Trends in wage inequality: the role of trade, technical change and labor market institutions

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1 Introduction

In the late 1970s Henry Aaron wrote that tracking the changes in the distribution of income in the US was "like watching the grass grow".[1] The attitude of the research community toward inequality was reversed a few years later, when it became clear that the distribution of wages in the US and other Anglo-Saxon countries underwent dramatic changes since the mid 1970s. Since the end of the 1980s the analysis of wage inequality became one of the most active fields of economics. In its issue of June 1997 the University of Chicago magazine referred to the growing wage inequality between high- and low-skilled workers as "the dominant phenomenon of the last quarter-century".[2]

The present work aims to contribute to a better understanding of the determinants of wage inequality focussing on the role of globalization. Rather than trying to prove that international trade is more important than the other factors in explaining wage inequality I attempt a re-evaluation of its role starting from the premise that globalization, technical change and the decline in labor market institutions are three interrelated phenomena. The focus on the interdependence of these three phenomena as possible explanations for inequality distinguishes the present study from most previous contributions.

The following Chapters are organized according to their focus on the particular aspects of inequality. This is important as different aspects of inequality generally require different explanations. The most common measures of inequality are introduced in Chapter 2. In the following Chapter 3 I focus on explaining that part of inequality that has been witnessed among equally skilled workers. This is an issue that has received relatively little attention in the literature as compared to the determinants of wage inequality between workers with different skills. In the subsequent Chapters 4, 5 and 6 I focus on the determinants of the skilled-unskilled wage differential.

It should be noted that chapters 3, 5 and 6, which are the core analytical Chapters, employ different methodological approaches. Chapter 3 employs a theoretical political economy model to analyze the endogenous response of labor market institutions to increased capital mobility. Chapter 5 extends one of the methods used widely to assess the role of trade and technical change, the cost share regression, and applies it to US manufacturing industry data. Chapter 6 develops a general equilibrium model that allows to reconcile the globalization-hypothesis with the most recent trends in inequality. In what follows I survey the content of the thesis in more detail and explain the contribution of each part.

[1] s. Aaron (1978:17).

[2] s. Sweet (1997).

The principal approach in this thesis is to proceed from the general to the specific. The motivation for this is that once the analysis becomes technical the problem is usually very much narrow-downed and so many (implicit) assumptions are made that we are most likely in a position that we "cannot see the wood for the trees". Following this general principle **Chapter 2** starts with a section aiming to provide a broad view on the topic. In this section I attempt to pinpoint the potential determinants of wage inequality starting with a discussion of the determinants of the individual's wage. I make a parallel discussion of some of the peculiarities of the labor market and their implications for the analysis of wage inequality. The next section of Chapter 2 introduces briefly the most common measures of inequality. The last section of this chapter uses these measures to document the basic empirical facts that will be object of analysis in the subsequent chapters. These can be summarized as follows:

1. Since the mid 1970s overall inequality as well as each of its components, between- and within-group inequality, increased more in Anglo-Saxon countries than in Continental Europe.
2. While inequality remained relatively stable in most Continental European countries, unemployment in those countries increased sharply.
3. After the sharp increases during the 1980s, inequality stabilized in the US in the 1990s.

Facts 1 and 2 have lead to an explanation known in the literature as the "two-sides-of-the-same-coin hypothesis" (s. Krugman 1994 and 1995, Freeman 1995, Beißinger and Möller 1998, Fitzenberger 1998). According to this hypothesis both facts are due to the same globally operating factors affecting the composition of labor demand (trade, technical change and capital mobility) with the differences in the response across countries arising from the differences in their labor market institutions. Interestingly, the two-sides-of-the-same-coin hypothesis is as much an explanation as a question. Namely, it answers the question of what the causes for the observed trends in inequality are but simultaneously it raises the problem of interaction (and thus competition) among countries with different systems of labor market institutions.

Chapter 3 addresses the latter problem. While several authors have discussed informally the competition among different labor market regimes or sets of labor market institutions in a world with ever growing interdependence among countries (Agell 1999, Freeman 1998), the model presented in this chapter is perhaps the first that addresses the issue formally. It differs from previous formal theoretical work on the two-sides-of-the-same-coin hypothesis (Krugman 1994 and 1995, Bertola and Ichino 1995, Davis 1998, Acemoglu and Newman, 2002) in that the labor market institutions accounting for the divergent experience in the US and in Continental Europe are endogenous. This has two main advantages.

First, as a modelling strategy it is logically superior because it replaces an assumption on the outcomes (the institutions) with assumptions on the process (the political process). The value of this approach is best seen in a comparison with the model of Davis (1998). Davis (1998) assumes that Europe and America are identical in every respect except that Europe has a binding minimum wage, and America has not. His main result is that trade with newly industrialized counties increases European unemployment, while America remains insulated from the shock, which suggests that the American flexible-wage model may be more suited to survive in a globalizing world as compared to the European rigid one. However, such a conclusion can be drawn only in light of a certain criterion. It appears that Davis (1998) implicitly assumes a criterion that treats unemployment as a loss. The problem with this is that according to the criterion chosen the European minimum wage is a priori irrational, i.e. it is equally unjustified before and after opening to trade with newly industrialized countries.

A second advantage of using a fully specified political economy model is that one can analyze the response of the political equilibrium (institutions) to globalization. Thus, the analysis in Chapter 3 emphasizes the interdependence between labor-market institutions and globalization. Thereby it offers a new perspective on the link between labor-market institutions and globalization on one hand and wage inequality on the other. It should be remembered that the existing empirical literature considers labor-market institutions and globalization as independent and competing explanations for the changes in wage inequality.

The main result of the presented model is that globalization acts as a political equalizer: when capital mobility increases, the level of the minimum wage is adjusted against the interests of the stronger national lobby. This means that the minimum wage can also be raised. It could be also abolished, but not if the flexible-wage paradigm is less efficient in terms of the attainable value of the utilitarian social welfare function. Of course, these results hinge on the assumed political process, which is adapted from Grossman and Helpman (1994). Therefore, one should be careful in drawing general conclusions. This analysis represents a first attempt to model international feed-back effects in the field of labor market policy and my hope is that it would stimulate further work on the the political economy of labor market policy that takes into account the economic and political development of partner countries.

The following three chapters 4-6 constitute one logical part. By contrast to Chapter 3 they address the inequality between skilled and unskilled workers and focus mainly on the US. The purpose of **Chapter 4** is twofold. First, it provides a literature survey that serves as a starting point for the analysis in Chapters 5 and 6. Second, it introduces the supply and demand framework, and critically evaluates its assumptions, most of which are necessary also for the subsequent analysis.

Chapter 5 undertakes a re-examination of the role of trade and technical change in increasing the relative demand for skilled labor. It should be noted that this has been an area of very active research in the past years. This is what attracted me, although it is a two-edged knife: the fact that many people have explored the issue implies that, ceteris paribus, making a contribution is more difficult. Still, my initial reading of the literature allowed me to spot some unexplored aspects. The final decision to opt for the topic was influenced also by the availability of data. All of the data used in the empirical analysis in this thesis are freely downloadable from the Internet except for the data on computer investment and the Feenstra-Hanson estimates of the imports of intermediate products. I am very grateful to David Autor who provided me with these data.

In Chapter 5 I combine two of the methods, which have always been used separately before: the factor-content approach (s. the Februar 2000 issue of the Journal of International Economics) and the cost-share regression (Berman, Bound and Griliches 1994, Feenstra and Hanson 1996, 1999, Autor, Katz and Krueger 1998, Machin and Van Reenen 1998). More precisely, I construct a new variable derived from the factor-content principle which I use to measure the effect of outsourcing in the cost-share regression. The use of this variable requires an innovation also in terms of the data: I combine the information traditionally used to explain skill-upgrading by industry with information of the skill-intensity of foreign production. Furthermore, I use the Scott (2004) data on imports of parts and components as an alternative to the Feenstra-Hanson estimates of the use of imported intermediate goods. I also evaluate critically the theoretical foundations of the cost-share regression in light of the activities of multinational enterprizes and argue in favor of postulating global as opposed to local production functions.

Overall, my conclusion from the analysis in Chapter 5 is that the role of trade has been unduly undervalued in a number of previous studies. Rather than arguing against the alternative, the skill-biased-technical-change explanation, I put forward the argument that the two phenomena, outsourcing and technical change, are strongly complementary. Previously, it was largely believed that the industries that experienced technical change were not the same as those that experienced important changes due to international trade (s. in particular Machin and Van Reenen 1998, p. 1233). The new measure of the effect of outsourcing developed here reveals the opposite: it turns out to be highly correlated with computer investment. While this result is striking in light of the previous evidence, it has a logical interpretation, which can be summarized as follows. Outsourcing represents in essence a spatial disintegration of production which is only possible/profitable if the productive activities performed at the various locations are well coordinated. Computer technology on, the other hand, can be viewed as in important input allowing such coordination. From this point of view it should not be surprising that the industries that engaged more actively in outsourcing were also those that invested more in computers.

The last **Chapter 6** addresses the more recent trends in wage inequality and asks whether its slow-down during the 1990s in the US is consistent with outsourcing being a major cause for its increases during the 1980s. The issue is addressed both from an applied and from a theoretical perspective. First, I provide evidence that similarly to wage inequality the growth rate of the imports of parts and components also slowed down during the 1990s. Second, I present a theoretical model illustrating that continuing integration with newly industrialized countries need not continuously increase the skilled-unskilled wage differential. The model suggests a U-shaped time path of the real wage of unskilled workers in the face of continuing globalization modelled as a fall in import prices. The model suggests the following interpretation of the observed facts: the 1980s were a period of rapid substitution of inputs produced at home for similar inputs produced abroad. The capacity for such substitution had been apparently exhausted to a large extent by the end of the 1980s when most of the unskilled-labor shifted to activities less susceptible to outsourcing (for example, activities that are spatially indivisible from those performed by highly skilled workers). The evidence of a slowdown in the share of parts and components produced abroad since the end of the 1980s also supports this interpretation.

Finally, it should be noted that the analysis in the present thesis is purely positive. The results, which generally support the view that globalization has had an important impact on wage inequality, should not be taken to imply any specific policy recommendation.

The thesis ends with a summary in German.

2 An overview of the factors shaping the wage structure

2.1 Why do wages differ across individuals: an overview

While most of this study is concerned with the determinants of wage inequality defined over a multitude of individuals, this subsection addresses the logically prior question of what factors determine the wage for each individual. The purpose of this discussion is to provide a broader view on the potential explanations for the observed inequality trends. Although I will not be able to account for all the factors affecting the wage in the rest of this thesis I believe that putting the analysis in a broader framework from the outset has a value in it. It will draw the attention of the reader to a multitude of assumptions, which are so common in this context that we often tend to overlook their importance.

What determines the wage of individual i at firm j? Is it not the individual i and the firm j themselves that do it? Indeed, whenever a wage is paid out, there is an underlying contract between the individual and the firm specifying its amount and the kind of work expected in return. Most people would therefore, agree with the conjecture that it is the two parties to the contract, namely the individual and the firm, who determine its content, including the wage. It is only from the point of view of an economist that the answer to this question appears less clear-cut. The reason is that we know of an influential alternative "actor" who may play a decisive role in determining the wage, namely the invisible hand of the market. Accordingly, some economists believe that the wage is determined by market conditions and that neither the firm nor the individual has sufficient power to influence it significantly, i.e. they are "price takers" rather than "price makers". This assumption about the extent to which an individual or a firm can influence the wage through quantity adjustments[3], negotiation or searching is maybe one of the most controversial issues in labor economics. The dissent among economists on this point has its underpinnings actually in the different conception of the functioning of the labor market: some believe it is functioning more perfectly competitively than others do.

Disagreement on this issue notwithstanding, there is one commonly accepted approach in labor economics to explaining wage determination. It consists of regarding the wage as the "price" for labor services and applying some form of supply and demand analysis[4]. Since this is the approach followed also later in this

[3]From the point of view of the individual a "quantity adjustment" would be, for example, an adjustment in the working hours offered; from the point of view of the firm, this could be an adjustment in the number of working places offered.

[4]One remarkable departure from this approach is the "Partial Gift Exchange Model", s.

study I am going to review here briefly its limitations. They arise from some features specific to the labor market. Although these peculiarities are well-known, they are generally difficult to account for in formal models, and it is perhaps impossible to account for all of them simultaneously. That's why I shall discuss them briefly in what follows. The order in which they appear is not meant to reflect their importance. There is no claim on exhaustiveness either.

2.1.1 The peculiarities of the labor market and their implications for the analysis of inequality

1. Labor income is a major source of income

Labor market outcomes are closely related to the personal distribution of income in modern societies. Not only the wage (wages and salaries constitute the largest component in aggregate household income) but also other forms of income such as pensions and unemployment benefits depend on the individual's past and present participation on the labor market. Many types of social benefits and transfer payments depend on the labor market experience of the individual or that of the other household members. Practically, the only component of household income which is independent of the labor market experience of household members is capital income in the form of dividends, interests and rents. However, this type of income constitutes a significant fraction of total income only for households at the very top of the income distribution.[5]

2. Paid work is a major item in the time budget of most individuals

Section 2.4.2 contains some evidence on that point. The labor contract determines not only how a person is going to spent a significant part of his time, but also whom he is going to meet and communicate with and also to some extent the treatment and respect he is going to receive from others.

