we obtain

$$\begin{aligned}
\hat{w}_H - \hat{w}_L|_{(\hat{\phi}_{YL}=\hat{\phi}_{YH}=0)} &= \left(\frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}} + \frac{\theta_{XL}\theta_{YH}}{\Delta_{\Theta}}\right)\hat{\phi}_{XL} + \left(\frac{\theta_{XH}\theta_{YL}}{\Delta_{\Theta}} + \frac{\theta_{XH}\theta_{YH}}{\Delta_{\Theta}}\right)\hat{\phi}_{XH} \\
&= \frac{\theta_{XL}}{\Delta_{\Theta}}\hat{\phi}_{XL} + \frac{\theta_{XH}}{\Delta_{\Theta}}\hat{\phi}_{XH}
\end{aligned} \tag{4.27}$$

If International Outsourcing takes place in the relative low skill intensive industry (Y), $\hat{\phi}_{YL} > 0$ and / or $\hat{\phi}_{YH} > 0$, whereas $\hat{\phi}_{XL} = \hat{\phi}_{XH} = 0$. In this scenario, (4.21) and (4.22) change to

$$\theta_{XL}\hat{w}_L + \theta_{XH}\hat{w}_H|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} = 0 \tag{4.28}$$

$$\theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} = \theta_{YL}\hat{\phi}_{YL} + \theta_{YH}\hat{\phi}_{YH} \tag{4.29}$$

These two equations can be solved for the percentage changes of low and high skilled labor. Therefore, apply some matrix algebra again

$$\begin{pmatrix} \theta_{XH} & \theta_{XL} \\ \theta_{YH} & \theta_{YL} \end{pmatrix} \begin{pmatrix} \hat{w}_H \\ \hat{w}_L \end{pmatrix} = \begin{pmatrix} 0 \\ \theta_{YL}\hat{\phi}_{YL} + \theta_{YH}\hat{\phi}_{YH} \end{pmatrix}$$

and solve for

$$\begin{aligned} \hat{w}_L|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} &= \frac{\begin{vmatrix} \theta_{XH} & 0 \\ \theta_{YH} & \theta_{YL}\hat{\phi}_{YL} + \theta_{YH}\hat{\phi}_{YH} \end{vmatrix}}{\Delta_{\Theta}} \\ &= \frac{\theta_{XH}\theta_{YL}\hat{\phi}_{YL} + \theta_{XH}\theta_{YH}\hat{\phi}_{YH}}{\Delta_{\Theta}} \\ &= \frac{\theta_{XH}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} + \frac{\theta_{XH}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} \end{aligned} \quad (4.30)$$

and

$$\begin{aligned} \hat{w}_H|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} &= \frac{\begin{vmatrix} 0 & \theta_{XL} \\ \theta_{YL}\hat{\phi}_{YL} + \theta_{YH}\hat{\phi}_{YH} & \theta_{YL} \end{vmatrix}}{\Delta_{\Theta}} \\ &= -\frac{\theta_{XL}\theta_{YL}\hat{\phi}_{YL} + \theta_{XL}\theta_{YH}\hat{\phi}_{YH}}{\Delta_{\Theta}} \\ &= -\frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} - \frac{\theta_{XL}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} \end{aligned} \quad (4.31)$$

For the percentage change in relative high skilled wages we obtain

$$\begin{aligned} \hat{w}_H - \hat{w}_L|_{(\hat{\phi}_{XL}=\hat{\phi}_{XH}=0)} &= -\left(\frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}} + \frac{\theta_{XH}\theta_{YL}}{\Delta_{\Theta}}\right)\hat{\phi}_{YL} - \left(\frac{\theta_{XL}\theta_{YH}}{\Delta_{\Theta}} + \frac{\theta_{XH}\theta_{YH}}{\Delta_{\Theta}}\right)\hat{\phi}_{YH} \\ &= -\frac{\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{YL} - \frac{\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{YH} \end{aligned} \quad (4.32)$$

Chapter 5

International Outsourcing and Wage Rigidity: A Formal Approach and First Empirical Evidence

Abstract

International Outsourcing effects on labor markets are mostly analyzed within flexible wage settings. Using a modern duality approach, this paper formally investigates differences occurring in industries with low skilled wage rigidity and, for the first time in literature, presents empirical evidence supporting the theoretical findings. Using a logit model to analyze microeconomic German panel data, results show that International Outsourcing significantly increases low skilled unemployment when taking place in industries characterized by low skilled wage rigidity. Thus, in terms of unemployment, not International Outsourcing but inflexible labor market institutions instead should be blamed for harming low skilled labor.

Keywords: International Outsourcing; wage rigidity; unemployment

JEL classification: F12, J64, F41

5.1 Introduction

Within the last decade, a huge area of theoretical as well as empirical literature emerged investigating implications of International Outsourcing. Most of these contributions assume flexible wage economies. With respect to labor market rigidities, that typically characterize major European economies, only few theoretical contributions emerged recently. However, there is still a lack of empirical evidence. This manuscript tries to contribute to fill this gap. Therefore, it formally analyzes the implications of low skilled wage rigidity on general equilibrium effects of International Outsourcing and provides this fields first empirical evidence: When industries are characterized by sticky wages for low skilled labor, International Outsourcing increases the wage gap between low and high skilled labor less extensively. This, however, has to be bought dearly with an increase in low skilled unemployment.

Concerning labor market effects of International Outsourcing in a flexible wage economies, Feenstra and Hanson (1996a,b) very early show that International Outsourcing increases the relative wage of high skilled labor on a more aggregated industry level in both, the insourcing (developing) as well as the outsourcing (developed) economy. Within a series of papers, Arndt (1997, 1998a,b) investigates general equilibrium effects of International Outsourcing at more disaggregated industry levels. Since producers shed their less competitive production blocks to become more efficient competitors on world markets, International Outsourcing has different effects depending on the relative skill intensity of the outsourcing industry. When taking place in the relative low skill intensive industry, International Outsourcing increases relative wages of the low skilled, and decreases them when taking place in the relative high skill intensive industry. Since the outsourcing industry gets more competitive on world markets, it increases output while the other industry, the one remaining integrated, contracts. Focusing on the implications on innovation, Glass and Saggi (2001) show that International Outsourcing decreases relative wages but increases the pace of innovation and therefore, accelerates the progression of the technology frontier. Deardorff (2001a,b) shows within a combination of a Ricardian and a Heckscher-Ohlin model, that adjustment effects of International Outsourcing depend on the factor intensities of the relocated production blocks. Egger and Falkinger (2003) focus on distributional effects of International Outsourcing. Considering different modes of final goods production, they investigate factor price consequences of International Outsourcing in several equilibrium situations. More recently, Grossman and Rossi-Hansberg (2008) present a simple paradigm investigating consequences of what they call “task-trade”

on prices, resource allocation, and welfare. Arguing in terms of factor augmenting technical changes, a decline in the costs of task trade directly boosts the productivity of the respective factor. Kohler (2008) presents a unified framework in order to explain the differences of the factor vs. the sector bias of International Outsourcing. His results show that the implications depend strongly on the shock that induces offshore sourcing (a reduction in factor costs of delocalization on the one hand or a change in prices for the tradable final good on the other hand). Thus, Kohler illuminates the huge importance of being explicit in this respect in order to avoid joint endogeneity of International Outsourcing with employment or wage effects.

In more recent recent years, economic literature started to consider labor market imperfections as well, not at least in an attempt to better fit the theoretical results to empirical findings as observed e.g. in the major European economies. There, due to powerful unions and high social standards, labor markets are characterized by rigid wages for low skilled labor. Violating the typically posed flexible wage assumption and introducing different forms of wage rigidity, results of the impact of International Outsourcing on labor are likely to change. As Krugman (1995) illuminates, trade implications differ fundamentally between a European case (assuming wage rigidity) and an American one (assuming flexible wages): With wage rigidity, a decrease in the production of the low skill intensive good leads to an increase of low skilled unemployment. Even if the effects of wage rigidities are well known since the discussion in Brecher (1974a,b),¹ theoretical investigations analyzing the effects with respect to International Outsourcing activities are still rare.

Skaksen (2004) e.g. examines the effects of International Outsourcing occurring in unionized labor markets. Since his general equilibrium model considers only one-sector and one kind of labor, it is not applicable to discuss the important factor or sector bias of International Outsourcing and thus, to fit into the main part of the International Outsourcing literature. Nevertheless, results are quite interesting: When firms relocate production fragments abroad, the wage rate increases in tandem with unemployment. Kohler (2007) investigates effects of International Outsourcing and embeds the results into the German discussion on the Bazaar Economy. Even though his main analysis occurs within a flexible wage economy, Kohler mentions the importance of wage rigidity and distills few points that may be of formal interest, like e.g. the skill intensity of the relocated production fragments. Considering one industry facing a

¹For recent examinations of different subsidization schemes within a traditional HOS framework considering skill biased technical progress in hand with labor market rigidities, see e.g. Dluhosch and Horgos (2008). Dluhosch (2008) enriches a traditional HO model with labor market rigidities and investigates the implications of globalization and skill biased technical change as well.

heterogeneous labor market, Koskela and Stenbacka (2007) investigate the effects of International Outsourcing and a solidaristically wage setting monopolistic labor union on the wage differential as well as unemployment for both skill groups. Following an increase of the wage differential due to outsourcing activities, unemployment of the high skilled increases while unemployment of the low skilled decreases. With unemployment arising not in hand, but as a consequence of wage settings, this result conflicts with traditionally assumed implications of International Outsourcing discriminating low skilled labor. Modeling International Outsourcing similar as in Jones (2000) and Jones and Kierzkowski (2001) and introducing a fair-wage approach (see Solow, 1979; Akerlof, 1982; Akerlof and Yellen, 1988, 1990) to focus on a special form of labor market imperfection, Egger and Kreickemeier (2008) present a model where wage inequality is able to coexists with unemployment. Thus, using a novel diagrammatic tool (based on the Lerner-Pearce diagram), they are able to address major public concerns of International Outsourcing: With high skill intensive home production, International Outsourcing mitigates the unemployment problem and reduces the high skill wage premium. Additionally, they explore how preferences with respect to fair wages and the size of employment benefits govern employment effects.

When leaving the theoretical world and studying the empirical literature, there is no contribution examining the differences in labor market implications occurring when International Outsourcing takes place in industries characterized by a rigid wage floor. Since there is a lack of macro-variables indicating the degree of an industry's labor market inflexibility, the necessary information needs to be generated. This statistical problem, however, may be the reason for the lack of empirical evidence testing the few theoretical results which recently emerged in this field of research. This paper tries to contribute to fill this gap.

Therefore, it first provides a formal model investigating how general equilibrium effects of International Outsourcing change if flexible wages are displaced by rigid wages for low skilled labor. In order to fit into the recently emerged discussion of the importance of the sector vs. the factor bias of International Outsourcing, the model assumes two sectors with two primary inputs of labor. Section 5.2 introduces the basic framework. Using Shephard's Lemma (cf. Shephard, 1953, 1970) and following the line of Uzawa (1964), Diewert (1971, 1974), Woodland (1977), and Mussa (1979), the model builds on the modern duality approach in international trade theory. In order to achieve the flexible wage benchmark model, Section 5.3 introduces International Outsourcing similar to skill biased technical change as defined in Jones (1965) and analyzes the occurring implications for general equilibrium. In Section 5.4, the flexible

wage assumption is violated by introducing wage rigidity for low skilled labor as in Brecher (1974a,b). As it turns out, results differ fundamentally from the flexible wage approach. When International Outsourcing takes place in the relative high skill intensive industry, relative wages of the high skilled still increase, however, not as strong as in the flexible wage scenario. In order to keep production positive, and to maintain the minimum cost level, the relative low skill intensive industry has to reduce output. This additional reduction in output forces the industry to set low skilled labor free. Since not all of these workers can be absorbed by the expanding relative high skill intensive industry, International Outsourcing increases unemployment of the low skilled as we move down the Rybczynski line towards the new equilibrium situation. Section 5.5 presents empirical results supporting the theoretical findings. Applying a logit model to analyze a German microeconomic panel data, results show that the probability for low skilled labor to get unemployed increases dramatically in extend and significance, if International Outsourcing takes place in industries characterized by low skilled wage rigidity. Section 5.6 concludes by summarizing the major findings and addressing some questions of high political relevance.