3. Asymmetry

Many employees (sellers) - one employer (buyer): that is the practice on the labor market. Although collective agreements involving numerous representatives on both sides of the market may regulate wages and other job characteristics, each employee typically joins and quits the employer individually. At a point of time a typical employer will have much more employees than a typical employee will have employers. If one considers consumer- and producer-goods together such

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Akerlof (1982).

[5] S. Section 2.4.1 for some evidence on the above statements

a consistent asymmetry between buyers and sellers would be difficult to establish.

4. Complexity of the exchange

Usually a deal on the labor market is more complex than a deal on the goods markets in the sense that the obligations of both parties consist of several items at a time. While exceptions exist, buyers on goods markets rarely offer something significant beyond the price. Buyers on labor markets (employers) by contrast usually do offer a number of valuable things beyond the wage, namely the prestige of working with that particular firm, the opportunity of learning, the possibility of using the company's mensa, car etc. Thus, a "deal" on the goods market usually consists of exchanging the good against money, while on the labor market a "deal" consists of exchanging labor services as well as a number of other rights and obligations against money and a number of non-pecuniary benefits.

5. No clear-cut units of measurement

This is a basic problem related to the difficulty of defining a homogeneous type of labor services. The problem is of great practical significance since talking about a wage makes sense only in relation to certain quantity of labor. Very often time is used to quantify labor services. For example, later in this thesis I shall present evidence on the distribution of the "hourly", "weekly" or "annual" wages. Such a time-oriented approach to quantifying labor services however is justified only from the workers side. Obviously from the point of view of the employer one hour work by individual i is not the same as one hour work by individual j.

6. Absence of arbitrage trade

While a typical good can go through the hands of many buyers and sellers before being consumed (or used in production), labor cannot. This precludes the possibility of arbitrage trade - one of the major price equalizing forces. Perhaps this is also one of the reasons why search models are more popular for modelling the labor market than they are for other markets. Of course, on goods markets one can also observe different prices for the same good, which leads to positive returns to searching. However, returns to searching on goods markets will generally be lower than on labor markets, since some persons (arbitrage traders) can specialize in this activity and bring returns to searching (and thus, the price dispersion) down. By contrast, on the labor market there is no scope for specialization in this activity - each person has to search a contract party offering an acceptable price on his own. Firms acting as intermediaries on the labor market do exist, but they cannot do the same job, or at least not so well, as the arbitrage traders on goods markets (for further argumentation on this point s. note 2.4.3 in the appendix to this chapter).

The list could be made even longer, but I prefer to stop here and discuss suggestively some implications of the above peculiarities. The fact that labor market outcomes are closely related to the personal distribution of income, for example, represents an important motive to analyze the distribution of wages from the workers side, focusing on socio-demographic covariates. Note that, in principle, analyzing the distribution of the wages from the employers side is equally interesting and perhaps more challenging analytically (because of the asymmetry discussed above).

Facts 2, 4 and 5 together make it difficult to regard the "hourly wage" as the price for an hour of work. Strictly speaking, the true "price of labor" should be the monetary value corresponding to the pure input of labor once non-pecuniary costs and benefits involved have been netted out. Such a netting out for the purposes of the analysis requires estimation of the monetary values of all non-wage aspects of the work contract (e.g. flexibility of working hours, annual leave, risk of injury or illness, etc.). In some cases such a netting out is worth attempting, in other cases working with the actual wages per hour is the best the researcher can do. For example, from the point of view of social justice, the concept of inequality in "attainable" wages might be more interesting than that of inequality in actual wages since the latter may simply reflect different preferences over non-wage aspects of the work contract. However, a decomposition of the actual wage into separate components associated with different aspects of the work contract is not generally feasible. One of the most frequently estimated aspects is the wage premium associated with the risk of injury and illness arising from the job-specific work environment. A good overview of the literature on compensating wage differentials is contained in Ehrenberg and Smith (1988).

The fact that gainful work is a major item in the time budget implies some interesting interdependencies between the labor market and other markets. Traditional analysis focuses on the link via income: working an additional hour or day increases income, with respective consequences for consumer demand. However, consumer behavior is strongly affected not only by the individual's monetary budget but also by its time budget. For example, it is easy to imagine that an additional hour or day free can affect demand for some goods or services well beyond the income effect associated with the reduced pay.
Finally, we should note that the peculiarities of the labor markets discussed above are related to a number of empirical findings, which are difficult to explain with a purely competitive model of labor supply and demand. The latter include the existence of: wage dispersion among similar workers; positive correlation between employer size and wages; wage discrimination; market provision of general training; persistent vacancies (i.e. firms cannot hire additional workers at the going wage); positive employment effects of minimum wages; etc. Boal and Ransom

(1997) and Bhaskar, Manning and To (2002) provide good reviews of the empirical literature documenting these findings. Both studies interpret this evidence to support the view that employers have some market power. They also discuss different theoretical models that are able to explain this evidence. Models featuring employer market power (monopsony, monopsonistic competition, etc.) play a central role in this respect. Other models with a capacity to account for some of the above findings include: search models that emphasize search costs and the absence of arbitrage trade on the labor market; efficiency wage models that emphasize the link between productivity and wages and the importance of motivation; models of implicit contracts that emphasize the dynamic nature of the labor relationship and the role of risk; models of bargaining that emphasize the role of non-market forces; etc. Of course, no single model can account for all empirical findings simultaneously.

2.1.2 From prices to wages. How far can drawing analogies be useful?

While in the previous subsection I emphasized some of the *peculiarities* of the labor market as potential explanations for the presence of wage inequality and its changes over time, in this subsection I draw on the *similarities* between the labor market and goods markets to point to further potential determinants of wage inequality. In fact, exchange takes place on both good and labor markets (e.g. goods against money; labor services + other obligations against money + other non-wage benefits) and on both markets sellers are interested in a higher and the buyers in a lower price (wage). This allows us to analyze the labor market by analogy with the goods markets. In what follows I consider briefly the price determination on the latter.

Price determination on goods markets.

Usually we associate each good with a certain price. For the purposes of this discussion let me figuratively decompose the way from the good to its price, i.e. the price determination process, into three stages. First, we define the good which is to be priced. While defining a good is not easy, in most cases it would be enough to specify its physical characteristics, time and location (I shall refer to this as Stage 1). Stage 1 allows potential buyers and sellers (a producer is always a potential seller, the consumer is a potential buyer, and a trader is both) to build personal valuations of this good (Stage 2). Finally, let those agents interact in some way (e.g. through an auction) and out of the (most probably quite different) personal valuations we get (hopefully) the (one) price of the good (Stage 3).

On the law of one price.

Whether the price formation process considered above leads to a unique price is decided at the first and the third stage. On one hand, if our working definition of a good is not precise enough (for example "new cars with 100 to 120 KW in 2005 in Germany") we may actually be pricing several goods at a time. Therefore, we should not be surprised if we end up with several prices for "our good".[6] On the other hand, even if we managed to define a truly homogeneous good at the first stage, we may end up with different prices depending on the way agents interact with each other. As a trivial example of this consider the case where producers and consumers negotiate by pairs and transactions with other pairs (arbitrage trade) are not allowed. In this case we may end up with as many prices for the good as there are negotiating pairs. Some appropriately designed auctions, by contrast, would ensure one price in all transactions.

On the role of market and non-market forces.

What I called here the third stage of the price formation process is the most interesting from an economist's point of view. Generally we can distinguish two basic types of interaction: market and non-market. The best example of market interaction is perfect competition, which predicts that the price of a good should be equal to the cost of producing it. One of the main characteristics of market interaction is that it is impersonal and non-discriminating, the price itself being the main exclusion mechanism.[7] Non-market interaction, on the other hand, is personal, characterized by special treatment accorded to each party, and usually involving some elements of bargaining. Examples of non-market interaction include bilateral and multilateral negotiations and the formation of all sorts of coalitions (cartels, labor unions, etc.).

Potential causes for price (and wage) changes over time

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[6] A definition of a good may be said to be "precise enough", if each agent is able to form a unique valuation for all objects satisfying the definition. In this case we may say that it defines a "homogeneous" good. Note that this allows heterogeneity with respect to characteristics agents don't care about.

[7] This does not mean that market interaction is incompatible with the existence of some barriers to entry. For example, both buyers and sellers of guns need a license, but we can still have a true market for guns, if there are enough agents with a license. While the number of agents is not the only thing that matters, a large number of participating agents contributes to the impersonal character of the interaction. A further important factor is the degree of competition. "Market interaction" always involves some form of competition, at least on one side of the market. Finally, while the classical monopoly with many buyers may, under some conditions, still be classified as a form of market interaction (though not, if the monopolist has information on the willingness of different buyers to pay and is able to price discriminate), a bilateral monopoly involving bargaining between just two parties can by no means be classified as such.

In my opinion, the presented schematic division of the price determination process into three stages is useful because it allows us to seek the reasons for witnessed price changes at the particular stages of the price formation.

First, as already noted, even the most detailed good's definition leaves some room for quality variation or changes.[8]. Defining a homogeneous type of labor services is generally much more difficult than defining a homogeneous good. In the context of an observed wage inequality increase this always raises the question whether there has been also a change in the underlying labor services or not.

Second, if we cannot conclude that the observed wage changes are due to skill-differentiation and changes in the quality of labor, then we can alternatively seek an explanation at the second stage of the price formation, i.e. behind the forces that affect the valuations of potential buyers and sellers for certain well-defined types of labor services. It is at this stage that the traditional analysis of market forces usually focuses. As an example on the demand side we can consider the changes in the valuation of employers for a given type of labor services when product-demand changes or when technological innovations allow firms to employ the same workers more efficiently, i.e. extracting a higher marginal product. In fact trade (through shifting product demand) and technical change (through creating a potential skill-bias) are two of the most often cited explanations for the inequality increases. There are also many other potential reasons for changes in valuations. One example is income effects, which generally affect labor supply (by this I mean not just the desired hours of work, but also the choice of an education subject, the choice of living place and many other decisions which are related to the choice of a job). Some further interesting insights on the formation of valuations come from the relatively recent literature on "peer effects": the valuation of an individual for a given job (and therefore, also his wage) depends among other things on what jobs other individuals do or like.

As a third class of factors potentially explaining changes in wage inequality we can consider changes at the third stage outlined above, i.e. changes in the way agents interact. Moreover, we should note that, whatever the kind of interaction between the agents, it obeys certain rules which we may call the regulatory environment or "the rules of the game". These could be anything ranging from the law of the jungle to the most elaborate and sophisticated legal system. Noteworthy, unwritten social norms of behavior represent an important part of the "rules of the game" on the labor market. In a broad sense the term "labor market institutions" comprises all the "rules of the game" on the labor market prescribed by the legal system on one hand and the unwritten social norms and practices

[8]By "variation" I mean the existence of several qualities at the same time, by "changes" I mean changes in quality over time

on the other. Changes in labor market institutions constitute therefore, a very broad and important set of explanations for changes in wage inequality.

One example of significant price changes attributable to changes in the interaction is the oil price shock in the early seventies. It was a collusion among major suppliers rather than changes in the quality of oil or its use (i.e. valuation by the buyers) which drew the price of oil up. Changes in the art of interaction are potentially important also on the labor market. For example, the declining role of labor unions in the UK and US is put forward as one of the major explanations for the inequality increase in these countries.

We may give yet another classification of the potential causes of price changes drawing on our previous discussion of market and non-market interaction. This alternative classification distinguishes between **market and non-market forces** as the two major reasons for price changes. Naturally, we would expect market forces to come into play when market interaction is the predominant form before and after the price change. They operate basically through changes in the valuations. Examples of price changes induced by market forces include changes of preferences (alter the valuations of consumers), technological change (alters the relative valuation of producers for their products and the inputs used), changes in the real income of consumers (alters their willingness to pay, i.e. their valuations, for different goods) etc. On the other hand we would expect non-market forces to come into play when non-market interaction prevails. An example of this would be the change in the price of some firm-specific inputs occurring after one of the firms has been taken over. [9]

It is slightly more difficult to distinguish between market and non-market forces when the type of interaction changes simultaneously with the price. Perhaps most people would attribute price changes accompanied by a movement toward more market interaction (e.g. the price reductions after a cartel has been split up) to market forces, and price changes accompanied by a movement toward non-market interaction (e.g. the oil price shock and the collusion of the major suppliers) to non-market forces. The changes in labor market institutions mentioned above should be also considered as an example of non-market forces.

Finally, we should note that changes in labor market institutions are not the only ones to affect the third stage of the price formation outlined above. Even if

[9] A market may not exist for firm-specific inputs. The price is then negotiated between the user and the supplier. A taking over of one of the two firms may alter their relative bargaining power and thus the price. Another possibility is that the user bought out the supplier. In this case the price would be most probably chosen to minimize taxes, thus again, we would observe a price change attributable to non-market forces.

pure market interaction is the type prevailing before and after we may observe changes in inequality due to changes in the elasticities of product (and thus also labor) demand as markets become more integrated. Some interesting insights on this point are provided by Rosen (1981). While his theory was motivated by the showing up of particularly bright "super-stars" from the worlds of sports, arts, letters and show-business, the "connection between personal reward and the size of one's own market", s. Rosen (1981:845), may actually exist for a much more broader set of individuals. This suggests a new potential role of technical change and globalization: they might simply have made skilled workers small superstars.