5.2 Theoretical Framework

In order to formally investigate equilibrium effects of International Outsourcing, this section uses the modern duality approach in international trade theory. Based upon an algebraic simplicity known as Shephard's Lemma, equilibrium conditions in the production sector are formulated in terms of unit cost functions rather than production functions. Following the line of Uzawa (1964), Diewert (1971, 1974), Woodland (1977), and Mussa (1979), this leads to a cost minimization problem in a factor-price space. The advantage of minimizing unit costs rather than maximizing output can be derived from Shephard (1953, 1970): With unit cost functions differentiable at the factor price w^* , the cost minimizing input-output-coefficients can simply be obtained with the partial derivative of the unit cost functions with respect to wages.

Consider an economy facing given world prices p with two industries, a relative high skill intensive (X) and a relative low skill intensive one (Y). Both industries use two primary inputs, low skilled labor L and high skilled labor H to produce goods of quantity q_i (with $i = X, Y$). The production function is of a typical Cobb Douglas kind with constant returns to scale. Goods as well as factor markets are perfectly competitive with factors mobile between industries, but immobile between countries. The home

country faces an inelastic supply of labor (\bar{L}, \bar{H}) and remains incompletely specialized ($q_i > 0$). In order to keep the model traceable, we focus on the supply side of the economy in setting the elasticity of demand unity ($\sigma^D = 1$). Thus, the world market is assumed to absorb changes in demand and, since $\hat{p} = 0$, possible effects from price changes. Thus, with free entry in both industries, we achieve the unit cost functions equaling the price

$$c_X = a_{XL}w_L + a_{XH}w_H = p \quad (5.1)$$

$$c_Y = a_{YL}w_L + a_{YH}w_H = 1 \quad (5.2)$$

with c_i as unit costs, a_{ij} as unit factor requirements ($j = L, H$), w_j as factor prices, the price of the relative low skill intensive good Y as numeraire, and the relative price of good X as $p \equiv p_X/p_Y$. When partially differentiating the unit cost functions with respect to the wages (Shepard's Lemma), we achieve

$$a_{XL} = \frac{\partial c_X(w_L, w_H)}{\partial w_L} \quad (5.3)$$

$$a_{XH} = \frac{\partial c_X(w_L, w_H)}{\partial w_H} \quad (5.4)$$

$$a_{YL} = \frac{\partial c_Y(w_L, w_H)}{\partial w_L} \quad (5.5)$$

$$a_{YH} = \frac{\partial c_Y(w_L, w_H)}{\partial w_H} \quad (5.6)$$

as cost minimizing labor unit requirements. Additionally, we have to consider

$$a_{XL}q_X + a_{YL}q_Y = \bar{L} \quad (5.7)$$

$$a_{XH}q_X + a_{YH}q_Y = \bar{H} \quad (5.8)$$

as labor market equilibrium conditions. Thus, we have a system of eight endogenous variables ($w_H, w_L, a_{XL}, a_{XH}, a_{YL}, a_{YH}, q_X$, and q_Y) in eight equations (5.1) - (5.8) that exactly determine the model.

5.3 General Equilibrium Effects with Flexible Wages: The Benchmark Model

In order to enable the industries relocating their production fragments abroad, we define φ_{ij} as an International Outsourcing parameter, similar to skill biased technical change as defined in Jones (1965). Since International Outsourcing is assumed to reduce labor unit requirements, the percentage change $\hat{\varphi}_{ij} \equiv -\frac{1}{a_{ij}(\partial a_{ij}/\partial IO)}$ is a measure showing the alteration in a_{ij} due to International Outsourcing activities (IO) that would take place at constant wages.² Thus, we have to rewrite the unit cost functions (5.1) and (5.2) into

$$c_X(\vec{w}_L, \vec{w}_H) = \vec{a}_{XL}\vec{w}_L + \vec{a}_{XH}\vec{w}_H \quad (5.9)$$

$$c_Y(\vec{w}_L, \vec{w}_H) = \vec{a}_{YL}\vec{w}_L + \vec{a}_{YH}\vec{w}_H \quad (5.10)$$

with $\vec{w}_j \equiv \frac{w_j}{\varphi_{ij}}$ and $\vec{a}_{ij} \equiv \varphi_{ij}a_{ij}$ as wages and labor unit requirements considering International Outsourcing activities. To minimize unit costs, (5.9) and (5.10) are totally differentiated in order to obtain

$$\theta_{XL}\hat{w}_L + \theta_{XH}\hat{w}_H = \theta_{XL}\hat{\varphi}_{XL} + \theta_{XH}\hat{\varphi}_{XH} \quad (5.11)$$

$$\theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H = \theta_{YL}\hat{\varphi}_{YL} + \theta_{YH}\hat{\varphi}_{YH} \quad (5.12)$$

as equilibrium production in both industries with factor income shares $\theta_{ij} \equiv \frac{a_{ij}w_j}{p_i}$ and “hats” over variables denoting percentage changes. As (5.11) and (5.12) show, in principle, there are four International Outsourcing situations: Both industries can either outsource their low skill intensive or their high skill intensive production block.³

In order to keep the focus on analyzing the changes of International Outsourcing implications occurring in rigid wage industries, it is sufficient to consider only the International Outsourcing situation, in which the high skill intensive industry relocates

²In this contribution, International Outsourcing is defined in a broad sense, without considering organizational firm characteristics. Thus, International Outsourcing activities indicate a reduction in domestic labor unit requirements of the respective skill group, without distinguishing whether the production fragment relocated abroad is produced in-house or at arm’s length. In order to keep the model traceable, determinants of International Outsourcing are also excluded. Thus, International Outsourcing here is modeled as illustrated in Arndt (1997, 1998a,b).

³A detailed examination of the four International Outsourcing scenarios and a discussion of the importance of the elasticities of substitution in these kind of models is presented in Chapter 3.

its low skill intensive production fragments.⁴ Thus, with $\hat{\phi}_{XL} > 0$ and $\hat{\phi}_{XH} = \hat{\phi}_{YL} = \hat{\phi}_{YH} = 0$, (5.11) and (5.12) change to

$$\theta_{XL}\hat{w}_L + \theta_{XH}\hat{w}_H = \theta_{XL}\hat{\phi}_{XL} \quad (5.13)$$

$$\theta_{YL}\hat{w}_L + \theta_{YH}\hat{w}_H = 0 \quad (5.14)$$

Wages and Labor Unit Requirements

To examine the effects of International Outsourcing on wages, we can solve (5.13) and (5.14) for the change in low and high skilled wages and obtain

$$\hat{w}_L = -\frac{\theta_{XL}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{XL} \quad (5.15)$$

$$\hat{w}_H = \frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{XL} \quad (5.16)$$

with Δ_{Θ} as the determinant of the matrix of factor income shares $\Theta \equiv \begin{pmatrix} \theta_{XH} & \theta_{XL} \\ \theta_{YH} & \theta_{YL} \end{pmatrix}$ and

$$\hat{w}_H - \hat{w}_L = \frac{\theta_{XL}}{\Delta_{\Theta}}\hat{\phi}_{XL} \quad (5.17)$$

as the percentage change in relative high skilled wages.⁵ Since $\Delta_{\Theta} > 0$, International Outsourcing of the low skill intensive production block in the relative high skill intensive industry increases the relative wage of the high skilled $\hat{w}_H - \hat{w}_L > 0$, as depicted in the Mussa-Woodland-Figure 5.1.

Since the relative high skill intensive industry relocates its low skill intensive production block, it needs less low skilled labor to produce one unit of commodity X. As the economy faces given world prices, this induces a reduction of unit costs. Thus, the respective unit cost curve shifts horizontally outward. Since relative wages of the high skilled increase in both industries, high skilled labor gains from this International Outsourcing activity in receiving a wage premium.

⁴As formally shown in Chapter 3, low skilled wages increase if International Outsourcing takes place in the relative low skill intensive industry. Thus, a possible downward wage rigidity for low skilled labor would not be binding.

⁵All the calculations of this paper are presented in detail in the Appendix (p. 122).

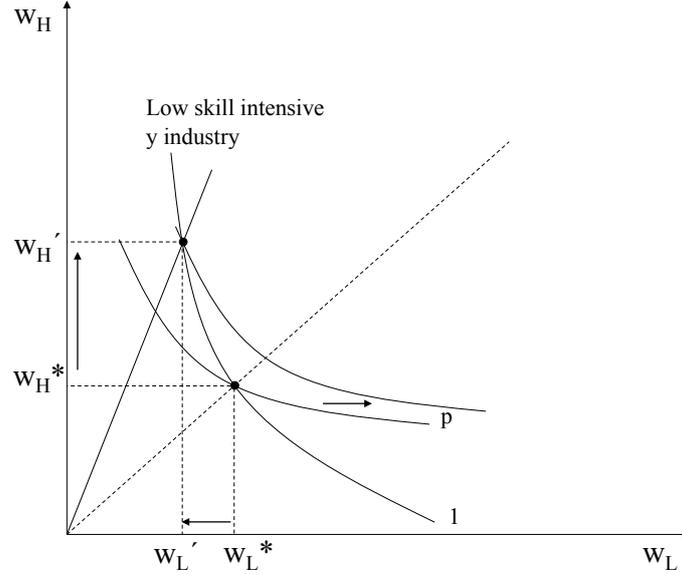


Figure 5.1: Effects of International Outsourcing on wages (low skill parts of relative high skill intensive industry)

As we know from Shephard's Lemma (5.3) - (5.6), equilibrium labor unit requirements can be obtained by differentiating the unit cost functions partially with respect to the wages. Considering International Outsourcing ($\vec{a}_{ij} = a_{ij}\varphi_{ij} = \frac{\partial c_i}{\partial \hat{w}_j}$ and thus, $a_{ij} = \frac{\partial c_i}{\partial \hat{w}_j \varphi_{ij}}$) we obtain

$$\hat{a}_{XL} = \theta_{XH}(\hat{w}_H - \hat{w}_L + \hat{\varphi}_{XL} - \hat{\varphi}_{XH}) - \hat{\varphi}_{XL} \quad (5.18)$$

$$\hat{a}_{XH} = -\theta_{XL}(\hat{w}_H - \hat{w}_L + \hat{\varphi}_{XL} - \hat{\varphi}_{XH}) - \hat{\varphi}_{XH} \quad (5.19)$$

$$\hat{a}_{YL} = \theta_{YH}(\hat{w}_H - \hat{w}_L + \hat{\varphi}_{YL} - \hat{\varphi}_{YH}) - \hat{\varphi}_{YL} \quad (5.20)$$

$$\hat{a}_{YH} = -\theta_{YL}(\hat{w}_H - \hat{w}_L + \hat{\varphi}_{YL} - \hat{\varphi}_{YH}) - \hat{\varphi}_{YH} \quad (5.21)$$

as the percentage change of the cost minimizing labor unit requirements. Now consider that only $\hat{\varphi}_{XL} > 0$ and substitute for the change in relative wages (5.17) we obtain

$$\hat{a}_H - \hat{a}_L = -\frac{\theta_{XL}}{\Delta_{\Theta}} \hat{\varphi}_{XL} \quad (5.22)$$

as the percentage change of relative labor unit requirements. Since International Outsourcing increases relative wages of the high skilled, relative labor unit require-

ments of the high skilled decrease in both industries. Thus, both industries shift skill requirements toward more low skilled labor.⁶

Output and Employment

To investigate the effects of International Outsourcing on output, take the total differential of the full employment conditions (5.7) and (5.8). In equilibrium, we obtain

$$\hat{q}_X \lambda_{XL} + \hat{q}_Y \lambda_{YL} = -(\hat{a}_{XL} \lambda_{XL} + \hat{a}_{YL} \lambda_{YL}) \quad (5.23)$$

$$\hat{q}_X \lambda_{XH} + \hat{q}_Y \lambda_{YH} = -(\hat{a}_{XH} \lambda_{XH} + \hat{a}_{YH} \lambda_{YH}) \quad (5.24)$$

with labor shares $\lambda_{iL} \equiv \frac{L_i}{L}$ and $\lambda_{iH} \equiv \frac{H_i}{H}$. Substituting for the changes of labor unit requirements and relative wages we can solve these equations for the percentage change in output of both industries, subject to the change in International Outsourcing activities

$$\hat{q}_X = \frac{\delta_H \lambda_{YL} + \delta_L \lambda_{YH}}{\Delta_\Theta \Delta_\Lambda} \theta_{XL} \hat{\phi}_{XL} + \theta_{XL} \hat{\phi}_{XL} \quad (5.25)$$

$$\hat{q}_Y = -\frac{\delta_H \lambda_{XL} + \delta_L \lambda_{XH}}{\Delta_\Theta \Delta_\Lambda} \theta_{XL} \hat{\phi}_{XL} \quad (5.26)$$

with $\delta_L \equiv \lambda_{XL} \theta_{XH} + \lambda_{YL} \theta_{YH}$, $\delta_H \equiv \lambda_{XH} \theta_{XL} + \lambda_{YH} \theta_{YL}$, and the determinant of the matrix of labor shares $\Delta_\Lambda > 0$ with $\Lambda \equiv \begin{pmatrix} \lambda_{XH} & \lambda_{YH} \\ \lambda_{XL} & \lambda_{YL} \end{pmatrix}$. Since International Outsourcing makes the respective industry more competitive on world markets, output increases in the relative high skill intensive industry ($\hat{q}_X > 0$), whereas output of the industry remaining integrated decreases ($\hat{q}_Y < 0$).