2.2 Basic concepts and definitions

The purpose of this Section is to introduce the basic concepts related to the measurement of wage inequality. We should distinguish between concepts and methods used to measure inequality and such that are used to explain its reasons. A comprehensive treatment of the latter is beyond the scope of this thesis, so I focus here on the former. Even with respect to these I will not be exhaustive: I provide only working definitions of selected concepts used in the subsequent analysis such as wage structure, overall and marginal wage distribution, three measures of inequality (variance, the Gini coefficient, the (log) ratios of different percentile points) and the traditional Mincerian wage regression allowing to decompose the variance of log-wages into a between- and a within-group component. A much more comprehensive introduction to the analysis of inequality can be found in Atkinson (1975).

By a **wage structure** I mean an information set referring to a given period of time and ideally containing information on the wages of all working individuals in the economy combined with information on their personal characteristics (age, education, sex etc) and on their employment relationship (working time, employer's size and industry affiliation, etc), properly analyzed. For brevity, I shall introduce the basic concepts assuming that such an ideal data set is available to the researcher.[10] We might call the subset of this information set containing the wages of all individuals the **overall wage distribution**. In what follows I shall introduce a number of **inequality measures** which can be derived from this distribution (as well as from any other). These reduce the rich information

[10]It should be noted that actual data sets (which are usually either surveys like for example the March supplement to the Current Population Survey in the USA or extracts from official records of the social security system like for example the IAB-Beschäftigtenstichprobe of the German Federal Employment Service, s. Bender et al., 1996) confront the researcher with a number of problems such as the presence of non-respondents, top-coding of wages, changes in the questionnaires from year to year etc. Solving these problems is a non-trivial task, which sometimes leads to disagreement even about basic "facts" concerning the wage structure.

contained in a distribution function to one or few scalars and facilitate in this way comparisons with corresponding distributions across time, countries etc. To introduce the most common of these measures formally, let $[w_i]$ be an increasing sequence of the wages of all n individuals in a given period and $\overline{w}$ be the mean wage.

The **variance** of the overall wage distribution is

$$V = \frac{1}{n}\sum_{i=1}^{n}(w_i - \overline{w})^2 \tag{2.2.1}$$

where we divide by n because we assume $[w_i]$ represents the whole population. As it is apparent from the above formula, one drawback of both the variance and its square root, the standard deviation, as measures of inequality is that they are sensitive to the choice of units. If $[w_i]$ is the sequence of the real wages and if over time the wage deflator grows more slowly than nominal wages do, for example, due to technological progress, then inequality as measured either by the variance or by the standard deviation would spuriously increase. The same problem of sensitivity to deflators arises when these measures are to be used for cross-country inequality comparisons. Another drawback of these measures, particularly if one takes into account the top-coding present in most wage data sets, is their sensitivity to extreme observations.

Another inequality measure more frequently applied to total disposable income rather than wages is the **Gini coefficient**. It is defined as

$$G = \frac{1}{n^2\overline{w}}\sum_{i=1}^{n}(2i - n - 1)w_i \tag{2.2.2}$$

A more intuitive definition of the Gini coefficient is the ratio of the area between the diagonal and the Lorenz curve on one hand and the area underneath the diagonal on the other. In the case of a wage distribution the Lorenz curve indicates what share of the total wage bill (measured on the vertical axis) is earned by a given share of the workers at the lower end of the wage distribution. The values of the Gini coefficient range theoretically from 0 (most equal distribution, all persons get the same wage) to 1 (extreme inequality, one person earns the whole wage bill). The Gini coefficient, like any other scalar measure of inequality has the potential drawback of mapping quite different distributions into the same number. Sometimes, points of the Lorenz curve are reported instead (or together) with the Gini coefficient.

A third measure of wage inequality is **the ratio of the wages earned by workers at different percentiles** of the wage distribution. So, for example,

$$R_{80/50}=\frac{w_{80}}{w_{50}} \tag{2.2.3}$$

represents the ratio of the wage of the worker at the the 80th percentile (i.e. the worker who earns more than what 80 percent of the group do, and less than what the remaining 20 percent do) to the wage of the median worker. This measure of inequality has a number of advantages over the previous two. It is insensitive to the choice of units as well as to top coding or misreporting at either tail of the distribution. In addition, it allows the researcher to control for the loss of information associated with the use of any measure of inequality by reporting several appropriately chosen percentile points (ratios). At the extreme, one can use 10 or more percentile points to reproduce nearly the entire wage distribution.

It should be also noted that the logarithmic transformation is often used in the analysis of wages. So, for example, the logarithm of the ratio of wages at different percentiles is often used instead of the ratio itself. The properties of the ratio discussed above apply also to its logarithm, which can equivalently be represented as the difference in log-wages at the given percentiles. Similarly, the variance or standard deviation of *log-wages* (the dependent variable in the traditional Mincerian regression) rather than *wages* is often considered. One advantage of this transformation is that the standard deviation of log-wages is not sensitive to the choice of units (deflators): if all wages are multiplied by the same constant, the distribution of log-wages is simply shifted to the side. Another property of the logarithmic transformation worth noting is that it disproportionately "compresses" the the upper end of the distribution. Since the logarithmic function is continuous and differentiable for any $w_i > w_j$ we have

$$|ln(w_i) - ln(w_j)| = \frac{1}{w^*}|w_i - w_j| \tag{2.2.4}$$

where w^* is an appropriately chosen interior point. Clearly, if the units of measurement are chosen so that $w_i > 1$ for all i, we may say that the logarithmic transformation "compresses" the entire distribution in the sense that the distance between any two wages is larger than the distance between their logs. Independent of the choice of units the "compression" is stronger to the right since the appropriate interior point w^* will tend to be larger when w_i and w_j are larger.

Although I introduced the above measures in the context of the overall wage distribution they can be, and in fact often are, applied to other wage distributions which we may call **marginal wage distributions**. These are obtained from the overall wage distribution by excluding some observations (i.e. individuals) according to some criterion. The criterion is based on the supplementary information we have in the data set: personal characteristics (for example, we may consider the wage distribution for highly educated females), details about the employment relationship (for example we may consider the wage distribution for workers employed in manufacturing enterprises of a given size) or a combination of both (for example full-time, male workers, employed outside the manufacturing sector). There can be important differences between these marginal distributions reflecting the fact that on both sides of the labor market we have fairly heterogeneous agents.

Another basic tool of analysis (it would not be exaggerated to call it the work horse of empirical labor economics) is the wage regression. The traditional (or Mincerian, s. Mincer, 1974) wage regression has the form

$$ln(w_i) = x_i'\beta + \varepsilon_i \tag{2.2.5}$$

where x_i contains education, labor market experience, labor market experience squared and possibly some control variables such as regional dummies. The choice of explanatory variables in the Mincerian wage regression is dictated by human capital theory. Namely, since human capital is accumulated either through formal education or on-the-job learning (experience) the wage is modelled as a function of these.

Of course, as we have discussed in the previous section, the accumulated human capital is not the only factor affecting the wage. However, at this stage we should distinguish between the wage regression as a tool for measuring wage inequality and as a tool for studying the determinants of the individual's wage. When used for the purposes of measuring inequality it is sufficient to focus on socio-demographic characteristics such as years of education, age, sex, etc. The orthogonality between the fitted values and the residuals in a least squares regression allows us to decompose the variance of the log wages into two components. The first one represents the variance attributable to observable socio-demographic characteristics and is called "between-group" component (this is the first term on the right-hand side of the equation below). The second one represents the variance not explained by the socio-demographic characteristics included in the regression and is called "within-group" (the second term in the equation below).

$$V(ln(w_i)) = V(x_i'\hat{\beta}) + V(\hat{e}_i) \tag{2.2.6}$$

The coefficients in this regression provide estimates of the mean differences in wages between workers in different socio-demographic cells. A focus on just a few socio-demographic characteristics in deriving the basic facts on the structure of wages can be motivated as follows. First, we want to derive the basic facts from as large a sample as possible; information on other relevant worker's characteristics is usually not available on a large scale. Second, regardless of the connection between productivity and years of schooling/experience, comparing socio-economic cells is of its own interest and the Mincerian wage regression provides a convenient and systematic way to do this.

2.3 Cross-country inequality comparisons: some stylized facts and puzzles. The two-sides-of-the-same-coin hypothesis

This Section attempts to concisely present the main trends in the evolution of the distribution of wages and unemployment as documented in a large body of empirical literature. This presentation of important stylized facts concerning the wage distribution and unemployment searches to pinpoint the main issues that need explanation, and thus motivates the analysis that follows in Chapters 3 through 6 of the current thesis. The reason that I present also some stylized facts about unemployment when the main subject of interest in the current thesis is wage inequality is that in the literature, especially in the cross-country comparative one, researchers have pointed out that looking at inequality and unemployment jointly may provide us with some interesting insights.

It should be noted that the derivation of these stylized facts does not represent a contribution of this thesis and that all the estimates of inequality and unemployment measures presented here are taken from the literature. In order to facilitate the reading of the present Section the referenced tables and figures have been included in an Appendix. It should be noted that all these 5 figures and 5 tables represent copies and that the original source is cited in the notes to each of them. They all originated in the following set of contributions: Acemoglu (2002), Katz and Autor (1999), Gottschalk and Smeeding (1997), Krugman (1994) and OECD (2005).

The interest in the distribution of wages expanded in the early eighties in the US after a period of relative stability. As Henry Aaron (1978), p. 17 notes tracking changes in the distribution of income in the US was "like watching the grass grow". Gottschalk and Smeeding (1997) point out two main reasons for the rise in the interest in the distribution of earnings in the US, in general, and in cross-sectional comparisons during the 1980s. First, there was found substantial empirical evidence for rising wage inequality in the US (s., for example, the survey of Frank Levy and Richard Murnane (1992)). Second, cross-national comparisons were facilitated by efforts to gather comparable data on a number of OECD countries, e.g. the Database Project of the Luxembourg Income Study described in Smeeding, OHiggins and Rainwater (1990) as well as the US-German Comparative Panel Project described in Wagner, Burkhauser and Behringer (1993).

In sum, the most important stylized facts concerning overall inequality and its components are:

1. The overall wages inequality increased substantially in most, though not all, OECD countries. It increased most in the US and in the UK, and least in the Nordic countries.

2. Wage differentials by skill (education, occupation and experience) have increased in most countries. The US is the country with the largest increase in the returns to education, followed by the UK.

3. Similarly, within-group inequality increased in most countries but the increase was at the largest again in the US and UK.

There is substantial agreement among researchers and data sets concerning these basic facts that need to be explained. [11]

4. The fourth stylized fact concerns the evolution of unemployment. There is a general consensus in the literature that since the mid 1980s the European Community, taken as a unit, has experienced considerably higher unemployment rates than the United States (Krugman, 1994 and 1995, Davis, 1998, OECD 2005, Nickell, 1997, Blanchard and Wolfers, 2000, Nickell, Nunziata, Ochel and Quintini, 2002, Belot and Ours, 2001).

As Krugman (1994, p. 31) notes the observation that wage inequality increased sharply mainly in the US, while at around the same time the unemployment increased steadily mainly in Europe "has led many observers to conclude that growing US inequality and growing European unemployment are different sides of the same coin." This has become known in the literature as the "two-sides-of-the-same-coin hypothesis" (Krugman, 1994 and 1995, Beißinger and Möler, 1998, Fitzenberger, 1998, Davis, 1998).

In the following, I focus on these four basic stylized facts in some more detail.

2.3.1 Overall inequality

Most studies in the US use the Current Population Survey (CPS) to examine the distribution of weekly or annual wages (s. Gottschalk and Smeeding (1997), p.

[11] Key studies documenting the recent evolution of the US wage distribution include Acemoglu (2002), Katz and Autor (1999), Gottschalk and Smeeding (1997), Bernstein and Lawrence (1997), Bound and Johnson (1992), Levy and Murnane (1992), Murphy and Welch (1992, 1997), Buchinsky (1994), Davis and Haltiwanger (1991), Freeman (1997), Hamermesh (1999), Juhn et al. (1993), Katz and Murphy (1992).

645). In order to concentrate on changes in wages and not on changes in hours worked most studies select only persons working full-time and full-year. Another issue is how to account for the large changes in the labor force participation of women in order to separate changes in the distribution of wages from changes in the composition of the female labor force. Some researchers solve this problem by simply focusing on the distribution of earnings of males. Other researchers adjust for these composition effects (e.g. Acemoglu (2002), s. p. 14 and his Appendix A3 on p. 65-68; Katz and Autor (1999), p. 1474-1476).

Virtually all studies find that the overall inequality rose sharply in the US in the early 1970s after a period of relative stability. Figure 2.4.1 in the Appendix to this Chapter taken from Acemoglu (2002) illustrates this pattern. It plots the 90th, 50th and 10th percentile of the overall wage (weekly earnings) distribution for white male workers between 1963 and 1997 (with the 1963 values for all series indexed to 100). As it can be seen from the figure , prior to the 1970s, the P90, P50 and P10 of the wage distribution followed each other closely, but came apart sharply in the 1970s. Moreover, the median wages stagnated from 1975 onwards, while workers at the 10th percentile saw their earnings fall in real terms to levels even below those in 1963, and those of workers at the 90th percentile rise.

Similar findings about the US have Katz and Autor (1999). The weekly earnings of the 90th-percentile worker relative to the 10th-percentile worker increased by over 25 per cent for both men and women from 1979 to 1995. Table 2.4.4 in the Appendix to this Chapter summarizes evidence on the alternative measures of wage inequality for weekly wages of full-time, full-year workers, which were introduced in the previous Section: standard deviation of log wage, percentiles of log wage distribution, and the Gini coefficient. It covers selected years in the period from 1963 to 1995. The estimates of these measures show similar patterns of rising inequality after the beginning of the 1970s.

The first column of Table 2.4.5 in the Appendix to this Chapter, taken from Gottschalk and Smeeding (1997), to this Chapter provides comparative information on changes in male wages inequality during the 1980s for several OECD countries. It summarizes estimates of different studies that benchmark the change in inequality in each country to the corresponding change in the US in the same time period. Thus what we observe is that the UK experienced an increase in overall inequality much similar in magnitude to that in the US, namely, at least 80 per cent of the change in the US; Canada and Australia follow with an increase in overall inequality of 50 to 80 per cent as large as that in the US. At the end are countries like Germany, Italy, the Netherlands and Finland with an increase of generally between -10 and 10 per cent, and according to some studies, of up to 50 per cent at most.

Thus what concerns the overall inequality there is a consensus among researchers that it generally increased in most OECD countries, though it increased most in the US and the UK, and least in the Nordic countries.

As already explained in the previous Section the overall inequality can be decomposed into a between-group and a within-group component. We now turn to each of them separately.

2.3.2 Between-group inequality

The increases in the returns to education during the 1980s in the US are in sharp contrast to the decreases in the returns to education during the 1970s. These trends can be read off in Figures 2.4.2 and 2.4.3 in the Appendix to this Chapter, both of which are from Katz and Autor (1999). Figure 2.4.2 presents the trend in the college-high school log wage differential for the period 1963-1995. Figure 2.4.3 presents the trend in the returns to experience for males for the same period: the log wage differential between workers with 25 and 5 years of experience. The declines in the returns to experience till the beginning of the 1970s are better spelled out for high-school workers than for college workers. Since the 1970s both groups experienced an increase in the returns to experience whereby these were sharper for college graduates up to the 1980s when the returns to experience for high-school workers rose sharply and remained higher than those for college graduates. Thus the increases in the returns to experience since the 1980s remained limited to the less-educated workers.

The increases in the returns to education were larger than those in the returns to experience. One can see this from Figure 2.4.2 and 2.4.3 in the Appendix to this Chapter. Similar findings have Gottschalk and Smeeding (1997). [12] After a period of a slight increase in the returns to education from early 1960s to the beginning of the 1970s, there followed a period of a decline in the returns to education till the end of the 1970s, and since then, the beginning of the 1980s, just like the returns to experience, the returns to education sharply rose whereby the increase was more spelled our for younger workers, i.e. those with less experience.

Table 2.4.6 taken from Katz and Autor (1999) summarizes the between-group changes by presenting log real wage changes from 1963 to 1995 for various groups defined by education and potential experience (age). The first 6 rows of the Table show the evolution of real wages by education group. The real wage changes are, for the most part, increasing by education group over the full period (s. last column), which reflects a rise in the education-based differentials. The rise was particularly sharp for those with at least a college degree (i.e. those with educa-

[12] s. Gottschalk and Smeeding (1997), p. 645.

tion of at least 16 years): 22.4, 16.6 and 34.5 log points. This is to be compared with 4.4 or 5.5 log points of those with less than college education. One can even note that the earnings of the less educated group even fell by 4.5 log points, which points to an increasing gap between highly educated and low-educated workers in the US. Turning to the next set of groups defined by experience, we notice a similar pattern: the returns to experience of those with 25-35 years of experience increased over the full period (6.4 log points), though not as sharply as the returns to college, while those for young, inexperienced workers declined by 5.3 log points. Thus the US wages distribution became less equal both because of growth at the top and decline at the bottom.

Turning to other developed countries we find that a few of them closely mirror the above described experience of the US, while others seem to have avoided the increasing between-group inequality. As it can be seen from Table 2.4.5, columns (4) and (5) most countries experienced increases in the returns to experience and education. The US stands out however as the country with the largest increase in the returns to education and experience, followed by the UK; the Nordic countries such as the Netherlands and Finland experienced even a decline in the returns to education.

2.3.3 Within-group inequality

In addition to the increased inequality between education and experience groups studies consistently find large increases in the wage dispersion also within skill groups. It started in the US already in the early 1970s (s. Gottschalk and Smeeding (1997), p. 646, Acemoglu (2002), p. 10). Figure 2.4.4 taken from Acemoglu (2002) illustrates the time path of three alternative measures of residual inequality for white males for the period 1963-1997: the 90-50 residual differences, the 0.5 times the 90-50 residual differences, and the 50-10 residual differences. [13] Residual inequality appears to have increased together with the overall inequality: sharp increase starting in the early 1970s. Moreover, all three measures of residual inequality behave very similarly suggesting that forces affecting the top of the male wage distribution are also affecting the bottom.

Turning to the last column of Table 2.4.5, which compares changes in the residual inequality in a number of OECD countries to those in the US, we notice that all countries except for Finland, Israel and Italy experienced a rise in inequality

[13] These measures are calculated from a standard Mincerian wage regression of the form described in Section 2.2, s. Eq. 2.2.5 , where the vector x_i includes nine education dummies, a quadratic in experience and region controls. For more details, s. Acemoglu (2002), p. 17. The measures of residual inequality are calculated as the difference between the 90th and the 10th (equivalently, the 50th and the 10th) percentile values of the residual distribution from this regression.

within skill groups. But this rise was again at the largest in the US and in the UK, followed by Australia and Canada.

After this brief review, we may say that inequality increased in most OECD countries but that the US stands out as the country with the largest increases. This is true both with respect to overall inequality, as well as with respect to the between- and the within-group components. Only the UK shows similar patterns, though of smaller magnitude. The inequality increases in most other OECD countries were less pronounced. Some countries, particularly those in Northern Europe, even experienced declines with respect to some aspects of inequality.

2.3.4 Unemployment

Thirty years ago unemployment did not seem to be a major problem for advanced economies. The US had the highest unemployment rate at 5.5 percent, but very little of this unemployment was long-term, and the extent of the short-term unemployment has been rationalized as an inevitable, and to a certain degree desirable, result of a dynamic economy; Western Europe had an unemployment rate that on a comparable basis was only 3 percent, and Japan had unemployment of 1.4 percent (Krugman, 1994, p. 23, Davis, 1998, p. 478).

Since the mid 1970s, however, unemployment started to raise in both the US and in Europe. Figure 2.4.5 in the Appendix to this Chapter, taken from Krugman (1994), presents the evolution of the unemployment rate in the US and in the European Community from 1973-1993. We can see that from the mid 1970s to mid 1980s the unemployment rate in the US fluctuated cyclically, while in Europe it exhibited a steady increase. Since the mid 1980s a large gap between the US and Europe opened, which has persisted to date. Tables 2.4.7 and 2.4.8 track the evolution of the unemployment rates in the EU-15 and US for the more recent years, from the 1990s to 2001: Table 2.4.7 presents evidence on aggregate unemployment rates, while Table 2.4.8 presents evidence on long-term unemployment as percentage of total unemployment. As one can see, the figures for both aggregate and long-term unemployment for Europe are systematically, and considerably, higher than those for the US throughout the whole period to 2001.

2.4 Appendix to Chapter 2

2.4.1 Evidence on the share of labor income in individual income

I present only piecewise evidence on selected countries. I had difficulties in finding comparable data for different countries. The data I found differed, first, in their focus on individuals vs. households, second, in the data collection methods - official income statistics (from tax accounts) vs. surveys, and third, in the categorization of the various sources of income.

Some interesting facts can be found in Piketty and Saez (2003). Using data from individual tax returns they have estimated the composition of income at the top of the US income distribution in 1998 as follows: P90-95 derive 89.6 percent of their income from wages and salaries, 5.3 percent from self-employment, partnership and small business, and only 5.1 percent from dividends, interest and rents. For P95-99 the share of wages and salaries is still 79.8, and that of the other two categories 12.3 and 7.9 respectively. The share of wages and salaries is below 50 percent only when the top 0.01 percent of the income is considered. Note that the fractiles are defined by size of total income, which means that the number of persons to which the corresponding income accrues is not proportional to the size of the fractile. Moreover, the above figures are based on observations of individuals and not households. Still, they provide a rough idea of what the composition of top household incomes may be.

Table 2.4.1: Composition of pre-tax household income in France

year	Earned income (percent)	Pensions(including early retirement and *minimum vieillesse* [benefit bringing income up to minimum required to live])(percent)	Unem-ployment -related benefits (percent)	Other forms of social income (percent)	Unearned income* (percent)	Regular payments from other households (percent)
1985	64.5	16.7	2.0	5.7	10.5	0.6
1995	58.5	19.8	2.4	5.4	13.0	0.9

Source: "Le revenu et le patrimoine des ménages," Données sociales, INSEE, 1999. The data are available also at
$http://www.insee.fr/en/ffc/docs_ffc/ds9945.html$

Table 2.4.2: Composition of household income after taxes by decile group in Norway, 2003

2003	Wages ε_t salaries	Self-employment income	Property income	Transfers
1	45	1	-10	64
2	38	4	2	57
3	53	5	2	40
4	64	5	1	30
5	71	4	2	24
6	76	4	1	19
7	79	5	2	14
8	81	5	2	11
9	81	6	3	9
10	55	11	29	4
All	67	6	9	18

Source: Statistics Norway "Income and property statistics for households, 2003", Table 5. The data are available also at
$http://www.ssb.no/english/subjects/05/01/ifhus_en/main.html$

Table 2.4.3: Composition of pre-tax household income in the UK

year	wages and salaries[1] (percent)	Operating income[2] (percent)	Net property income (percent)	Social benefits[3] (percent)	Other current[4] transfers (percent)
1987	52	11	15	19	3
1996	47	12	14	21	5
2002	50	13	12	21	4

Notes:
1 Excludes employers' social contributions.
2 Includes self-employment income for sole-traders and rental income.
3 Comprises pensions and benefits.
4 Mostly other government grants, but including transfers from abroad and non-profit making bodies.
Source: United Kingdom Office for National Statistics. The Data are available also at
http://www.statistics.gov.uk/STATBASE/Expodata/Spreadsheets/D7419.xls

2.4.2 Evidence on the amount of time devoted to paid work

According to survey data from 10 European countries men aged between 20 and 74 years spent on average about 4 hours a day on gainful work, which corresponds to slightly more than a quarter of their consciously spent time (excluding sleeping). The exact hours and minutes for the ten countries are Belgium 3:30, Germany 3:35, Estonia 3:40, France 4:03, Hungary 3:46, Slovenia 4:07, Finland 4:01, Sweden 4:25, United Kingdom 4:18 and Norway 4:31. The data are averages over the whole year, including holidays, and over all individuals in the samples which are representative of the population in the corresponding countries. Among employed men the corresponding fraction is about one third. Women spent on average less time on payed work than men - about two hours and a half against four for men in the age group 20-74. See "Comparable time use statistics - National Tables from 10 European countries", February 2005, Eurostat.

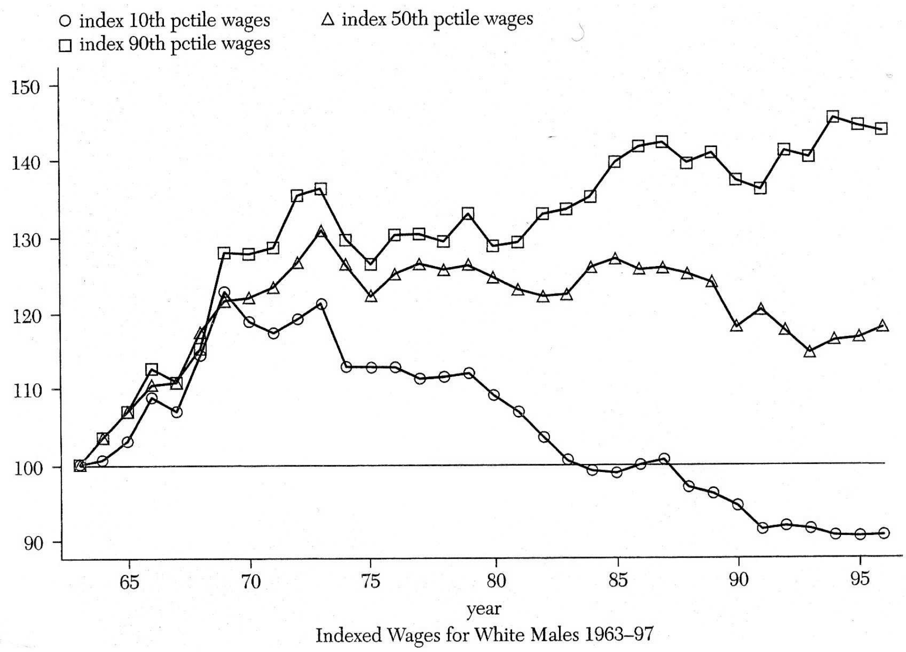
Note that these figures underestimate the significance of the labor market outcome in the individuals' time budget in one respect - the definition of "gainful work" in this survey does not include a number of activities which take place outside the formal working hours but are directly work-related like, for example, dressing in a professional outfit, travel to and from work, meals, snacks and drinks next to the working place during breaks, professional talks during golf sessions etc.