As we know, assuming wage flexibility, high and low skilled labor remain fully employed. However, provided that labor can freely move between the industries, within industry employment effects arise. Taking the total differential of the full employment conditions and substituting for the change in relative wages, labor unit requirements as well as output, we obtain

⁶The unambiguity of this result depends strongly on the assumption of a Cobb Douglas production process and the flexible wage set-up. Chapter 3 provides a more detailed discussion of the importance of elasticities of substitution in these kind of International Outsourcing models. Since the shift toward more low skill intensive production does not hold empirically, this may be a first hint pointing to labor market rigidities. Then, firms would reduce low skill employment which adds to unemployment (cf. Dluhosch, 2008).

$$\hat{L}_X = \frac{\theta_{XH}\Delta_\Lambda + (\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_\Theta\Delta_\Lambda} \theta_{XL}\hat{\phi}_{XL} \quad (5.27)$$

$$\hat{L}_Y = \frac{\theta_{YH}\Delta_\Lambda - (\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda} \theta_{XL}\hat{\phi}_{XL} \quad (5.28)$$

$$\hat{H}_X = \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH}) - \theta_{XL}\Delta_\Lambda}{\Delta_\Theta\Delta_\Lambda} \theta_{XL}\hat{\phi}_{XL} \quad (5.29)$$

$$\hat{H}_Y = -\frac{\theta_{YL}\Delta_\Lambda + (\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda} \theta_{XL}\hat{\phi}_{XL} \quad (5.30)$$

as the percentage change in within industry employment of low and high skilled labor. Since International Outsourcing increases employment of the low skilled in the relative high skill intensive industry ($\hat{L}_X > 0$), employment of the low skilled in the relative low skill intensive industry has to decrease ($\hat{L}_Y < 0$). The same pattern occurs for high skilled labor. With employment of the high skilled decreasing in the relative low skill intensive industry ($\hat{H}_Y < 0$) employment of the high skilled in the relative high skill intensive industry has to increase ($\hat{H}_X > 0$). Thus, since International Outsourcing increases output in the relative high skill intensive industry, low as well as high skilled labor quit employment in the low skill intensive industry and move to the high skill intensive one.

Summarizing the Main Findings

Since the relative high skill intensive industry relocates its low skill intensive production block, it needs less low skilled labor and thus, faces a reduction in unit costs. Assuming an economy facing given world prices, the additional return is used to pay a wage premium for high skilled labor. Thus, with labor assumed to be mobile between the industries, relative wages of the high skilled increase in both industries. Consequently, labor unit requirements of high skilled labor decrease. This implies a skill shift toward more low skilled labor. Since the industry facing International Outsourcing activities gets more competitive on world markets, output increases while output of the other industry (the one keeping its integrated production structure) decreases. All these results have to be considered for the effects on within industries' employment: Since labor moves from the contracting relative low skill intensive to the expanding relative high skill intensive industry, low skill as well as high skill employment increases in the industry with International Outsourcing activities, while it decreases in the industry remaining integrated.

5.4 General Equilibrium Effects with Wage Rigidity

After examining general equilibrium effects of International Outsourcing with flexible wages, this section considers an empirically more realistic scenario for major European economies. There, powerful unions as well as high social standards induce some kind of wage rigidity for low skilled labor. As employees would not accept wages beneath the margin set by social standards, wages are prevented from adjusting to shocks. Thus, results are likely to differ fundamentally from the flexible wage benchmark model. In order to consider these differences we violate the flexible wage assumption and subject the entire labor market of the economy to a wage floor for low skilled labor. Following Brecher (1974a,b), labor market inflexibility is modeled with real wages for the low skilled rigid with respect to the numeraire.

The rigid wage, exogenously given in real terms, is specified at a fixed level denoted by \bar{w}_L , the real wage before the respective industry decides to relocate production fragments abroad. Thus, at \bar{w}_L low skilled labor is fully employed but with downward inflexibility of the real wage

$$w_L \geq \bar{w}_L \text{ or } \hat{w}_L \geq 0 \quad (5.31)$$

To investigate the implications of International Outsourcing with wage rigidity assume again the case that the relative high skill intensive industry relocates its low skill intensive production fragment ($\hat{\phi}_{XL} > 0$ whereas $\hat{\phi}_{XH} = \hat{\phi}_{YL} = \hat{\phi}_{YH} = 0$). As we know from (5.15) and (5.17) real wages of the low skilled decrease in absolute as well as in relative terms. Thus, the above defined minimum wage (5.31) is binding, preventing low skilled wages from downward adjustment ($\hat{w}_L = 0$).

With wage rigidity we have to rewrite (5.13) and (5.14) and obtain

$$\theta_{XH}\hat{w}_H = \theta_{XL}\hat{\phi}_{XL} \quad (5.32)$$

$$\theta_{YH}\hat{w}_H = 0 \quad (5.33)$$

as equilibrium conditions. Solving for the percentage change in high skill wages, different results *ceteris paribus* emerge for the two industries

As Figure 5.2 shows, International Outsourcing of the low skill intensive production fragment in the relative high skill intensive industry shifts the respective unit cost

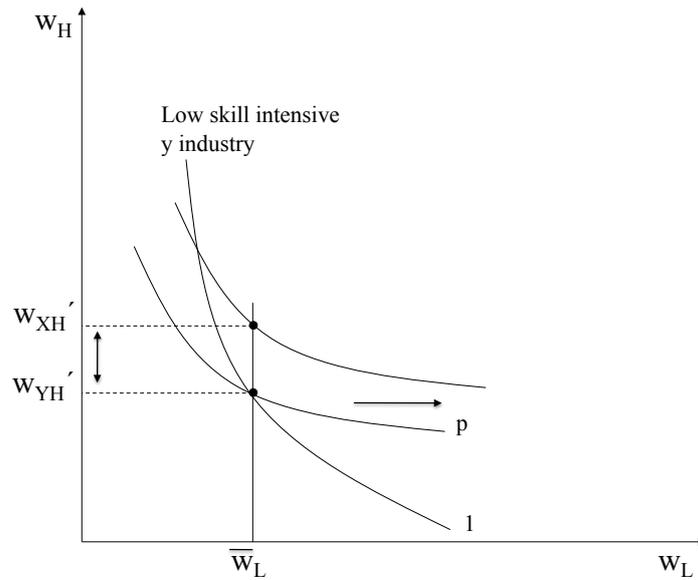


Figure 5.2: Effects of International Outsourcing on wages (with wage rigidity)

function horizontally outside. Due to the wage rigidity for the low skilled, wages of the high skilled increase in the same industry but, in a first step, remain unchanged in the relative low skill intensive industry. As we assumed labor to be completely mobile between industries, the high skilled employed in the relative low skill intensive industry would immediately move to the relative high skill intensive industry in order to achieve the wage premium. Thus, the low skill intensive industry would stop production. However, holding to the assumption of incomplete specialization, this is not an equilibrium anymore. Thus, in order to keep production positive, the relative low skill intensive industry is forced to accept the high skill wage premium paid in the relative high skill intensive industry ($\hat{w}_{YH} = \hat{w}_{XH} = \hat{w}_H = \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL}$). Then, however, the relative low skill intensive industry is no longer producing at minimum costs. The only way for the relative low skill intensive industry to remain at the minimum cost level is to reduce output.

Wages and Labor Unit Requirements

Provided that the relative low skill intensive industry has to accept the high skill wage premium, implied by International Outsourcing occurring in the relative high skill intensive industry, and since the wage floor for low skilled labor is binding ($\hat{w}_L = 0$), the change in relative wages of the high skilled equals the respective absolute change with

$$\hat{w}_H - \hat{w}_L = \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} \quad (5.34)$$

Thus, also with a wage floor for low skilled labor, International Outsourcing in the relative high skill intensive industry increases relative wages of the high skilled, however, not as strong as in the flexible wage scenario

$$(\hat{w}_H - \hat{w}_L)|_{\text{flex}} - (\hat{w}_H - \hat{w}_L)|_{\text{rigid}} = \frac{\theta_{XL}}{\Delta_{\Theta}} \hat{\phi}_{XL} - \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} > 0 \quad (5.35)$$

since $\Delta_{\Theta} \equiv \theta_{XH} - \theta_{YH} < \theta_{XH}$. Thus, the minimum wage for low skill labor mildens the widening of the wage gap.

For the effects of International Outsourcing on relative labor unit requirements remember (5.18) - (5.21) and substitute for the change of relative wages assuming the binding minimum wage (5.34). Solving for the change in relative labor unit requirements, we obtain

$$\hat{a}_H - \hat{a}_L = -\frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} \quad (5.36)$$

Since relative wages of the high skilled increase also with a minimum wage for low skilled labor, International Outsourcing again induces a skill shift towards more low skilled labor in both industries. However, the skill shift is, as the effects on relative wages, not as strong with wage rigidity as with flexible wages.

Output and Employment

In order to achieve the equilibrium pattern of output and employment, call the endowment of the economy with fixed overall factor supplies (\bar{L} and \bar{H}) constraining the employment conditions. With the assumption of wage rigidity, we have to rewrite (5.7) and obtain

$$L \equiv a_{XL}q_X + a_{YL}q_Y \leq \bar{L} \quad (5.37)$$

considering that unemployment of the low skilled may occur ($\hat{L} \leq 0$). Thus, there is the possibility of low skilled labor being not employed in the X or in the Y industry. Since high skill wages remain flexible, high skilled labor stays fully utilized

$$H \equiv a_{XH}q_X + a_{YH}q_Y = \bar{H} \quad (5.38)$$

Taking the total differential of the employment conditions (5.37 and 5.38), we obtain

$$\hat{q}_X \lambda_{XL} + \hat{q}_Y \lambda_{YL} = \hat{L} - (\hat{a}_{XL} \lambda_{XL} + \hat{a}_{YL} \lambda_{YL}) \quad (5.39)$$

$$\hat{q}_X \lambda_{XH} + \hat{q}_Y \lambda_{YH} = -(\hat{a}_{XH} \lambda_{XH} + \hat{a}_{YH} \lambda_{YH}) \quad (5.40)$$

as equilibrium condition. Considering the changes in labor unit requirements as well as relative wages, we can solve (5.39) and (5.40) for \hat{q}_X and \hat{q}_Y and achieve

$$\hat{q}_X = \frac{\lambda_{YL}(\lambda_{XH} + \theta_{YL}\lambda_{YH}) + \lambda_{YH}(\theta_{YH}\lambda_{YL})}{\Delta_\Lambda} \cdot \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} - \frac{\lambda_{YH}\hat{L}}{\Delta_\Lambda} \quad (5.41)$$

$$\hat{q}_Y = -\frac{\lambda_{XL}(\lambda_{XH} + \theta_{YL}\lambda_{YH}) + \lambda_{XH}(\theta_{YH}\lambda_{YL})}{\Delta_\Lambda} \cdot \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} + \frac{\lambda_{XH}\hat{L}}{\Delta_\Lambda} \quad (5.42)$$

as equilibrium output patterns for both industries. Since low skilled labor was fully employed before slicing up the value chain, employment of the low skilled can either remain unchanged or decrease ($\hat{L} \leq 0$). Thus, International Outsourcing increases output in the relative high skill intensive industry and leads to a contraction of the relative low skill intensive one. By contrast to the benchmark-case of flexible wages, the change in output occurring with rigid wages is due to two different forces, one “normal” effect of the International Outsourcing activity as well as an “additional” effect as the low skill intensive industry sets low skilled labor free ($\hat{L}_Y \leq 0$), in order to maintain the minimum cost level. Since $\lambda_{XH} > \lambda_{YH}$, the change of low skilled employment decreases the output in the relative low skill intensive industry (Y) by more than it expands output in the relative high skill intensive industry (X) (i.e. $\frac{\lambda_{YH}\hat{L}}{\Delta_\Lambda} < \frac{\lambda_{XH}\hat{L}}{\Delta_\Lambda}$).

To examine the effects on employment, consider again the change within the industries. Substituting for the change in relative wages, the change in labor unit requirements as well as the change in output, we obtain

$$\hat{H}_X = -\frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} + \frac{\lambda_{YL}(\lambda_{XH} + \theta_{YL}\lambda_{YH}) + \lambda_{YH}(\theta_{YH}\lambda_{YL})}{\Delta_\Lambda} \frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} - \hat{L} \frac{\lambda_{YH}}{\Delta_\Lambda} \quad (5.43)$$

$$\hat{H}_Y = -\frac{\theta_{YL}\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} - \frac{\lambda_{XL}(\lambda_{XH} + \theta_{YL}\lambda_{YH}) + \lambda_{XH}(\theta_{YH}\lambda_{YL})}{\Delta_\Lambda} \frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} + \hat{L} \frac{\lambda_{XH}}{\Delta_\Lambda} \quad (5.44)$$

as the effects of International Outsourcing on within industries' high skill employment. Provided that high skilled wages stay flexible, the relative low skill intensive industry (Y) again decreases employment of the high skilled ($\hat{H}_Y \leq 0$), whereas the relative high skill intensive industry increases high skilled employment. For the within industries' change in low skill employment we achieve

$$\hat{L}_X = \frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} - \frac{\lambda_{YH}}{\lambda_{YL}}\hat{L}_Y \quad (5.45)$$

as the long run equilibrium. Thus, after some painful adjustment processes in the short run, some of the low skilled labor set free in the relative low skill intensive industry (Y) is absorbed by the relative high skill intensive industry (X). However, since not all of the unemployed low skilled can be absorbed at given wages by the relative high skill intensive industry (X), International Outsourcing of the low skill intensive parts in the relative high skill intensive industry increases unemployment of the low skilled as long as we move down the Rybczynski line to find the new equilibrium situation.

Summarizing the Main Findings

Subjecting the labor market of the economy to a rigid wage floor for low skilled labor, International Outsourcing of the low skill intensive part in the relative high skill intensive industry enables the industry to pay a high skill wage premium. However, due to the wage rigidity, high skill wages do not increase in the relative low skill intensive industry in the first step. Thus, since the high skilled in the relative low skill intensive industry would move to the relative high skill intensive one, in order to benefit from the wage premium, the low skill intensive industry would stop production. This is no equilibrium situation holding to the assumption of incomplete specialization. Thus, the relative low skill intensive industry has to accept the high skill wage premium. In order to remain at the minimum level of unit costs, the industry has to reduce output. Thus, absolute as well as relative wages of the high skilled increase in both industries, however, not as strong as in the flexible wage scenario. Assuming Cobb Douglas pro-

duction structures, this induces a skill shift in both industries towards more low skilled labor. With wage rigidity, the output pattern depends on two different forces. Since International Outsourcing increases the competitiveness in the relative high skill intensive industry, the industry expands while the low skill intensive contracts. However, since the relative low skill intensive industry is forced to accept the high skill wage premium paid in the relative high skill intensive industry, there is an additional force constraining the low skill intensive industry. Since the low skilled labor set free by the relative low skill intensive industry can not be completely absorbed by the relative high skill intensive one, we move the Rybczynski line downward, with low skill unemployment increasing until we reach the new equilibrium situation.

5.5 Empirical Evidence for Germany

In order to empirically test the theoretical findings stated above, this section provides a micro-econometric panel data analysis investigating the different implications of International Outsourcing that occur when being adopted in a flexible wage industry, or in an industry characterized by a rigid wage floor for low skilled labor instead. Due to small but important differences between the empirical situation and the theoretical assumptions made above, empirical results are expected to differ slightly from the theoretical findings. Thus, the expected empirical outcomes are stressed first, before the section describes the data and the econometric tests in detail.

In order to focus on a long run perspective and to keep the theoretical equilibrium traceable, one crucial assumption imposed was labor being completely mobile between the industries. This, however, is not reflected in the data. Due to personal characteristics like e.g. education or family status, labor is not completely mobile empirically. Thus, painful short run adjustment effects need to be accepted. Given these facts, International Outsourcing is expected to increase unemployment of the low skilled when taking place in high skill intensive industries, even when wages can adjust. However, when outsourcing takes place in industries with wage rigidity, the increase in unemployment is expected to be more extensive. When Outsourcing takes place in the relative low skill intensive industries, unemployment of the low skilled should not increase since the wage floor is assumed not to be binding. At more aggregated industry levels, like the whole economy or the service industry, we are not able to make any presumptions.

Data and Econometric Methodology

In order to provide empirical evidence for the way wage rigidity affects International Outsourcing implications, the analysis bases on microeconomic panel data for the German economy between 1991 and 2000. Within a multiple logit model, individual unemployment is regressed on the International Outsourcing activity of the industry the individual's employed in, as well as several variables controlling for observable individual-specific as well as industry-specific characteristics.

$$U_{ijt} = \beta_0 + \beta_1 VS_{jt} + \beta_2 Y_{jt} + \beta_3 age_{it} + \beta_4 deast_{it} + \beta_5 dmale_{it} + \tau_j + \delta_t + \mu_i + \epsilon_{it} \quad (5.46)$$

U is a binary variable indicating if individual i is unemployed at time t , VS is an index proxying International Outsourcing activities in industry j at time t ,⁷ Y is the output of industry j , age the age of individual i . The dummy variable $deast$ indicates if the individual's residence is in East Germany, and the dummy variable $dmale$ the gender of the individual. Additionally, we control for time specific effects (δ), industry specific effects (τ), as well as unobservable individual heterogeneity (μ). Thus, with the error term ϵ allowing for unspecified correlation of errors within industries, the regression cares for contemporaneous correlation even though maximum likelihood estimation is used instead of OLS.⁸ In order to focus on the implications of wage rigidity, we run this regression for all industries and compare the results with results when considering only rigid wage industries.

The data is taken from the German Socio Economic Panel GSOEP and from input-output tables provided by the German Federal Statistical Office. The input-output tables are used to calculate the VS-index and the output of each two-digit NACE industry for the period 1991 to 2000. The endogenous variable U , indicating the employment status of an individual, is taken from the GSOEP (waves H/8, 1991 to Q/17, 2000). The GSOEP additionally provides information on the age of an individual,

⁷On a more aggregated industry level it is necessary to proxy International Outsourcing activities. Therefore, several indices are developed and some of them are very common in use. One of these indices, called the VS-index, is a proxy of imported inputs in production and can be calculated using $VS_t = \sum_{j=1}^n \sum_{w=1}^z \frac{(m_{wt}/s_{wt}) \cdot q_{wjt}}{p_{jt}}$ with q as total inputs from industry w used in industry j , p as production value in industry j , m as total imports and s as the domestic use of goods w . For a descriptive overview of International Outsourcing activities in Germany, measured by the VS-index, and an empirical investigation of often used International Outsourcing indices, see Chapter 2.

⁸See Moulton (1990) for the necessity to include industry controls in order to account for correlation of errors within groups and thus, to provide spurious regression when estimating the effects of macro-variables on micro-units.

the individual's residence, gender, as well as the education of each individual with respect to the international comparable ISCED from UNESCO (1997).⁹

In order to perform the required estimations, additional information on the existence of wage rigidity at the industry level is needed. However, since wage rigidity is typically not observable on a more aggregated sectoral bases, there is a need to proxy wage rigidity at the industry level. This, however, is an empirical challenge and thus, may be the reason why there is no empirical evidence for wage rigidities affecting the implication of economic phenomena, like e.g. International Outsourcing activities. In order to generate an indicator denoting if an industry is characterized by a rigid wage structure or not, the analysis follows a similar procedure as in Holden (2004), Goette et al. (2007), Knoppik and Beissinger (2005), and Bauer et al. (2007).¹⁰

In order to obtain the information whether an industry is characterized by rigid wages for the low skilled or not, the percentage change of the mean wage \hat{w}_{it} of the low skilled is calculated for each year in each two-digit NACE industry as a first step. Based on the percentage changes, a normalized distribution of the corresponding wage changes per industry-year is generated by adjusting the empirically observed wage changes with the industry specific median and standard deviation $\hat{w}_{it}^n \equiv \frac{\hat{w}_{it} - \mu(\hat{w})_i}{sd(\hat{w})_i}$. Afterward, the industry-year specific samples of the empirical distribution need to be calculated. As the empirical samples and their moments are stochastic and thus burdened with unknown uncertainty, a bootstrap method is used. Thus, we create a distribution of the low skilled wage changes in bootstrapping the empirically observed percentage changes for each industry-year sample. Based on the generated empirical distribution, the number of wage cuts per industry is calculated and, in this regard, the respective probability of a wage cut occurring in this industry is computed. The empirically observed probability of wage cuts needs to be related to a normalized probability of wage cuts (assuming no wage rigidity). Therefore, a notional distribution of the normalized wage cuts is created by adjusting the normalized wage changes with the bootstrapped mean and standard deviation $\tilde{w}_{it} \equiv \hat{w}_{it}^n sd^B + \mu^B$. Based on this notional normalized distribution, the number of wage cuts and the respective probability of these wage cuts occurring per industry are calculated. The notional normalized probability of wage cuts per industry can then be related to the empirically observed probability of wage cuts per industry. If the empirically observed probability of wage cuts per

⁹In 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 workers are individuals with some form of post secondary education.

¹⁰For more papers on the measurement of wage rigidities see the special edition of the Economic Journal, Vol. 117, Iss. 524, Nov. 2007.

industry is smaller than the notional normalized one, it is assumed that the respective industry is characterized by rigid wages for low skilled labor.¹¹

Results

In order to empirically test the effects of wage rigidity on the implications of International Outsourcing activities, (5.46) is first regressed for the whole economy, differing between all industries and industries with rigid wages for low skilled labor.¹² The results are presented in the first two columns of Table 5.1.

As the results show, International Outsourcing (proxied by the VS index) increases the probability of low skilled labor to get unemployed, however, with a z-value of 1.60, not at a statistically significant level. By contrast, when considering that International Outsourcing takes place in industries with wage rigidity for low skilled labor, the probability of getting unemployed due to International Outsourcing activities is twice as high, and in addition, highly statistically significant at a level of 1 percent. The included control variables also yield a variety of very interesting results. While the output of an industry has only insignificant effects, the individual control variables strongly influence the possibility of an individual getting unemployed on a statistically significant level. The age of an individual, e.g., decreases the probability of getting unemployed slightly, but statistically significant at the 1 percent level. Living in the eastern part of Germany or being female, by contrast, significantly increases the likelihood of getting unemployed. These highly statistically significant effects ensure that the overall model is fitted well with highly significant chi2-values. The model is based on approx. 15,000 individual observations, includes industry, year, and region controls to avoid contemporaneous correlation, and thus, is necessarily representative to derive generalizable results.

When International Outsourcing takes place in the service sector, results also confirm the increasing effect of wage rigidity on unemployment of the low skilled. Considering all service industries, International Outsourcing indeed increases the probability

¹¹Table 5.3 in the Appendix provides an overview of the two-digit NACE industries in Germany characterized as rigid-wage industries due to this classification (considering the period 1991-2000).