2.4.3 On the absence of arbitrage trade on the labor market

The difference between goods and labor markets with respect to arbitrage trade can be illustrated with the following example. Suppose that individual i would be willing to do certain work for firm j for 7 euro and firm j would be willing to pay individual i 10 euro for this work but the two do not know of each other. A true arbitrage trader in this situation could hire individual i on his own at 7 euro and "rent" him to firm i for 10 euro yielding a repeated return of 3 euro over the whole period individual i stays at firm j. Although the contracts of some sport stars allow "hiring" and "renting" a person in this way, most intermediaries in labor markets do not hire people on their own in order to "rent" them at a higher wage. The amount which intermediaries on the labor market earn for a successful match will typically be a percentage of the wage offered by the firm, but not a function of the difference between the two valuations which would be the typical case on goods markets. This example illustrates that contrary to arbitrage traders operating on goods markets, arbitrage traders on the labor market cannot appropriate but a small fraction of the surplus resulting from a given match.

It may be argued that the described situation is similar to that on the market for renting real estates. Intermediaries there also yield a percentage of the monthly rent. There is however one fundamental difference to the labor market: if the surplus from matching a certain real estate with a certain client grows very large, than the intermediary may appropriate most of it by simply buying the apartment and renting it on his own to the client. Since nothing prevents arbitrage trade on the market for real estates which is closely linked to the market for rents, the latter will not offer many arbitrage opportunities. On the labor market there is no similar mechanism to depress returns to searching.

Figure 2.4.1: Changes in the indexed value of the 90th, 50th and 10th percentiles of the wage distribution for white males.



Notes: This Figure is taken from Acemoglu (2002:16, Figure 2). 1963 values are normalized to 100. The data are from the March CPS.

Table 2.4.4: Measures of wage inequality for weekly wages of full-time, full-year workers, March CPS, 1963-1995

	SD of log wage	Percentiles of log wage distribution			Gini coefficient
		90-10	90-50	50-10	
A.Males					
1963	0.469	1.19	0.51	0.68	0.250
1971	0.495	1.16	0.55	0.61	0.270
1979	0.517	1.27	0.55	0.72	0.277
1987	0.579	1.47	0.65	0.82	0.313
1995	0.616	1.54	0.74	0.79	0.343
B.Females					
1963	0.406	1.04	0.50	0.54	0.223
1971	0.430	1.08	0.54	0.55	0.238
1979	0.432	1.05	0.54	0.51	0.243
1987	0.506	1.30	0.61	0.69	0.281
1995	0.544	1.38	0.68	0.70	0.304
C.All males and females					
1963	0.502	1.27	0.57	0.70	0.272
1971	0.530	1.31	0.62	0.68	0.293
1979	0.539	1.35	0.66	0.69	0.299
1987	0.580	1.44	0.70	0.74	0.320
1995	0.603	1.54	0.76	0.78	0.340

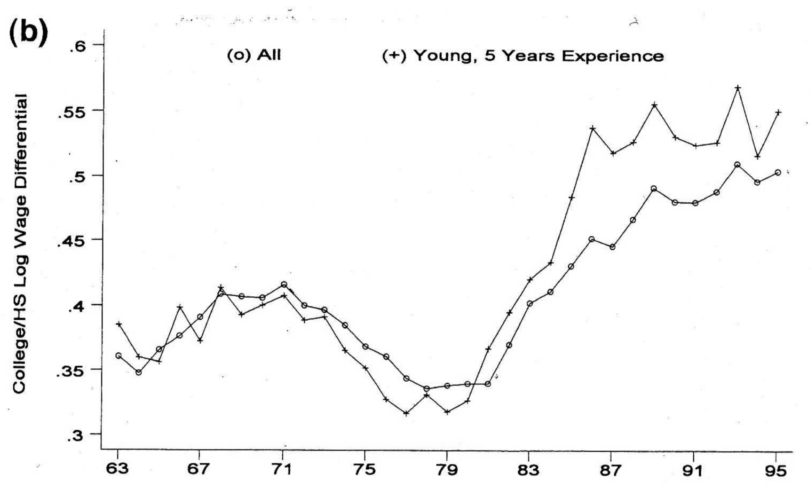
Notes: This Table is taken from Katz and Autor (1999:1475), Table 1.

Table 2.4.5: Changes in male earnings inequality over the 1980s in industrialized countries

Country and Authors	Years	Overall Earnings Inequality	Returns to Experience	Returns to Education of Occupation[b]	Earnings Inequality Within Group
(1)	(2)	(3)	(4)	(5)	(6)
Australia	1981-89	+	++	mixed	++
*Borland(1992)	1981-85	++	+++	-	+++
Gottschalk and Joyce(1995)	1976-90	+++	na		na
Gregory(1993)					
Canada	1979-87	++	++	-	+++
Blackburn and Bloom(1994)	1981-87	++	++	+	++
Gottschalk and Joyce(1995)					
Finland	1980-90	0	0	0	0
*Ericksson and Jantti(1994)[c]	1987-91	+	-	-	0
Gottschalk and Joyce(1995)					
France	1976-87	+	+	(0)	mixed
Katz, Loveman, Blanchflower(1995)	1979-84	++[a]	+++b	(-)	+
Gottschalk and Joyce(1995)					
Germany	1983-88	0	0	0	na
*Abraham and Houseman(1994)					
Israel	1979-86	+	+++	++[a]	0
Gottschalk and Joyce(1995)					
Italy	1978-87	0[c]	0[c]	oa	-[c]
Ericksson and Ichino(1995)					
Japan	1974-90	+[b]	mixed	+	na
Katz, Loveman, Blanchflower(1995)					
The Netherlands	1979-89	0	0	-	+
*Hartog, Oosterbeek, Teulings(1992)	1983-87	+[b]	+++	-	+
Gottschalk and Joyce(1995)					
Sweden	1984-91	++	+	++	+++
*Edin and Holmlund(1995)[d]	1981-87	+[b]	-	(+++)	+++
Gottschalk and Joyce(1995)					
United Kingdom	1979-90	+++	++	(++)	+++
Katz, Loveman, Blanchflower(1995)	1979-86	+++	+++	(+++)	+++
Gottschalk and Joyce(1995)					

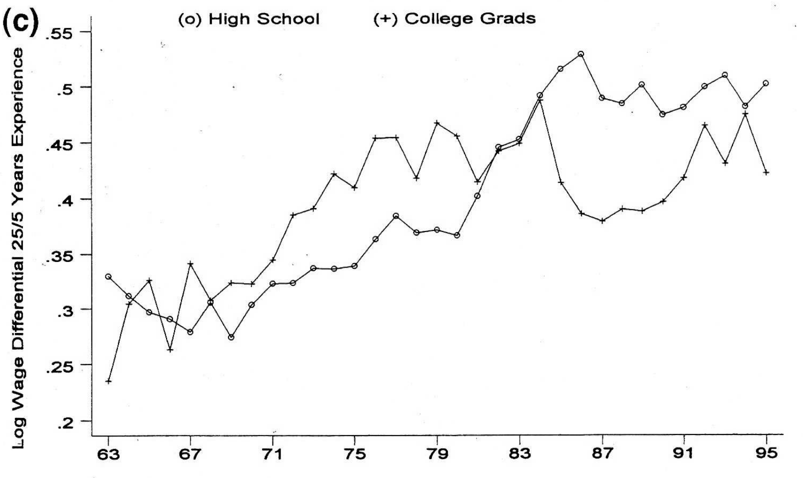
Notes:This Table is taken from Gottschalk and Smeeding (1997), Table 2, p. 654. Their notes follow.
[a]Classification for studies that compare country to the United States in same time period(for measures, s. Appendix A):
+++ increase in inequality at least 80 percent as large as in the United States
++ increase 50 to 80 percent as large as in the United States
+ increase 10 to 50 percent as large as in the United States
0 increase from -10 to +10 percent of change in the United States
- decrease greater than -10
∗Classification for other countries based on authors' qualitative comparison.
[b]Parentheses signify returns to higher paid occupations (e.g., non-manual). Wherever possible, returns to education are for recent labor market entrants.
[c]Small changes over decade reflect decline followed by sharp increase after 1985
[d]Inequality was constant from 1974-84 in this study.

Figure 2.4.2: College-high school log weekly wage differential, 1963-1995.



Notes: This Figure is taken from Katz and Autor (1999:1478, Figure 5b).

Figure 2.4.3: Returns to experience, males, 1963-1995.



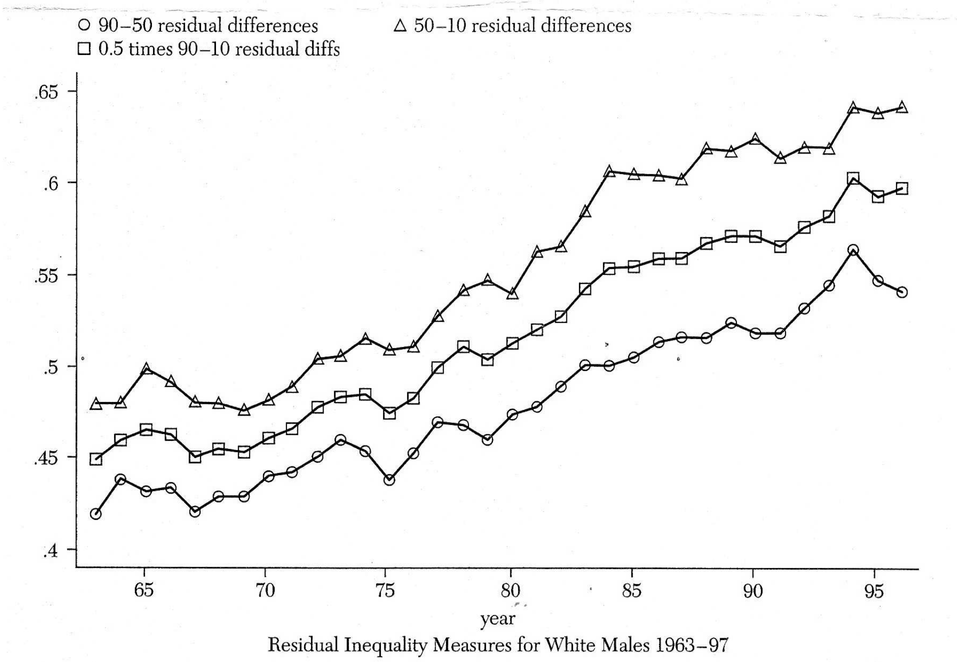
Notes: This Figure is taken from Katz and Autor (1999:1478, Figure 5c).

Table 2.4.6: US real weekly wage changes for full-time, full-year workers, March CPS, 1963-1995

Group	Change in mean log real weekly wage (multiplied by 100)				
	1963-1971	1971-1979	1979-1987	1987-1995	1963-1995
All	19.1	-1.4	-4.0	-7.2	6.6
Sex					
Men	20.4	-2.1	-7.3	-10.1	0.9
Women	16.9	-0.1	1.5	-2.5	15.8
Education(years of schooling)					
0-11	15.6	1.6	-10.8	-9.4	-4.5
12	17.5	1.3	-6.3	-7.1	5.5
13-15	18.6	-1.9	-2.2	-10.2	4.4
16+	26.0	-7.1	5.3	-1.8	22.4
16-17	23.0	-7.4	3.9	-2.9	16.6
18+	32.3	-6.5	8.1	5.9	34.5
Experience(men)					
5 years	19.9	-5.8	-9.7	-9.7	-5.3
25-35 years	20.1	1.4	-4.7	-10.5	6.4
Education and experience					
Education 12					
Experience 5	19.1	-0.8	-18.3	-10.7	-10.7
Experience 25-35	16.8	4.5	-4.6	-6.6	10.1
Education 16+					
Experience 5	24.2	-12.7	7.8	-8.0	11.2
Experience 25-35	34.8	-0.3	3.5	-2.0	32.9

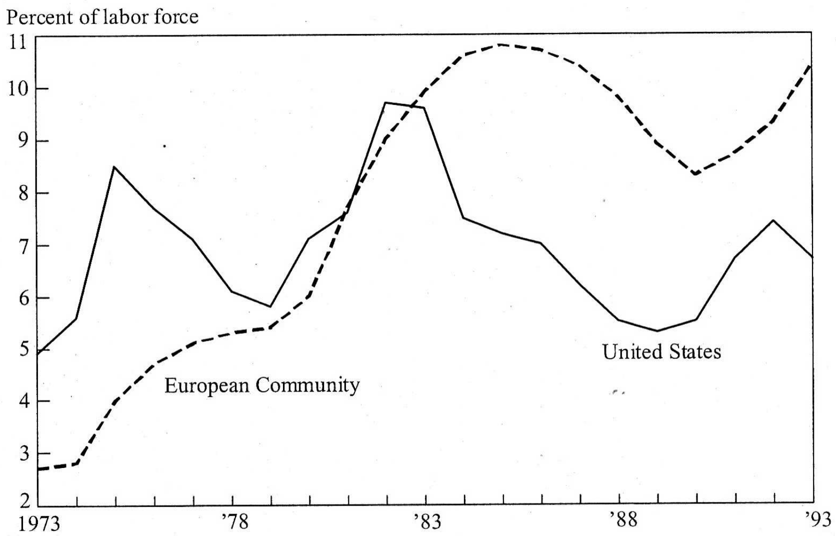
Notes: This Table is taken from Katz and Autor (1999): Table 2, p. 1476. Their notes follow. The numbers in the table represent changes in the (composition-adjusted) mean log wage for each group, using data on full-time, full-year workers from the March CPS covering calendar years 1963-1995. The data were sorted into sex-education-experience groups based on a breakdown of the data into 2 sexes, 8 education categories (0-8, 10, 11, 12, 13-15, 16-17, and 18+ years), and 4 potential experience categories (1-10, 11-20, 21-30, 31+ years). Log weekly wages of full-time, full-year workers were regressed in each year separately by sex on the dummy variables for the 8 education categories, a quartic in experience, 3 region dummies, black and other race dummies, and the interactions of the experience quartic with 3 broad education categories (high school graduate, some college, and college plus). The (composition-adjusted) mean log wage for each of the 64 groups in a given year is the predicted log wage from these regressions evaluated for whites, living in the mean region based on the 1980 Census distribution of employment, at the relevant experience level (5, 15, 25 or 35 years, depending on the experience group). Mean log wages for broader groups in each year represent weighted averages of the relevant (composition-adjusted) cell means using a fixed set of weights (the 1980s share of total hours worked from the 1980 Census PUMS). All earnings numbers are deflated by the chain-weighted (implicit) price deflator for personal consumption expenditures.

Figure 2.4.4: Residual inequality measures for white males, 1963-1997.



Notes: This Figure is taken from Acemoglu (2002: 17, Figure 3).

Figure 2.4.5: Unemployment rates in the European Community and the United States.



Notes: This Figure is taken from Krugman (1994: 24, Figure 1).

Table 2.4.7: Standardized unemployment rates in the US and EU-15.

	1990	1993	1994	1995	1996	1997	1998	1999	2000	2001
US	5.6	6.9	6.1	5.6	5.4	4.9	4.5	4.2	4.0	4.7
EU-15	8.1	10.0	10.4	10.1.6	10.1	9.8	9.3	8.5	7.6	7.2

Notes: This Table is from OECD(2005), Table A, p.237. The unemployment rates are computed as a percentage of the total labor force.

Table 2.4.8: Incidence of long-term unemployment.

	1990		2001	
	6 months and over	12 months and over	6 months and over	12 months and over
US	10.0	5.5	11.8	6.1
EU-15	65.3	48.7	61.8	45.3

Notes:Source: This Table is from OECD(2005), Table G, p.258. Long-term unemployment is computed as a percentage of total unemployment.

3 A focus on within-group wage inequality: labor market imperfections, incentives and institutions.

[14]

3.1 Observed versus unobserved heterogeneity

In this Chapter I focus on explaining cross-country trends in within-group inequality and more precisely that part of it which reflects inequality among similar workers. The purpose of this section is to clarify this concept from the outset in order to prevent confusion.

By similar workers here I mean workers that can be considered as perfect substitutes (marginally) in the production of at least one of the goods actually produced in the economy based on their abilities or skills. In simple words, if Smith can do the same job with the same productivity as Peter currently does, and vice versa, then Smith and Peter are "similar" workers. Note that this definition allows that "similar" workers differ in terms of other characteristics unrelated to their ability (and productivity).

Some economists believe within-group inequality reflects nothing else but differences in ability that firms and individuals observe, but the researcher does not. According to this view "similar" workers can effectively compete on the labor market, which would tend to equalize their wages. Other economists, by contrast, while acknowledging the fact that unobserved heterogeneity accounts for a large part of the residual inequality in the wage regression, believe that it cannot account for all of it. They attribute some part of the residual (or within-group) inequality to factors unrelated to the individual's ability (rents, wage discrimination, chance etc.).

While the role of chance is not so much a matter of disagreement, the role of rents and wage discrimination are. This leads us to the roots of the divide between the two groups, which are almost philosophical: the first group believes in the nearly perfectly functioning labor market, while the second group emphasizes market failures such as imperfect information and market power.

Empirically, it is very difficult to test these competing views against each other. Indeed the measures of skill we have at our disposal are too crude leaving room

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[14] This Chapter is based on the joint paper Dimitrova and Tchipev (2004). Large parts of that paper are reproduced below without further reference.

for much unobserved heterogeneity. Even with the finest available proxies of skill such as subject of education, grades, test scores, etc., some variation in unobserved ability will always remain. Yet, there exists some evidence supporting the view that equal workers are not always payed the same wage. A good survey of this evidence is provided by Bhaskar, Manning and To (2002). In the following I summarize their main arguments.

They start by documenting the existence of substantial wage dispersion among workers who do the same job (presumably the same jobs have the same skill requirements) in the same city by referring to the classical studies of Lester (1946), Reynolds(1951) and Slichter (1950). In addition, they report results from an informal telephone survey of fast food restaurants in Northern Virginia located within a circle of one mile radius, where the starting hourly wage ranged from 5.15 dollars (the national minimum wage) up to 6.00 dollars with a mean of 5.78 (Bhaskar, Manning and To, 2002).

Next, they address the issue of unobserved ability. They refer to the studies of Krueger and Summers (1988) and Gibbons and Katz (1992) who provide evidence that the change in wages for an individual is related to the change in industry affiliation. Based on the premise that individual ability is constant over time, they suggest that we should interpret these inter-industry differentials as evidence of an existence of wage dispersion among similar workers (i.e. wage dispersion that cannot be attributed to unobserved individual ability (Bhaskar, Manning and To, 2002).

Finally, as an alternative approach to demonstrating the existence of wage dispersion among similar workers they suggest testing predictions of this view on separation rates and job search. If wages are set purely according to productivity, they argue, "then high wage workers and low-wage workers will have little reason to quit jobs at different rates; after all, the high-wage worker will just be moving to another job where high productivity leads to high wages, and the low-wage worker to another job where low productivity leads to low wages" (Bhaskar, Manning and To, 2002, p.157). By contrast, if there exist "good" (high-paying) and "bad" (low-paying) jobs for workers of similar quality, then, we would expect workers having "bad" jobs to search more intensively and to quit at higher rates. They present evidence that both separation rates and search effort are higher for workers with lower wages even after controlling for a number of other characteristics (Bhaskar, Manning and To, 2002).

They conclude that "a fair reading of the evidence suggests that the wage dispersion among similar workers is a real phenomenon" (Bhaskar, Manning and To, 2002, p. 159). This is the starting point for my analysis in this Chapter. In addition, I assume that the cross-country trends in this kind of inequality are well reflected by the cross-country trends in within-group inequality documented in the last Chapter.

3.2 Theoretical explanations for the deviation from the equal-pay-for-equal-work principle

In Chapter 2 I presented a schematic division of the wage determination process into three stages. In terms of this conceptualization, we should search the reasons for the existence of inequality among identical workers at the third stage: the way of interaction among the agents on the labor market and the role of non-market forces.

One simple explanation for the phenomenon of different-pay-for-equal-work relies upon search costs: workers of equal quality cannot compete effectively with each other due to limited access to information. However, if workers are indeed equally able, then they should be so also with respect to their ability to obtaining information on job offers. While search costs are a potential explanation for the existence of inequality among similar workers, they are probably not the main cause for changes in that inequality.

The existing theoretical literature offers two main alternative explanations for the phenomenon of different-pay-for-equal-work. The first relies upon the existence of market power on side of employers. Bhaskar, Manning and To (2002) present a variety of models where market power leads to wage inequality among identical workers. The second explanation relies upon the link between inequality and incentives. Efficiency wage models provide a convenient framework to study this link and I shall adopt it in this Chapter. Since the analysis here focuses on Europe-America differences in inequality it is interesting to mention the findings of Bell and Freeman (1995). In a comparative study of Germany and the US they find that the differences in the hours worked (which can be considered also as a signal for the effort put in at the workplace in general) are related to differences in earnings inequality. They explain this finding with "high rewards to success in the US, lack of job security, and low social safety net as compared to Germany or other European countries" (Bell and Freeman, 1995, abstract), i.e. basically with differences in labor market institutions.

3.3 The two-sides-of-the-same-coin hypothesis from the perspective of within-group inequality

The proposition that labor market institutions might be the primary explanation for cross-country differences in wage inequality among identical workers does not mean that trade or technical change have no rapport to this issue. This is so because globalization is likely to affect all of the factors shaping the distribution of wages of similar workers: search costs, employers' market power and labor market institutions. This insight opens a new perspective on the role of globalization: it suggests to investigate its indirect effect operating via the changes it induces in the flows of information, employers' market power, labor market institutions and labor mobility. In what follows I shall focus on the interplay between one aspect of globalization, namely increased capital mobility, and one stylized representation of labor market institutions, namely a minimum wage.

As explained in the general Introduction to the thesis the analysis in this Chapter is motivated by the two-sides-of-the-same-coin hypothesis, which raises the question of competition among countries with different systems of labor market institutions: Will countries retain their labor market institutions, or will there be some adjustment as they become more integrated through trade and/or FDI? Will there be a tendency for institutional convergence? Which labor market regime, if any, will prove to be the most successful in the global economy? I address these issues in the context of the Europe-America dichotomy. Europe and America are main trading and investment partners[15] with significantly different labor market regimes[16]. The existing theoretical literature on the Europe-America dichotomy is substantial (notable contributions are Wood 1994, Krugman 1994 and 1995, Bertola and Ichino 1995, Davis 1998, Acemoglu and Newman, 2002). This literature seeks to explain the stylized fact that "rigid" Europe has witnessed higher unemployment and a more compressed wage structure than "flexible" America by taking into account that the two economies operate in the same international environment and are thus exposed to the same external shocks (technical progress,

[15]The EU share of the US inward direct investment stock was 60 percent in 1989 and 65 percent in 2000. The EU share of the US outward investment stock was 43 percent in 1989 and 46 percent in 2000 (OECD, 2001, p.409). Moreover, EU (resp.EEC) has been a net exporter of direct investment to the US both cumulative over the period 1982-2000 and in each single year of this period except in the period 1991-1995 (OECD 2001, p.408-415 and OECD 1993, p. 242-248).

[16]Europe is often being referred to in the literature as "rigid", and America as "flexible" as regarding the operation of the labor market. While European countries cannot be easily lumped up together, these labels are not totally unjustified. The employment protection index and the labor standards index drawn up by the OECD clearly point to the fact that virtually all countries of continental Europe have far more inflexible labor markets than the US (s. Nickell 1997, p. 60-61).

trade, etc.). Typically, the divergent labor market experiences are attributed to the different labor market institutions, which are assumed to be exogenous. I follow the tradition of this literature to model Europe and America as two identical economies, which are exposed to a common shock: in this case, an increase in capital mobility. I do, however, endogenize the pertaining labor market regulations. This modelling strategy allows us to study not only how the effects of a given policy change as the economy opens, but also how openness affects the policy itself through the political process. To portray the political process I rely on the Grossman-Helpman approach (Grossman and Helpman, 1994) that builds upon the common agency model by Bernheim and Whinston (1986). As it is well known this modelling approach implies a government that sets economic policy as if it maximized a weighted sum of social welfare and contributions from organized interest groups. I focus on the conflict between workers and capital owners[17]. In this framework these two interests lobby the government on minimum wage legislation.