¹²Since it can not be assumed that the individuals exhibit a systematic intercept, but instead, that they are randomly drawn from a binomial distribution, all the models below are tested using a random-effects logit estimator. Additionally, since the data consists of a huge amount of observations and a comparably small amount of years, the random effects logit model can be assumed to be much more efficient than its fixed effects variant. When regressing the unemployment status on the contemporaneous industries' output, a possible endogeneity problem could be assumed. Therefore, Durbin-Wu-Hausman tests are applied to assure that possible endogeneity does not significantly affect the consistency of the estimated coefficients.

Table 5.1: Effects on low skilled unemployment in Germany (1)

in considering	Whole Economy		Service Industry	
	all industries	rigid wage industries	all industries	rigid wage industries
VS	12.7423 (1.60)	25.8744*** (2.46)	27.7687 (1.56)	41.3825* (1.83)
Y	4.75e-06 (1.50)	-2.66e-06 (-0.42)	-5.55e-06 (-0.91)	-1.37e-05 (-1.39)
age	-0.0551*** (-10.79)	-0.0546*** (-9.27)	-0.0583*** (-9.18)	-0.0610*** (-7.59)
d East Ger.	.2544* (1.64)	-.2107 (1.15)	.2281 (1.31)	.1278 (.59)
d Male	-.3102** (2.33)	-.3272** (-2.21)	-.0518 (-.32)	-.0272 (-.14)
cons	-3.0526*** (-3.59)	-5.2270*** (-3.66)	-1.5433 (-1.13)	-3.3119*** (-2.45)
Observations	16,194	13,195	9,921	7,218
Groups	5,039	4,173	3,563	2,664
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Industry Controls	YES	YES	YES	YES
Year Controls	YES	YES	YES	YES
Region Controls	YES	YES	YES	YES

(z-Statistics in parantheses)

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

for the low skilled to get unemployed, however, as for the whole economy, not at a statistically significant level. When focusing solely on the service industries characterized by a rigid wage floor for low skilled labor, the effect is nearly twice as intensive and statistically significant at the 10 percent level. The results of the other control variables confirm the above stated findings, as well as the robustness of the model.

After providing empirical evidence for more aggregated industry levels, the results presented in Table 5.2 move the focus on more disaggregated industry levels, the high as well as low skill intensive industries of the manufacturing sector. Considering the above mentioned differences between the theoretical model (adopting a long run perspective) and the empirical methodology (accounting for short run adjustment) the empirical results strongly support the theoretical picture of section 5.4. If International Outsourcing takes place in high skill intensive industries, the probability for low skilled individuals to get unemployed increases, statistically significant at the 10 percent level. However, when International Outsourcing takes place in high skill intensive industries characterized by wage rigidity for low skilled labor, the probability of getting unemployed nearly doubles and becomes statistically even more significant with the z-value increasing up to 2.16. The results of the additional control variables do not change compared to the whole economy, however, the gender and the east German dummy variable are outside the statistically significant range.

Table 5.2: Effects on low skilled unemployment in Germany (2)

in considering	High Skill Industries		Low Skill Industries	
	all industries	rigid wage industries	all industries	rigid wage industries
VS	36.8284*	61.0233**	-4.5951	-6.0987
	(1.68)	(2.16)	(-.21)	(-.29)
Y	9.78e-07	-4.25e-06	1.14e-04*	7.77e-05
	(.08)	(-.32)	(1.69)	(1.05)
age	-.0702***	-.0676***	-.0616***	-.0569***
	(-4.18)	(-4.03)	(-4.64)	(-4.29)
d East Ger.	.3054	.3714	.3779	.4915
	(.56)	(.69)	(.80)	(1.04)
d Male	-.1085	-.0234	-.6600**	-.6916**
	(-.28)	(.06)	(-2.16)	(-2.22)
cons	-9.2156**	-12.7672**	-17.2181*	-12.8314
	(-1.95)	(-2.18)	(-1.72)	(-1.16)
Observations	2,768	2,738	3,042	2,802
Groups	1,018	1,003	1,085	1,006
Prob > chi2	0.0120	0.0043	0.0330	0.0238
Industry Controls	YES	YES	YES	YES
Year Controls	YES	YES	YES	YES
Region Controls	YES	YES	YES	YES

(z-Statistics in parantheses)

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

When International Outsourcing takes place in the relative low skill intensive industries, the probability for the low skilled to get unemployed decreases, however, not at a statistically significant level. This result, occurring even in industries with wage rigidity, supports the expected results known from the sector bias of International Outsourcing (cf. Arndt, 1997): Since low skilled labor gains when International Outsourcing occurs in relative low skill intensive industries, the demand for low skilled labor increases as does employment and wages. Thus, a possible wage floor would not be binding and unemployment would be expected to decrease. The results of the included control variables again confirm the findings. One interesting point to note additionally is that the increasing effect of being a female on the probability of the low skilled to get unemployed is statistically significant, and even much higher, in relative low skill intensive industries compared to the relative high skill intensive ones.

5.6 Conclusions

In order to examine general equilibrium effects of International Outsourcing, research mostly assumes a flexible wage set-up. However, in major European economies, labor markets are characterized by powerful unions and high social standards, inducing an

implicit wage rigidity for low skilled labor. While only few contributions theoretically examining International Outsourcing effects within a rigid-wage economy emerged recently, there is still no empirical evidence which support these findings. This paper contributes to fill this gap.

Therefore, general equilibrium effects of International Outsourcing are formally examined by employing a modern duality approach. Assuming a binding wage floor for low skilled labor, results differ fundamentally from the flexible wage scenario: With International Outsourcing of the low skill intensive production block in the relative high skill intensive industry, real wages of the high skilled increase in the outsourcing industry while *ceteris paribus* not changing in the relative low skill intensive industry. However, with labor completely mobile between industries, the relative low skill intensive industry had to quit production since all high skilled would move to the skill intensive industry. Thus, for staying afloat, the relative low skill intensive industry is forced to accept the high skill wage premium and thus, to decrease output. Therefore, International Outsourcing increases relative wages of the high skilled, however, not as strong as in the flexible wage scenario. This induces a skill shift in both industries toward more low skilled labor. Since the outsourcing industry gets more competitive on world markets, it expands while output in the industry remaining integrated decreases. However, since wage rigidity forces the low skill intensive industry to set low skilled labor free, the contraction of the industry gets additionally amplified. Since not all of the low skilled can be absorbed by the high skill intensive industry, unemployment of the low skilled occurs as we move down the Rybczynski line toward the new equilibrium. Thus, the smaller increase of the wage gap occurring with International Outsourcing in a rigid wage economy has to be bought dearly with unemployment of low skilled labor.

The link between International Outsourcing and the increase of low skilled unemployment when low skilled wages are assumed to be rigid is tested within a microeconomic panel data analysis. Therefore, a variable indicating if wages are rigid within an industry is created. The empirical results strongly support the theoretical findings: If International Outsourcing takes place in industries characterized by inflexible labor markets, the probability of an individual getting unemployed increases dramatically in extent and significance.

Since the link between International Outsourcing and labor market imperfections is rarely explored yet, plenty of room exists for future research. Empirical contributions could also investigate the remaining general equilibrium effects occurring if International Outsourcing takes place in rigid wage industries. It would e.g. be worth

examining the difference of the implications on the wage gap between low and high skilled labor as well as on the output of the industries. However, not only the effects of International Outsourcing are worth being examined: The change in determinants of International Outsourcing due to wage rigidity would additionally being worth to get investigated. Maybe there is a force of minimum wages toward more or less International Outsourcing activities, leading an economy to even more intensively participate or to retire from the international division of labor.

This contribution tries not to explain the main causes for unemployment in major European economies. Instead, the paper highlights the importance of labor market institutions to gain or lose from a non-stoppable economic process, International Outsourcing. Policy makers can either stand for more flexibility, and accept a larger wage gap, or for more rigid labor markets, and buying a decrease in the wage gap dearly with low skilled unemployment. Thus, in terms of unemployment, not International Outsourcing but inflexible labor market institutions should instead be blamed for harming low skilled labor.

Appendix 1: Calculations

The formal model of this chapter is an extension of the model presented in Chapter 3 as dropping the flexible wage assumption by introducing real wage rigidity. The other assumptions still remain as in the model of Chapter 3.

Thus, we again obtain the unit cost framework of the relative low (3.57) as well as relative high skill intensive industry (3.58) considering International Outsourcing activities and, slightly rearranging, achieve (3.59) and (3.60) as equilibrium production.

These two equations can now be solved for changes in w_L and w_H due to exogenous changes in different International Outsourcing situations.

In order to investigate the changes occurring with wage rigidity, we only focus on scenario (iii) in this chapter, the relative high skill intensive industry outsourcing its low skill intensive production parts. In scenarios (i) and (ii), the minimum wage assumption would not be binding since the absolute as well as relative wage of the low skilled increases.

Thus, as we already know from the Appendix of Chapter 3, we achieve

$$\hat{w}_L = -\frac{\theta_{XL}\theta_{YH}}{\Delta_{\Theta}}\hat{\phi}_{XL} \quad (5.47)$$

$$\hat{w}_H = \frac{\theta_{XL}\theta_{YL}}{\Delta_{\Theta}}\hat{\phi}_{XL} \quad (5.48)$$

and

$$\hat{w}_H - \hat{w}_L = \frac{\theta_{XL}}{\Delta_{\Theta}}\hat{\phi}_{XL} > 0 \quad (5.49)$$

as the effects of International Outsourcing on relative wages (3.65).

Considering Cobb Douglas production patterns, we achieve

$$\hat{a}_{XL} = \theta_{XH}(\hat{w}_H - \hat{w}_L + \hat{\phi}_{XL} - \hat{\phi}_{XH}) - \hat{\phi}_{XL} \quad (5.50)$$

$$\hat{a}_{XH} = -\theta_{XL}(\hat{w}_H - \hat{w}_L + \hat{\phi}_{XL} - \hat{\phi}_{XH}) - \hat{\phi}_{XH} \quad (5.51)$$

$$\hat{a}_{YL} = \theta_{YH}(\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL} - \hat{\phi}_{YH}) - \hat{\phi}_{YL} \quad (5.52)$$

$$\hat{a}_{YH} = -\theta_{YL}(\hat{w}_H - \hat{w}_L + \hat{\phi}_{YL} - \hat{\phi}_{YH}) - \hat{\phi}_{YH} \quad (5.53)$$

and thus,

$$\hat{a}_H - \hat{a}_L = -\frac{\theta_{XL}}{\Delta_{\Theta}}\hat{\phi}_{XL} \quad (5.54)$$

as the effects of International Outsourcing on relative labor unit requirements.