One central feature of this analysis is that I consider an imperfect labor market. Thus the framework used here accommodates the argument by Agell (1999) that potential efficiency benefits of labor market regulation may be important in the context of globalization.[18] Adopting a perfectly competitive labor market would imply that, other things being equal, more regulated countries should have a lower per capita labor income, which would be at odds with the fact that living standards within the developed world have been converging while the institutional variety among these countries remains substantial (Freeman 1998, Acemoglu and Newman 2002). To model the labor market I build on the efficiency wage hypothesis. In particular, I use the dual labor market model of Bulow and Summers (1985) augmented by capital in the secondary sector. In this model identical workers are accidentally assigned to either high-paying (primary) or to low-paying (secondary) jobs in equilibrium. The inefficiency of the labor market stems from the inability of primary firms to observe the effort of their workers,

[17]This focus is motivated by the open economy perspective that I adopt here. In the context of globalization union leaders often voice concerns about increased bargaining power of firms due to their increased mobility and call for stronger cooperation among workers. Here I consider homogeneous labor and do not analyze any conflict among workers. For an analysis of the conflict between workers with different employment opportunities in a closed economy s. Saint-Paul (2000)

[18]In an imperfectly competitive framework labor market institutions that promote wage compression may be beneficial in various ways: e.g., through facilitating the expansion of high-productivity sectors, creating incentives for human capital accumulation and providing social insurance when private one is undersupplied (s. Agell 1999 for a review of these arguments). Further, wage compression may reduce wasteful use of resources in monitoring (Acemoglu and Newman 2002) and may stimulate technological development that increases the productivity in low-paid occupations (Acemoglu 2003)

which results in a larger than optimal secondary sector.

The dual model itself does not say anything about the nature of the goods produced in the two sectors. The usual interpretation is that primary jobs are offered by large manufacturing establishments such as IBM while fast-food outlets, such as McDonalds, are typical suppliers of secondary jobs (Bulow and Summers 1986, p. 380, Saint-Paul 1996, p. 3). For the purposes of the present analysis, however, the nature of the goods produced by the two types of jobs is not important. As recent theoretical work has shown good and bad jobs may coexist within the same industry or even within the same firm (Saint-Paul 1996). The key insight in Saint-Paul's model is that the firm has two basic methods at its disposal to motivate its workers: offer wages higher than the reservation wage or invest in more intensive monitoring. Under some circumstances the firm may find it optimal to combine the two methods and split its workforce into two. Namely, part of the workers are prevented from shirking by means of higher wages (these are the primary workers who are envisaged as those enjoying greater employment security), and part by means of more intensive monitoring (these are the secondary workers, which are used by the firm as a buffer against fluctuations in product demand). Note that from this perspective the skill content of primary and secondary jobs need not be different.

I believe Saint-Paul's model of internal dualism offers an important insight into the forces at work behind the wage inequality among similar workers. Nevertheless, I model dualism as an inter-sectoral phenomenon. This amounts to assuming fixed total supply of primary and secondary jobs and is done mainly for simplicity. I believe that a model of internal dualism where firms optimally decide how to split their workforce into primary and secondary could generate similar interdependencies. In any case, one would expect labor market institutions to reduce the number of secondary jobs and increase that of primary, perhaps at the cost of some unemployment. Moreover, as firms become increasingly mobile one would expect to see some shift of secondary jobs occurring from regulated to deregulated countries. These are basically the interdependencies that arise in this framework.

In the presented model the minimum wage reduces profits, benefits workers in the aggregate (provided it is set sufficiently high), reduces wage inequality and increases unemployment. The model, moreover, gives rise to a double-peaked social welfare function: one local social-welfare maximum occurring at no intervention, and the other at some binding level of the minimum wage. To the extent that social welfare matters in the political process (in the Grossman-Helpman set-up it is assumed to enter the government's objective function) this translates into institutional variety: some countries may end up at the no-regulation peak, others at the high-regulation peak. This argument provides some intuition for the first result: similar countries may have substantially different labor market regulations, and these differences may arise because of small differences in the political process.

The main results however relate to the influence of economic integration via capital mobility. First, I analyze the effects of international capital mobility on a laissez-faire and on a regulated economy, which are otherwise identical, keeping the policy in each country fixed. This is the kind of comparative-statics analysis performed in the related literature. I find that the protective effects of regulation (in terms of higher wages for the low-wage workers) spread over to the deregulated country while unemployment remains restricted to the regulated one and increases after the opening. In this respect my results parallel those of Davis (1998)[19].

Second, when I allow for an endogenous policy response, I find that the increase in capital mobility may lead to either more or less strict regulation in the regulated country. The direction of the policy response turns out to be related to the relative political influence of the economic interests involved. In particular, I find that deregulation occurs whenever the labor interest is more influential in the political process. Furthermore, if the regulated country is assumed to be a small open economy, the policy response always goes against the interests of the stronger lobby, i.e. the minimum wage is reduced, or even abolished, whenever the workers' political influence is stronger, and it is increased whenever the capital owners dominate in the political process. In other words, economic integration turns out to work as a political equalizer in this model. The intuition for this result is that the minimum wage is less effective as a tool for redistribution in an integrated economy and the government is then less willing to deviate from social welfare maximization in order to accommodate the stronger political interest.

In sum, I do not find support for the argument that globalization will necessarily erode the established labor market regulations: the regulated country may or may not adopt the flexible-wage paradigm. Interestingly, worldwide deregulation does not appear to represent an equilibrium outcome, if regulation can be justified on efficiency grounds.

3.4 The baseline model

Consider an economy with two types of infinitely lived individuals, workers and capital owners. The only source of income for the workers is their wages, and for the capital owners it is firms' profits. There are two types of competitive

[19] It should be noted that I focus on inequality among similar workers, while the Davis paper addresses inequality among skilled and unskilled.

firms, primary and secondary. Each secondary firm uses one unit of specific capital and labor. Its profits are equal to the marginal value product of capital by the homogeneity of degree one of the production function $Y(L, K)$. Primary firms produce with labor only and make no profit. Throughout the Chapter I abstract from product market interactions and keep the relative price of the goods produced by primary and secondary firms fixed. A composite numeraire good is defined. The output of both primary and secondary firms is measured in terms of the numeraire. Labor input is measured in efficiency units. A worker contributes one unit of effective labor, if he exerts effort $e, e > 0$. There are only two levels of effort, e and 0. If a worker shirks[20], i.e. exerts 0 effort, he contributes nothing to production. A major difference between secondary and primary firms is that the former can perfectly monitor the effort of their workers while the latter cannot. Primary firms are conscious of the effort elicitation problem and take workers' preferences into account in their employment decisions[21]. There are N identical and risk neutral workers with instantaneous utility separable in income and effort and normalized to

$$U = w - e \tag{3.4.1}$$

where w is the wage and e is the effort level. Workers maximize expected lifetime utility

$$V = E\int_0^\infty U_t \exp(-rt)dt \tag{3.4.2}$$

The effort decision of a worker employed in a primary firm is based upon a comparison between his lifetime utility if shirking, V^{PS}, and that if not shirking, V^{PN}. In steady state we have

$$rV^{PN} = w_p - e + s_n(V^{alt} - V^{PN}) \tag{3.4.3}$$

$$rV^{PS} = w_p + s_s(V^{alt} - V^{PS}) \tag{3.4.4}$$

where the instantaneous interest rate $r(r > 0)$, the separation rate for non-shirkers $s_n(s_n > 0)$, and that for shirkers $s_s(s_s > s_n)$ are exogenous parameters; V^{alt} is the lifetime utility of a worker fired from the primary sector, and w_p is the primary wage. Workers choose not to shirk whenever $V^{PN} \geq V^{PS}$. Substituting for V^{PN} and V^{PS} from 3.4.3 and 3.4.4 into this no-shirking condition we obtain

$$w_p \geq \frac{(r + s_s)e}{s_s - s_n} + rV^{alt} \tag{3.4.5}$$

[20]The model described in this Section draws heavily on Shapiro and Stiglitz (1984). It is set in continuous time and analyzes only steady state equilibria. Similar two-sector extensions of the Shapiro-Stiglitz model are developed in Bulow and Summers (1986) and Jones (1987)

[21]Competitive firms producing with labor only do pay efficiency wages in Bulow and Summers (1986) as well.

Noting that there will be no shirking in equilibrium, we can write the corresponding asset equation for V^{alt} as

$$rV^{alt} = w_s - e + a(V^{PN} - V^{alt}) \tag{3.4.6}$$

where w_s is the secondary sector wage, and a is the instantaneous probability of a worker fired from the primary sector to find a job in that sector again. The first term in (3.4.6), $w_s - e$, is the instantaneous utility of a worker outside the primary sector. Since in the absence of intervention secondary jobs are freely accessible, the latter is equal to the instantaneous utility of having a secondary job. If $w_s = e$, the instantaneous utility of having a secondary job equals the instantaneous utility of being unemployed[22], thus, without intervention, the model is consistent with voluntary unemployment. The flow probability a can be found from the steady state condition

$$a(N - L_p) = s_n L_p \tag{3.4.7}$$

where L_p denotes employment in the primary firms. Normalizing the marginal product of labor in the primary sector to one and using the zero-profit condition for the primary firms, the equilibrium in the case of no intervention can be described by the following three equations in w_s, L_p and L_s (employment in the secondary sector):

$$1 = w_s + c_0 + c_1 \left[\frac{N}{N - L_p}\right] \tag{3.4.8}$$

$$w_s = Y_L^{'}(L_s, \bar{K}) \tag{3.4.9}$$

$$N = L_p + L_s \tag{3.4.10}$$

I denote the solution of the above system (w_s^0, L_s^0, L_p^0). Eq. (3.4.8) is obtained by first solving the system consisting of (3.4.3), (3.4.6) and (3.4.7) for a, V^{PN} and V^{alt}, and then substituting the solution for V^{alt} into the no-shirking condition (3.4.5), whereby I denoted the constants $\frac{er}{s_s - s_n}$ and $\frac{es_n}{s_s - s_n}$ by c_0 and c_1 respectively. Eq. (3.4.9) says that the wage in the secondary sector equals the marginal product of labor. I denote by $\bar{K}$ the number of secondary firms (which equals also the aggregate capital endowment since each firm is endowed with one unit of capital). Eq. (3.4.10) says that the sum of primary and secondary employment equals total labor force[23]. I assume that $w_s^0 > e$, i.e. in the case of no intervention there is full employment and equilibrium is given by (3.4.8) - (3.4.10).

[22] The latter is zero. I do not consider unemployment benefits.

[23] If the secondary wage that solves the above system is below e, equilibrium is found by solving a system consisting of (3.4.8), (3.4.9) and the following two equations

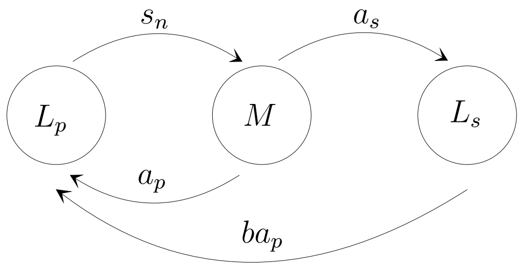
$$w_s = e$$
$$L_p + M + L_s = N$$

where M is unemployment (here voluntary).

3.5 The effects of regulation

In this Section I describe the effects of the government's policy. I assume that the government can directly set the wage in the secondary sector. The choice set W is given by the closed interval $[w_s^0, 1]$, where w_s^0 is the secondary-sector wage obtained in the absence of intervention and 1 is the wage in the primary sector. If the government chooses $w = w_s^0$, i.e. the policy of no intervention, equilibrium is given by Eqs. (3.4.8)-(3.4.10). Alternatively, the government may choose $w \in (w_s^0, 1]$, i.e. a binding minimum wage. The imposition of a binding minimum wage entails that workers fired from the primary sector cannot immediately obtain a job in the secondary sector. In equilibrium this leads to involuntary unemployment: primary jobs are rationed due to the no-shirking condition, secondary jobs are rationed due to the binding minimum wage. This implies that in each instant a worker is in one of three possible states, each associated with different lifetime utility: employed in a primary firm, employed in a secondary firm, and unemployed. Therefore, we have to consider a new flow system in equilibrium (s. Figure 3.5.1 below).