Concerning the implications on output, we obtain

$$\hat{q}_X = \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{XL}\hat{\phi}_{XL} + \theta_{XL}\hat{\phi}_{XL} \quad (5.55)$$

$$\hat{q}_Y = -\frac{(\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_{\Theta}\Delta_{\Lambda}}\theta_{XL}\hat{\phi}_{XL} \quad (5.56)$$

and for the effects on employment

$$\hat{L}_X = \frac{\theta_{XH}\Delta_\Lambda + (\delta_H\lambda_{YL} + \delta_L\lambda_{YH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XL}\hat{\phi}_{XL} > 0 \quad (5.57)$$

$$\hat{L}_Y = \frac{\theta_{YH}\Delta_\Lambda - (\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XL}\hat{\phi}_{XL} \quad (5.58)$$

$$\hat{H}_X = \frac{(\delta_H\lambda_{YL} + \delta_L\lambda_{YH}) - \theta_{XL}\Delta_\Lambda}{\Delta_\Theta\Delta_\Lambda}\theta_{XL}\hat{\phi}_{XL} \quad (5.59)$$

$$\hat{H}_Y = -\frac{\theta_{YL}\Delta_\Lambda + (\delta_H\lambda_{XL} + \delta_L\lambda_{XH})}{\Delta_\Theta\Delta_\Lambda}\theta_{XL}\hat{\phi}_{XL} < 0 \quad (5.60)$$

International Outsourcing with Wage Rigidity

In order to consider wage rigidity, we subject the labor market of the economy to a wage floor for low skilled labor, exogenously given in real terms as in Brecher (1974a,b). Therefore, labor markets are inflexible in the sense that real wages for the low skilled are rigid with respect to the numeraire \bar{w}_L , set before International Outsourcing takes place. Thus, at \bar{w}_L , L is fully employed but, however, with downward inflexibility of the (uniform) real wage of the low skilled

$$w_L \geq \bar{w}_L \text{ or } \hat{w}_L \geq 0 \quad (5.61)$$

In the scenario assumed ($\hat{\phi}_{XL} > 0$), real wages of the low skilled decrease ($\hat{w}_L < 0$) (see 5.47 and 5.48). In this case, the minimum wage is binding at \bar{w}_L and thus, $\hat{w}_L = 0$. Therefore, we need to rewrite (3.59) and (3.60)

$$\theta_{XH}\hat{w}_H = \theta_{XL}\hat{\phi}_{XL} \quad (5.62)$$

$$\theta_{YH}\hat{w}_H = 0 \quad (5.63)$$

With labor completely mobile between industries, all high skilled workers would stop to work in the relative low skill intensive industry and move to the relative high skill intensive industry (X). Thus, the relative low skill intensive industry (Y) would stop production. This, however, is no equilibrium situation assuming incomplete specialization. Thus, the low skill intensive industry (Y) has to accept the changes of high skilled wages (caused by International Outsourcing in the relative high skill intensive industry) to keep its production pattern positive ($\hat{w}_{YH} = \hat{w}_{XH} = \hat{w}_H = \frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL}$).

With the change in high skilled wages $\hat{w}_H = \frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL}$, the relative high skill intensive industry minimizes unit costs

$$\begin{aligned} dc_X &= \theta_{XL}(\hat{w}_L - \hat{\phi}_{XL}) + \theta_{XH}(\hat{w}_H - \hat{\phi}_{XH}) \\ &= -\theta_{XL}\hat{\phi}_{XL} + \theta_{XH}\frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} \\ &= -\theta_{XL}\hat{\phi}_{XL} + \theta_{XL}\hat{\phi}_{XL} = 0 \end{aligned}$$

but the relative low skill intensive industry produces not at the cost minimization level

$$\begin{aligned} dc_Y &= \theta_{YL}(\hat{w}_L - \hat{\phi}_{YL}) + \theta_{YH}(\hat{w}_H - \hat{\phi}_{YH}) \\ &= \theta_{YH}\frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} > 0 \end{aligned}$$

The only way for the relative low skill intensive industry to minimize unit costs (considering the acceptance of the high skilled wage premium), is to reduce the level of output ($\hat{q}_Y < 0$).

Relative Wages

Since the relative low skill intensive industry has to accept the increase in high skill wages ($\hat{w}_H = \hat{w}_{XH} = \hat{w}_{YH} = \frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL}$), and since $\hat{w}_L = 0$

$$\hat{w}_H - \hat{w}_L = \frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} \quad (5.64)$$

Since $\theta_{XH} > \Delta_\Theta$, the increase in relative wages of the high skilled is not as strong as in the benchmark model (assuming flexible wages).

$$\begin{aligned} (\hat{w}_H - \hat{w}_L) |_{\text{flex}} - (\hat{w}_H - \hat{w}_L) |_{\text{rigid}} &= \frac{\theta_{XL}}{\Delta_\Theta}\hat{\phi}_{XL} - \frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} > 0 \\ \frac{\theta_{XL}}{\Delta_\Theta}\hat{\phi}_{XL} &> \frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} \\ \theta_{XH} &> \Delta_\Theta \\ \theta_{XH} &> \theta_{XH} - \theta_{YH} \end{aligned} \quad (5.65)$$

Relative Labor Unit Requirements

From Shephard's Lemma we know that labor unit requirements can be described as

$$\begin{aligned}\hat{a}_{XL} &= \theta_{XH}(\hat{w}_H - \hat{w}_L + \hat{\phi}_{XL}) - \hat{\phi}_{XL} \\ \hat{a}_{XH} &= -\theta_{XL}(\hat{w}_H - \hat{w}_L + \hat{\phi}_{XL}) \\ \hat{a}_{YL} &= \theta_{YH}(\hat{w}_H - \hat{w}_L) \\ \hat{a}_{YH} &= -\theta_{YL}(\hat{w}_H - \hat{w}_L)\end{aligned}$$

Thus, for relative labor unit requirements, we achieve

$$\begin{aligned}\hat{a}_{XH} - \hat{a}_{XL} &= -\theta_{XL}(\hat{w}_H - \hat{w}_L + \hat{\phi}_{XL}) - \theta_{XH}(\hat{w}_H - \hat{w}_L + \hat{\phi}_{XL}) + \hat{\phi}_{XL} \\ &= -(\hat{w}_H - \hat{w}_L) - \hat{\phi}_{XL} + \hat{\phi}_{XL} \\ &= -(\hat{w}_H - \hat{w}_L) \\ &= -\frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL}\end{aligned}$$

in the relative high skill intensive industry (X) and

$$\begin{aligned}\hat{a}_{YH} - \hat{a}_{YL} &= -\theta_{YL}(\hat{w}_H - \hat{w}_L) - \theta_{YH}(\hat{w}_H - \hat{w}_L) \\ &= -(\hat{w}_H - \hat{w}_L) \\ &= -\frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} < 0\end{aligned}$$

in the relative low skill intensive industry (Y). Thus, relative labor unit requirements change with

$$\hat{a}_H - \hat{a}_L = -\frac{\theta_{XL}}{\theta_{XH}}\hat{\phi}_{XL} \quad (5.66)$$

Output

In order to achieve the equilibrium output patterns, additional information is necessary. We have to remember the endowment of the economy with fixed, overall factor supplies (\bar{L} and \bar{H}), constraining the total employment conditions. In the case of wage rigidity

for low skilled labor, unemployment of the low skilled is possible ($\hat{L} \leq 0$). Thus, (3.55) has to be rewritten

$$L \equiv a_{XL}q_X + a_{YL}q_Y \leq \bar{L} \quad (5.67)$$

Since high skilled wages can adjust flexible, high skilled labor must be fully utilized

$$H \equiv a_{XH}q_H + a_{YH}q_Y = \bar{H} \quad (5.68)$$

Taking the total differential, we achieve

$$\hat{q}_X\lambda_{XL} + \hat{q}_Y\lambda_{YL} = \hat{L} - (\hat{a}_{XL}\lambda_{XL} + \hat{a}_{YL}\lambda_{YL}) \quad (5.69)$$

and

$$\hat{q}_X\lambda_{XH} + \hat{q}_Y\lambda_{YH} = -(\hat{a}_{XH}\lambda_{XH} + \hat{a}_{YH}\lambda_{YH}) \quad (5.70)$$

Substituting for the change in wages and labor unit requirements, we achieve

$$\begin{aligned} \hat{q}_X\lambda_{XL} + \hat{q}_Y\lambda_{YL} &= \hat{L} - \left\{ (\theta_{XH} \left(\frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} + \hat{\phi}_{XL} \right) - \hat{\phi}_{XL}) \lambda_{XL} + (\theta_{YH} \left(\frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} \right)) \lambda_{YL} \right\} \\ &= \hat{L} - \left\{ \theta_{XL} \hat{\phi}_{XL} \lambda_{XL} + \theta_{XH} \hat{\phi}_{XL} \lambda_{XL} - \hat{\phi}_{XL} \lambda_{XL} + \frac{\theta_{YH} \theta_{XL} \hat{\phi}_{XL} \lambda_{YL}}{\theta_{XH}} \right\} \\ &= \hat{L} - \frac{\theta_{YH} \theta_{XL}}{\theta_{XH}} \lambda_{YL} \hat{\phi}_{XL} \end{aligned}$$

and

$$\begin{aligned} \hat{q}_X\lambda_{XH} + \hat{q}_Y\lambda_{YH} &= -\left\{ (-\theta_{XL} \left(\frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} + \hat{\phi}_{XL} \right)) \lambda_{XH} + (-\theta_{YL} \left(\frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} \right)) \lambda_{YH} \right\} \\ &= -\left\{ -\frac{\theta_{XL} \theta_{XL} \hat{\phi}_{XL} \lambda_{XH}}{\theta_{XH}} - \frac{\theta_{XL} \hat{\phi}_{XL} \lambda_{XH} \theta_{XH}}{\theta_{XH}} - \frac{\theta_{YL} \theta_{XL} \hat{\phi}_{XL} \lambda_{YH}}{\theta_{XH}} \right\} \\ &= \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} \lambda_{XH} + \frac{\theta_{YL} \theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} \lambda_{YH} \end{aligned}$$

Applying some matrix-algebra,

$$\begin{pmatrix} \lambda_{XH} & \lambda_{YH} \\ \lambda_{XL} & \lambda_{YL} \end{pmatrix} \begin{pmatrix} \hat{q}_X \\ \hat{q}_Y \end{pmatrix} = \begin{pmatrix} \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} (\lambda_{XH} + \theta_{YL} \lambda_{YH}) \\ \hat{L} - \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} (\theta_{YH} \lambda_{YL}) \end{pmatrix}$$

and solve for \hat{q}_X and \hat{q}_Y , we obtain

$$\begin{aligned} \hat{q}_X &= \frac{\begin{vmatrix} \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} (\lambda_{XH} + \theta_{YL} \lambda_{YH}) & \lambda_{YH} \\ \hat{L} - \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} (\theta_{YH} \lambda_{YL}) & \lambda_{YL} \end{vmatrix}}{\Delta_\Lambda} \\ &= \frac{\frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} \lambda_{YL} (\lambda_{XH} + \theta_{YL} \lambda_{YH}) - \hat{L} \lambda_{YH} + \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} \lambda_{YH} (\theta_{YH} \lambda_{YL})}{\Delta_\Lambda} \\ &= \frac{\lambda_{YL} (\lambda_{XH} + \theta_{YL} \lambda_{YH}) + \lambda_{YH} (\theta_{YH} \lambda_{YL})}{\Delta_\Lambda} \cdot \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} - \hat{L} \frac{\lambda_{YH}}{\Delta_\Lambda} \end{aligned} \quad (5.71)$$

and

$$\begin{aligned} \hat{q}_Y &= \frac{\begin{vmatrix} \lambda_{XH} & \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} (\lambda_{XH} + \theta_{YL} \lambda_{YH}) \\ \lambda_{XL} & \hat{L} - \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} (\theta_{YH} \lambda_{YL}) \end{vmatrix}}{\Delta_\Lambda} \\ &= \frac{\lambda_{XH} \hat{L} - \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} \lambda_{XH} (\theta_{YH} \lambda_{YL}) - \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} \lambda_{XL} (\lambda_{XH} + \theta_{YL} \lambda_{YH})}{\Delta_\Lambda} \\ &= -\frac{\lambda_{XL} (\lambda_{XH} + \theta_{YL} \lambda_{YH}) + \lambda_{XH} (\theta_{YH} \lambda_{YL})}{\Delta_\Lambda} \cdot \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} + \frac{\lambda_{XH} \hat{L}}{\Delta_\Lambda} \end{aligned} \quad (5.72)$$

Employment

For the change on employment, consider

$$\hat{L}_X = \hat{a}_{XL} + \hat{q}_X$$

$$\hat{L}_Y = \hat{a}_{YL} + \hat{q}_Y$$

$$\hat{H}_X = \hat{a}_{XH} + \hat{q}_X$$

$$\hat{H}_Y = \hat{a}_{YH} + \hat{q}_Y$$

and substitute for the change in labor unit requirements as well as the change in output. Thus, we achieve for within industry employment of the high skilled

$$\begin{aligned}
\hat{H}_X &= -\theta_{XL} \left(\frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} + \hat{\phi}_{XL} \right) + \frac{\lambda_{YL}(\lambda_{XH} + \theta_{YL}\lambda_{YH}) + \lambda_{YH}(\theta_{YH}\lambda_{YL})}{\Delta_\Lambda} \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} - \frac{\lambda_{YH}}{\Delta_\Lambda} \hat{L} \\
&= -\frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} + \frac{\lambda_{YL}(\lambda_{XH} + \theta_{YL}\lambda_{YH}) + \lambda_{YH}(\theta_{YH}\lambda_{YL})}{\Delta_\Lambda} \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} - \frac{\lambda_{YH}}{\Delta_\Lambda} \hat{L} \quad (5.73)
\end{aligned}$$

$$\hat{H}_Y = -\frac{\theta_{YL}\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} - \frac{\lambda_{XL}(\lambda_{XH} + \theta_{YL}\lambda_{YH}) + \lambda_{XH}(\theta_{YH}\lambda_{YL})}{\Delta_\Lambda} \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} + \frac{\lambda_{XH}}{\Delta_\Lambda} \hat{L} \quad (5.74)$$

And for the change in employment of the low skilled, we obtain

$$\begin{aligned}
\hat{L}_X &= \hat{a}_{XL} + \hat{q}_X \\
&= 0 + \frac{\lambda_{YL}(\lambda_{XH} + \theta_{YL}\lambda_{YH}) + \lambda_{YH}(\theta_{YH}\lambda_{YL})}{\Delta_\Lambda} \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} - \frac{\lambda_{YH}}{\Delta_\Lambda} \hat{L}_X - \frac{\lambda_{YH}}{\Delta_\Lambda} \hat{L}_Y \\
\frac{\Delta_\Lambda + \lambda_{YH}}{\Delta_\Lambda} \hat{L}_X &= \frac{\lambda_{YL}(\lambda_{XH} + \theta_{YL}\lambda_{YH}) + \lambda_{YH}(\theta_{YH}\lambda_{YL})}{\Delta_\Lambda} \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} - \frac{\lambda_{YH}}{\Delta_\Lambda} \hat{L}_Y \\
\frac{\lambda_{YL}}{\Delta_\Lambda} \hat{L}_X &= \frac{\lambda_{YL}(\lambda_{XH} + \theta_{YL}\lambda_{YH}) + \lambda_{YH}(\theta_{YH}\lambda_{YL})}{\Delta_\Lambda} \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} - \frac{\lambda_{YH}}{\Delta_\Lambda} \hat{L}_Y \\
\hat{L}_X &= \frac{\lambda_{XH} + \theta_{YL}\lambda_{YH} + \lambda_{YH}\theta_{YH}}{\theta_{XH}} \theta_{XL} \hat{\phi}_{XL} - \frac{\lambda_{YH}}{\lambda_{YL}} \hat{L}_Y \\
&= \frac{\lambda_{XH} + (1 - \theta_{YH})\lambda_{YH} + \lambda_{YH}\theta_{YH}}{\theta_{XH}} \theta_{XL} \hat{\phi}_{XL} - \frac{\lambda_{YH}}{\lambda_{YL}} \hat{L}_Y \\
&= \frac{\theta_{XL}}{\theta_{XH}} \hat{\phi}_{XL} - \frac{\lambda_{YH}}{\lambda_{YL}} \hat{L}_Y \quad (5.75)
\end{aligned}$$

Appendix 2: Wage Rigidity at the two-digit NACE Industry Level

Table 5.3: Two-digit NACE industries with wage rigidity (Germany, 1991-2000)

NACE	Industry	Wage Rigidity
1	Agriculture	1
2	Forestry	0
5	Fishing	0
10	Mining of coal and lignite	1
11	Extraction of crude petroleum and natural gas	0
12	Mining of iron ores	0
13	Mining of non-ferrous metal ores	0
14	Quarrying of stone, sand and clay	0
15	Manufacture of food products and beverages	1
16	Manufacture of tobacco products	0
17	Manufacture of textiles	1
18	Manufacture of wearing apparel	1
19	Manufacture of leather and related products	1
20	Manufacture of wood except furniture	0
21	Manufacture of paper and paper products	1
22	Printing and reproduction of recorded media	1
23	Manufacture of coke and refined petroleum products	0
24	Manufacture of chemicals and chemical products	1
25	Manufacture of rubber and plastic products	1
26	Manufacture of other non-metallic mineral products	0
27	Manufacture of basic metals	1
28	Manufacture of fabricated metal products, except machinery	1
29	Machinery	1
30	Manufacture of computer, electronic and optical products	1
31	Manufacture of electrical equipment	1
32	Radio, TV, and telecommunications	1
33	Manufacture of machinery and equipment	1
34	Manufacture of motor vehicles, trailers and semi-trailers	1
35	Manufacture of other transport equipment	0
36	Manufacture of furniture	1
37	Repair and installation of machinery and equipment	1
40	Electricity, gas, steam and air conditioning supply	1
41	Water collection, treatment and supply	0
45	Construction of buildings	1
50	Wholesale and retail trade and repair of motor vehicles	0
51	Wholesale trade	1
52	Retail trade	1
55	Accommodation	1
60	Land transport and transport via pipelines	1
61	Water transport	0
62	Air transport	0
63	Warehousing and support activities for transportation	1
64	Postal and courier activities	1
65	Financial service activities, except insurance	1
66	Insurance, reinsurance and pension funding	1
67	Activities auxiliary to financial services	0
70	Real estate activities	1
71	Rental and leasing activities	0
72	Data processing and data warehouse	0
73	Scientific research and development	0
74	Office administrative and other business support activities	0
75	Public administration and defense; compulsory social security	1
80	Education	0
85	Human health activities	0
90	Activities of households as employers of domestic personnel	0
91	Activities of membership organizations	1
92	Culture, sports, and entertainment	1
93	Other services	1
95	Sewerage	0
96	Industry - not assigned	1
97	Handcraft - not assigned	0
98	Services - not assigned	1
99	Activities of extraterritorial organizations and bodies	0
100	Undifferentiated goods and services producing activities	0

Chapter 6

Summary

As outlined in Chapter 1, it was the intention of this thesis to analyze different aspects concerning implications of the sector bias of International Outsourcing in industrialized economies. Therefore, Chapter 1 provided an introduction by defining what is exactly meant when talking about International Outsourcing in this thesis. In order to motivate the subsequent analysis, some descriptive statistics were presented, giving a firm indication of the magnitude and the development of International Outsourcing in various economies. Referring to an ongoing discussion, the chapter continued to identify several gaps in the International Outsourcing literature. With the four manuscripts presented as main chapters, this thesis tried to contribute to fill some of these gaps.

The manuscript “Labor Market effects of International Outsourcing: How Measurement Matters” (Chapter 2) investigated empirical problems arising when measuring International Outsourcing. Since there is no variable observing outsourcing activities at the industry level, there is a need to proxy International Outsourcing when it comes to macroeconomic analyses. Therefore, several indices exist and some of them are very common in use. Motivated by different, sometimes contradicting, results which are achieved in the empirical outsourcing literature, the manuscript explored how measurement matters when estimating labor market effects of International Outsourcing. As the results show, huge differences exist between the various indices. While some of them exhibit a high quality in terms of truly being driven by International Outsourcing activities, the variance of other indices strongly depends on structural changes as well. When using the indices to estimate labor market effects, their performance in addition depends on the level of industry aggregation. Considering the measurement differences in tandem with the aggregation bias, several findings of the empirical literature on International Outsourcing can be reconciled.

The manuscript “The Elasticity of Substitution and the Sector Bias of International Outsourcing: Solving the Puzzle” (Chapter 3) formally investigated the sector bias of International Outsourcing. When analyzing International Outsourcing within a traditional trade framework, four different outsourcing scenarios emerge. However, with standard assumptions in general equilibrium, only two of them can be solved unambiguously. In order to investigate this puzzle, the paper set up a traditional 2×2 Heckscher-Ohlin model, where International Outsourcing got introduced as a reduction in unit costs, and calibrated the model using German micro-census data. Following a modern duality approach to general equilibrium, results showed that the puzzle can be solved when moving the focus on the elasticity of substitution between low and high skilled labor. If the elasticity exceeds a critical value, all four possible scenarios lead to unambiguous results for implications on wages, labor unit requirements, output, and employment.

Since there is no contribution testing the sector bias of International Outsourcing empirically, the aim of the manuscript “International Outsourcing and the Sector Bias: New Empirical Evidence” (Chapter 4) was to fill this gap. Therefore, it formally investigated labor market effects of International Outsourcing by first highlighting the sector bias. Subsequently, the development of International Outsourcing got calculated for different industry aggregation levels in Germany. Applying a macro-econometric panel data analysis, the wage gap between high and low skilled labor was regressed on the International Outsourcing activity and different control variables. Using the SOEP data and input-output tables provided by the German Federal Statistical Office, results show that the sector bias of International Outsourcing is an important feature significantly affecting the German labor market between 1991 and 2000. When International Outsourcing takes place in relative high skill intensive industries, the wage gap between high and low skilled labor significantly increases. By contrast, if International Outsourcing takes place in relative low skill intensive industries, the wage gap significantly decreases. With this first empirical evidence supporting the sector bias, the manuscript concluded that the negative implications of International Outsourcing for low skilled labor might well be exaggerated.

As most contributions investigating International Outsourcing effects assume a flexible wage economy, the manuscript “International Outsourcing and Wage Rigidity: A Formal Approach and First Empirical Evidence” (Chapter 5) aimed at extending the model presented in Chapter 3 with downward real wage rigidity for low skilled labor. Secondly, it applied a panel data analysis in order to provide first empirical evidence on the impact of wage stickiness. Theoretical results show that, if International

Outsourcing takes place in the relative high skill intensive industry (the cases where low skilled wage rigidity is binding), relative wages of the high skilled still increase, however, not as strong as in the flexible wage scenario. With Cobb Douglas production patterns, relative labor unit requirements of the high skilled decrease, however, again, not as strong as in the flexible wage scenario. In order to retain production, the low skill intensive industry needs to cut back on output. Thus, the contraction of the low skill intensive industry is accentuated. Since not all of the low skilled laid off in the relative low skill intensive industry can be absorbed by the relative high skill intensive industry, unemployment of the low skilled increases as we move along the Rybczynski line. Based on the SOEP data and on input-output tables provided by the Federal Statistical Office, the chapter featured a micro-econometric panel data analysis supporting the theoretical findings: If International Outsourcing takes place in industries characterized by wage rigidity for low skilled labor, the likelihood of low skilled workers to get unemployed increases strongly in magnitude as well as in significance. Thus, the chapter concluded that, in terms of unemployment, it is not International Outsourcing, but inflexible labor market institutions which should instead be blamed for harming low skilled labor.

The aim of this thesis was to try to enrich the discussion on the implications of International Outsourcing in industrialized economies. In particular, it tied in with the economic literature by addressing several questions concerning the sector bias of International Outsourcing, which were unexplored or at least under research thus far. With the research questions necessarily focused, the thesis can not claim to provide an exhaustive investigation of International Outsourcing implications. Necessarily, several aspects had to be considered as being beyond the scope of the analysis. Determinants of International Outsourcing e.g. were not investigated. In order to focus on the implications, International Outsourcing was (theoretically as well as empirically) modeled as a relocation of production fragments abroad, without considering the forces driving those decisions. In addition, the analysis adopted a macroeconomic approach throughout. Therefore, it could not distinguish between different forms of firm characteristics as a micro-approach would have delivered, however, at the expense of losing sight of the skill bias and its repercussions on labor markets and sectoral employment. Thus, as mentioned in the introduction, this thesis considered intra-firm in conjunction with arm's length International Outsourcing. Shifting the focus on similarities or differences of the effects of International Outsourcing related to these different organizational structures could provide an interesting question of future research.

Bibliography

- Akerlof, G. (1982). Labor contracts as partial gift exchange. *Quarterly Journal of Economics* 97, 543–569.
- Akerlof, G. and J. Yellen (1988). Fairness and unemployment. *American Economic Review* 78, 44–49.
- Akerlof, G. and J. Yellen (1990). The fair wage-effort hypothesis and unemployment. *Quarterly Journal of Economics* 105, 255–283.
- Amiti, M. and S.-J. Wei (2005a). Fear of service outsourcing: Is it justified? *Economic Policy* 20, 308–348.
- Amiti, M. and S.-J. Wei (2005b). Service offshoring, productivity, and employment: Evidence from the United States. *IMF Working Paper* 05 / 238.
- Arndt, S. W. (1997). Globalization and the open economy. *North American Journal of Economics and Finance* 8 (1), 71–79.
- Arndt, S. W. (1998a). Globalization and the gains from trade. Koch, K.-J. and K. Jaeger (eds). *Trade, growth, and economic policy in open economies: Essays in honor of Hans-Jürgen Vosgerau*, Springer, Berlin, 3–12.
- Arndt, S. W. (1998b). Super-specialization and the gains from trade. *Contemporary Economic Policy* 16 (4), 480–485.
- Balassa, B. (1979). The changing international division of labor in manufactured goods. *Banca Nazionale del Lavoro Quarterly Review* 130, 243–285.
- Bardhan, A. D. and C. A. Kroll (2003). *The New Wave of Outsourcing, Research Report*, Fischer Center for Real Estate and Urban Economics. University of California, Berkeley.
- Bauer, T., H. Bonin, L. Goette, and U. Sunde (2007). Real and nominal wage rigidities and the rate of inflation: Evidence from West German micro data. *Economic Journal* 117, F508–F529.

- Berman, E., J. Bound, and Z. Griliches (1994). Changes in the demand for skilled labor within US manufacturing: Evidence from the annual survey of manufactures. *Quarterly Journal of Economics* 109 (2), 367–397.
- Brecher, R. A. (1974a). Minimum wage rates and the pure theory of international trade. *Quarterly Journal of Economics* 88 (1), 98–116.
- Brecher, R. A. (1974b). Optimal commercial policy for a minimum-wage economy. *Journal of International Economics* 4, 139–149.
- Burda, M. and B. Dluhosch (2002). Cost competition, fragmentation, and globalization. *Review of International Economics* 10 (3), 424–441.
- Campa, J. and L. S. Goldberg (1997). The evolving external orientation of manufacturing: A profile of four countries. *Economic Policy Review* 3 (2), 53–81.
- Chen, H., M. Kondratowicz, and K.-M. Yi (2005). Vertical specialization and three facts about U.S. international trade. *North American Journal of Economics and Finance* 16, 33–59.
- Chipman, J. S. (1966). A survey of the theory of international trade: Part 3, the modern economy. *Econometrica* 34, 18–76.
- Deardorff, A. V. (2001a). Fragmentation across cones. *Arndt, S. W. and H. Kierzkowski (eds). Fragmentation, New Production Patterns in the World Economy, Oxford University Press, Oxford*, 35–51.
- Deardorff, A. V. (2001b). Fragmentation in simple trade models. *North American Journal of Economics and Finance* 12, 121–137.
- Diewert, W. E. (1971). An application of the Shephard Duality theorem: A generalized Leontief production function. *Journal of Political Economy* 79, 481–507.
- Diewert, W. E. (1974). Applications of duality theory. *M. D. Intriligator and D. A. Kendrick (eds). Frontiers of Quantitative Economics, Volume II, North-Holland Publications, Amsterdam*, 106–171.
- Dluhosch, B. (2008). Globalization and skill biased technical change: The implications of labor market rigidities. *Economia Internazionale LXI (1)*, 25–45.

- Dluhosch, B. and D. Horgos (2008). Wage vs. industry subsidies: Coping with technology related unemployment in a globalized economy. *Journal of International Economics and Economic Policy* 5 (4), 371–388.
- Egger, H. and P. Egger (2002). How international outsourcing drives up Eastern European wages. *Weltwirtschaftliches Archiv* 138, 83–96.
- Egger, H. and P. Egger (2003). On market concentration and international outsourcing. *Applied Economics Quarterly* 49, 49–64.
- Egger, H. and P. Egger (2005). Labor market effects of outsourcing under industrial interdependence. *International Review of Economics and Finance* 14, 349–363.
- Egger, H. and J. Falkinger (2003). The distributional effects of international outsourcing in a 2 x 2 production model. *North American Journal of Economics and Finance* 14, 189–206.
- Egger, H. and U. Kreickemeier (2008). International fragmentation: Boon or bane for domestic employment? *European Economic Review* 52, 116–132.
- Ethier, W. (2005). Globalization, globalisation: Trade, technology, and wages. *International Review of Economics and Finance* 14, 237–258.
- European Economic Advisory Group (2005). Outsourcing. *CESifo (ed). Report on the European Economy, Chapter 2, Ifo Institute for Economic Research, Munich*, 39–50.
- Falk, M. and B. M. Koebel (2002). Outsourcing, imports and labor demand. *Scandinavian Journal of Economics* 104 (4), 567–586.
- Feenstra, R. C. (1998). Integration of trade and disintegration of production in the global economy. *Journal of Economic Perspectives* 12 (4), 31–50.
- Feenstra, R. C. and G. H. Hanson (1996a). Foreign investment, outsourcing, and relative wages. *Feenstra, R. C., G. M. Grossman and D. A. Irwin (eds). The Political Economy of Trade Policy, Essays in Honor of Jagdish Bhagwati, MIT Press, Cambridge, Mass.*, 89–127.
- Feenstra, R. C. and G. H. Hanson (1996b). Globalization, outsourcing, and wage inequality. *American Economic Review* 86, 240–245.
- Feenstra, R. C. and G. H. Hanson (1997). Foreign direct investment and relative wages: Evidence from Mexico's maquiladoras. *Journal of International Economics* 42, 371–393.

- Feenstra, R. C. and G. H. Hanson (1999). The impact of outsourcing and high-technology capital on wage estimates for the United States, 1979-1990. *Quarterly Journal of Economics* 114, 907–940.
- Geishecker, I. and H. Görg (2005). Do unskilled workers always lose from fragmentation. *North American Journal of Economics and Finance* 16, 81–92.
- Geishecker, I. and H. Görg (2008). Winners and losers: a micro-level analysis of international outsourcing and wages. *Canadian Journal of Economics* 41 (1), 243–270.
- Glass, A. J. and K. Saggi (2001). Innovation and wage effects of international outsourcing. *European Economic Review* 45, 67–86.
- Goette, L., U. Sunde, and T. Bauer (2007). Wage rigidity: Measurement, causes and consequences. *Economic Journal* 117, F499–F507.
- Grossman, G. M. and E. Helpman (2005). Outsourcing in a global economy. *Review of Economic Studies* 72, 135–159.
- Grossman, G. M. and E. Rossi-Hansberg (2008). Trading tasks: a simple theory of offshoring. *American Economic Review* 98 (5), 1978 – 1997.
- Haisken-DeNew, J. P. and J. R. Frick (2005). *Desktop Companion to the German Socio-Economic Panel*. Available at www.diw.de/deutsch/sop/service/dtc/dtc.pdf.
- Harrigan, J. and R. A. Balaban (1999). U.S. wages in general equilibrium: the effects of prices, technology, and factor supplies, 1963-1991. *NBER Working Paper* 6981.
- Hijzen, A. (2007). International outsourcing, technological change, and wage inequality. *Review of International Economics* 15 (1), 188–205.
- Hijzen, A., H. Görg, and R. C. Hine (2005). International outsourcing and the skill structure of labour demand in the United Kingdom. *Economic Journal* 115, 860–878.
- Holden, S. (2004). The cost of price stability: Downward nominal wage rigidity in Europe. *Economica* 71 (282), 183–208.
- Horgos, D. (2006). International outsourcing - some measurement problems: An empirical analysis of outsourcing activities in Germany. *IAW-Report* 34 (1), 77–103.
- Hummels, D., J. Ishii, and K.-M. Yi (2001). The nature and growth of vertical specialization in world trade. *Journal of International Economics* 54, 75–96.

- Jones, R. W. (1965). The structure of simple general equilibrium models. *Journal of Political Economy* 73 (6), 557–572.
- Jones, R. W. (2000). *Globalization and the Theory of Input Trade*. MIT Press, Cambridge, Mass.
- Jones, R. W. (2001). Technical progress, price adjustment, and wages. *Choi, E. K. and D. Greenaway (eds). Globalization and Labor Markets. Blackwell Publishers Ltd. Oxford, 125–131.*
- Jones, R. W. and H. Kierzkowski (1990). The role of services in production and international trade: A theoretical framework. *Jones, R. W. and A. O. Krueger (eds). The Political Economy of International Trade, Essays in Honor of Robert E. Baldwin, Blackwell, Cambridge, Mass., 31–48.*
- Jones, R. W. and H. Kierzkowski (2001). A framework for fragmentation. *Arndt, S. W. and H. Kierzkowski (eds). Fragmentation, New Production Patterns in the World Economy, Oxford University Press, Oxford, 17–34.*
- Jones, R. W., H. Kierzkowski, and C. Lurong (2005). What does evidence tell us about fragmentation and outsourcing? *International Review of Economics and Finance* 14, 305–316.
- Kierzkowski, H. (2005). Outsourcing or fragmentation: Blessing or threat. *International Review of Economics and Finance* 14, 233–235.
- Kimura, F. and M. Ando (2005). Two-dimensional fragmentation in East Asia: Conceptual framework and empirics. *International Review of Economics and Finance* 14, 317–348.
- Knoppik, C. and T. Beissinger (2005). Downward nominal wage rigidity in europe: An analysis of European micro data from the ECHP 1994-2001. *IZA Discussion Paper* 1492.
- Kohler, W. (2001). A specific-factors view on outsourcing. *North American Journal of Economics and Finance* 12, 31–53.
- Kohler, W. (2003). The distributional effects of fragmentation. *German Economic Review* 4 (1), 89–120.
- Kohler, W. (2007). The bazaar effect, unbundling of comparative advantage, and migration. *CESifo Working Paper* 1932.

- Kohler, W. (2008). Offshoring: Why do stories differ? *CESifo Working Paper 2231*.
- Koskela, E. and R. Stenbacka (2007). Equilibrium unemployment with outsourcing and wage solidarity under labour market imperfections. *CESifo Working Paper 1988*.
- Krugman, P. R. (1995). Growing world trade: Causes and consequences. *Brookings Papers on Economic Activity I (1)*, 327–362.
- Krugman, P. R. (2000). Technology, trade and factor prices. *Journal of International Economics* 50, 51–71.
- Leamer, E. E. (1996). In search of Stolper-Samuelson effects on U.S. wages. *NBER Working Paper 5427*.
- Lerner, A. P. (1932). The diagrammatical representation of cost conditions in international trade. *Economica* 12, 346–356.
- Moulton, B. R. (1990). An illustration of a pitfall in estimating the effects of aggregate variables on micro units. *Review of Economics and Statistics* 72, 334–338.
- Mussa, M. (1979). The two-sector model in terms of its dual: A geometric exposition. *Journal of International Economics* 9, 513 – 526.
- Shephard, R. W. (1953). *Cost and Production Functions*. Princeton University Press, Princeton.
- Shephard, R. W. (1970). *Theory of Cost and Production Functions*. Princeton University Press, Princeton.
- Skaksen, J. R. (2004). International outsourcing when labor markets are unionized. *Canadian Journal of Economics* 37 (1), 78–94.
- Solow, R. (1979). Another possible source of wage stickiness. *Journal of Macroeconomics* 1, 79–82.
- Strauss-Kahn, V. (2003). The role of globalization in the within-industry shift away from unskilled workers in France. *NBER Working Paper 9716*.
- Tombazos, C. G. (2003). A production theory approach to the imports and wage inequality nexus. *Economic Inquiry* 41 (1), 42–61.
- UNESCO (1997). *International Standard Classification of Education*. Unesco, Paris.

- Uzawa, H. (1964). Duality principles in the theory of cost and production. *International Economic Review* 5 (2), 216–220.
- Wood, A. (1994). *North-south trade, employment and inequality: Changing fortunes in a skill driven world*. Clarendon Press, New York.
- Woodland, A. D. (1977). A dual approach to equilibrium in the production sector in international trade theory. *Canadian Journal of Economics* X (1), 50–68.
- Wooldridge, J. M. (2002). *Econometric Analysis of Cross Section and Panel Data*. MIT Press, Cambridge, Mass.
- Xu, B. (2001). Factor bias, sector bias, and the effects of technical progress on relative factor prices. *Journal of International Economics* 54, 5–25.
- Yeats, A. J. (2001). Just how big is global production sharing? Arndt, S. W. and H. Kierzkowski (eds). *Fragmentation, New Production Patterns in the World Economy*, Oxford University Press, Oxford, 108–143.