Figure 3.5.1: Flows in steady state



The arrows in Figure 3.5.1 indicate the flows between the three states, in steady state, the letters above indicate the instantaneous probability of a worker in a given state to get in the respective flow. Note that workers fired from the primary sector enter directly the unemployment pool, there is no arrow from L_p to L_s. There is no arrow from L_s to M either, which indicates that secondary sector workers cannot be falsely accused of shirking and fired. The unemployed acquire primary jobs at rate a_p and secondary jobs at rate a_s. The parameter b reflects how successful an unemployed worker is on average in finding a primary job relative to a secondary worker. We have the following equilibrium conditions:

$$
\begin{aligned}
rV^{alt} &= a_p(V^{PN} - V^{alt}) + a_s(V^{sec} - V^{alt}) && (3.5.1)\\
rV^{sec} &= w_s - e + ba_p(V^{PN} - V^{sec}) && (3.5.2)\\
s_n L_p &= a_p M + ba_p L_s && (3.5.3)\\
s_n L_p &= (a_p + a_s)M && (3.5.4)\\
N &= L_p + M + L_s && (3.5.5)
\end{aligned}
$$

Eqs. (3.5.1) and (3.5.2) define the lifetime utility of the unemployed (V^{alt}) and that of the employed in the secondary sector (V^{sec}). The next two equations say that the flows into and out of the primary sector (3.5.3) as well as the secondary sector (3.5.4) must be equal. Eq. (3.5.5) says that the sum of employment in both sectors and unemployment (M) equals total labor force. Solving (3.4.3) and (3.5.1) - (3.5.5) simultaneously for $M, a_p, a_s, V^{PN}, V^{sec}, V^{alt}$, and substituting the solution for V^{alt} into (3.4.5) yields a no-shirking condition in w_p, w_s, L_s and b. Since w_p has been normalized to 1, $w_s = w$, as set by the government, and L_s is given by the requirement that marginal value product of labor equals the wage (3.4.9), it remains only to pin down the parameter b to close the model. One possibility would be to assume that $b = 1$, i.e. the typical secondary worker and unemployed have equal chance of finding a primary job at any point of time. It may be argued however that the involuntarily unemployed have an incentive to search harder since the utility gain from obtaining a primary job for them is larger. This would imply $b < 1$. Moreover, the government may provide assistance in the job search to the unemployed to compensate them for the adverse effects of the minimum wage. In any case, I will treat b here as exogenous and will consider the extreme case of $b = 0$. This significantly simplifies the equilibrium dynamics as the flows into and out of the secondary sector drop out.[24] Setting $b = 0$ yields the following no-shirking condition

$$w_p \geq e + c_0 + c_1 \left(\frac{N - L_s}{N - L_s - L_p} \right) \tag{3.5.6}$$

The model in the binding minimum wage case reduces then to the following two equations in L_p and L_s.

$$L_p = \alpha(N - L_s) \tag{3.5.7}$$
$$w = Y_L^{'}(L_s, \bar{K}) \tag{3.5.8}$$

Eq. (3.5.7) is obtained by solving (3.5.6) for L_p and setting $w_p = 1$. It implies that employment in the primary sector is proportional to the labor force outside the secondary sector with a constant of proportionality $a \equiv \frac{1-e-c_0-c_1}{1-e-c_0}$. It follows that unemployment[25] is also proportional with $M = (1-\alpha)(N - L_s)$. Employment in the secondary sector is directly obtained from the condition that

[24]It should be noted that in a world with heterogeneous agents having a secondary job may represent a positive signal to potential employers and enhance the chances of obtaining a primary job. This argument is often put forward in the literature on part-time employment, which is considered as a gateway ("stepping stone") to full-time (primary) employment (Stepping-Stone Hypothesis). In this model, however, all workers are identical, and having a secondary job has no signaling value.

[25]The condition that unemployment is involuntary is $V^{alt} < \int_0^\infty (w - e) \exp(-rt) dt$ and I assume that it is satisfied in equilibrium.

marginal product equals the minimum wage (3.5.8).

We are now in a position to derive the welfare effects of the policy instrument w on the politically active groups. To focus on the social conflict between capital and labor I consider just two lobby groups that comprise the whole population: the one lobby group is that of the capital owners and the other that of the workers[26]. I assume that the two lobbies have overcome the collective action problem[27] and each maximizes the aggregate utility of its members. I denote the aggregate lifetime utility of the capital owners by V_K and that of workers by V_U. V_K and V_U are obtained by double integration, once over time for each individual, and once over individuals. Given that the number of workers in each of the three possible states does not change over time in equilibrium we can change the order of integration and write $V_i = U_i \int\limits_0^\infty \exp(-rt)dt$, $i = K, U$ where U_i, $i = K, U$, stands for the aggregate instantaneous utility found by summing over individuals. Since the aggregate lifetime utilities are proportional to U_K and U_U we can use these latter measures in the subsequent analysis without loss of generality. They are defined as follows:

$$U_K \equiv Y(L_s, \bar{K}) - wL_s \tag{3.5.9}$$

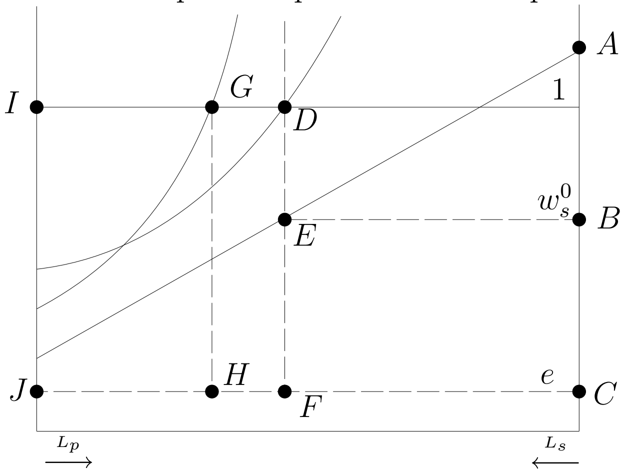
$$U_U \equiv (1-e)L_p + (w-e)L_s \tag{3.5.10}$$

A graph should be useful in the derivation of the functions $U_K(w)$ and $U_U(w)$ (s. Figure 3.5.2 below).
The two lines starting at points I and A represent the marginal product of labor in the primary and the secondary sector respectively. The curve passing through point D is the right-hand side of (3.4.8), the no-shirking condition in the case of no intervention. The position of the horizontal line JC reflects the effort level e. In the case of no intervention employment in the primary sector equals the distance ID and employment in the secondary sector - the distance EB. The aggregate welfare of the capital owners is found as the area of the triangle ABE and that of the workers as the area of the rectangles IDFJ and EBCF, which represent the aggregate utility of the workers employed in the primary and the secondary sector respectively. The introduction of a just binding minimum wage only marginally affects point E (the intersection of the marginal product in the secondary sector and the policy level) while shifting the no-shirking condition to

[26] A standard result in the Grossman-Helpmann model is that the equilibrium policy departs from the social-welfare maximizing one due to the existence of an unrepresented part of the population. Even though in the present framework all individuals are organized the same result is obtained because of the unequal power of the two lobby groups.

[27] A source of additional tension within the workers' group may be their ex-post heterogeneity. Nevertheless, the fact that they are identical ex-ante and the uncertainty about who will end up unemployed make it reasonable to assume that workers act as a homogeneous group.

Figure 3.5.2: Graphical representation of equilibrium.



point G[28]. After the introduction of a binding minimum wage therefore, aggregate welfare of the workers employed in the primary sector is given by the area IGHJ. Further increasing the minimum wage implies that the point E moves along the marginal product line toward point A whereby the employment in the secondary sector is progressively diminished and the no-shirking condition progressively relaxed (shifted to the right). I now proceed with the algebraic derivation of the functions $U_K(w)$ and $U_U(w)$. The results are graphed in Figure 3.5.3.
Capital owners' utility $U_K(w)$ is continuous and decreasing at a diminishing rate over the whole range $[w_s, 1]$. Differentiating (3.5.9) and using (3.5.8) and (3.4.9) we obtain

$$U_K^{'}(w) = -L_s < 0 \tag{3.5.11}$$

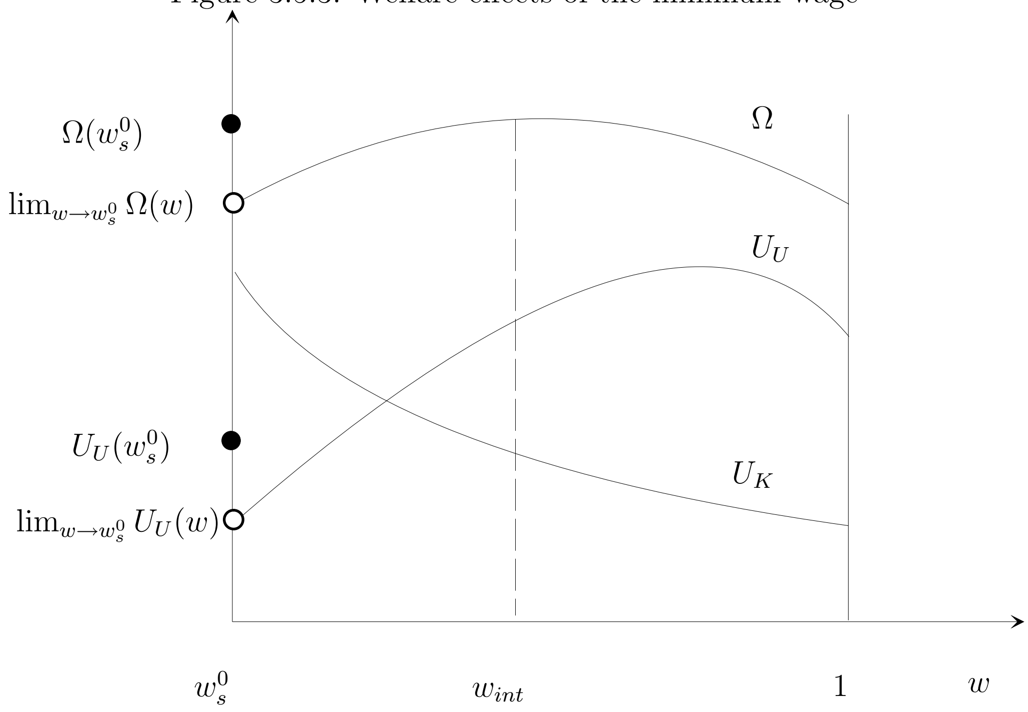
where, for any wage, L_s is obtained from Eq. (3.5.8). Workers' aggregate utility is discontinuous at $w = w_s^0$. This is so because the introduction of a just binding minimum wage tightens the no-shirking condition relative to its initial position as illustrated in Figure 3.5.2. The utility loss from a just binding minimum wage for the workers as whole is

$$U_U(w_s^0) - \lim_{w \to w_s^0, w > w_s^0} U_U(w) \quad = \quad (1-e)(1-\alpha)(N - L_s^0) > 0 \tag{3.5.12}$$

where $(1-e)$ is the loss in instantaneous utility of a primary worker who becomes unemployed, and $(1-\alpha)(N - L_s^0)$ is the size of the affected workforce. For

[28] This can be seen from (3.5.6), where the right-hand side goes to infinity when L_p goes to $N - L_s$. Since L_s equals the distance EB it follows that with a binding minimum wage the no-shirking condition is asymptotic to the vertical line going through point E.

Figure 3.5.3: Welfare effects of the minimum wage



$w \in (w_s^0, 1]$ the function $U_U(w)$ is continuous and differentiable. Using (3.5.7) and (3.5.10) we find

$$U_U(w) = (1-e)\alpha N + (w - w_{int})L_s, \qquad \text{for } w > w_s^0 \qquad (3.5.13)$$

where I have denoted the constant $\alpha + (1-\alpha)e < 1$ by w_{int}. Differentiating this expression we obtain

$$U_U'(w) \;=\; (w - w_{int})\frac{dL}{dw} + L_s, \qquad (3.5.14)$$

where, for any wage, L_s and $\frac{dL}{dw} = \frac{1}{Y_{LL}''(L_s,\bar{K})}$ are found from (3.5.8). I assume that $w_s^0 < w_{int}$, which guarantees that the function U_U has a well defined maximum over the interval $(w_s^0, 1]$[29]. Furthermore, I assume that this maximum is higher than $U_U(w_s^0)$, i.e. in the aggregate workers can gain from the imposition of a minimum wage. This implies a conflict of interest between capital owners and workers with respect to the policy. The workers' preferred policy is some binding minimum wage, while capital owners' preferred policy is no intervention.

[29]Since $\frac{dL}{dw} = \frac{1}{Y_{LL}''(L_s,\bar{K})} < 0$ we have $U_U'(w) > 0$ for all w$\in (w_s^0; w_{int})$, i.e. $U_U(w)$ reaches its maximum somewhere after w_{int}.

It is also of interest to look at the utilitarian social welfare function $\Omega(w) \equiv U_K(w) + U_U(w)$. This definition together with (3.5.11) and (3.5.14) implies:

$$\Omega' = U_K' + U_U' = (w - w_{int})\frac{dLs}{dw} \gtrless 0 \qquad \text{as} \qquad w \gtrless w_{int} \tag{3.5.15}$$

It is clear that labor market regulation in this model entails both efficiency costs and benefits, in terms of Ω, leaving the net effect ambiguous. When we start at the laissez-faire equilibrium, "marginal" costs dominate "marginal" benefits. This is captured in an extreme way here by the jump in Ω, which is equal to the jump in U_U, when a just binding minimum wage is introduced. Further, as it is clear from (3.5.15), Ω is increasing over the range (w_s^0, w_{int}), i.e. over this range it is the marginal benefits that become dominant, and to the right of w_{int} Ω is decreasing again, i.e. it is the marginal costs that dominate. A similar two-peak relationship between efficiency and regulation may be obtained in more general settings as well. Here the costs of regulation are associated with a surge in involuntary unemployment. The benefits stem from shifting workers from low-productivity to high-productivity sectors[30]. The interpretation would be different, if one views the presence of primary and secondary jobs as intra- rather than as an inter-sectoral phenomenon. On the benefit side, the shift from secondary to primary jobs induced by the minimum wage would potentially relocate resources from monitoring to productive activities. On the cost side, it would reduce the flexibility of the firms and entail that production opportunities in periods of economic boom be not fully realized. The presence of both costs and benefits to labor market institutions provides a natural explanation of the institutional variety among the leading industrialized counties. Accordingly, in this model two different institutional settings, the laissez-faire and the binding minimum wage one, may generate the same aggregate welfare[31]. This follows from the fact that either of the two peaks $\Omega^0 \equiv \Omega(w_s^0)$ or $\Omega^{int} \equiv \Omega(w_{int})$ may be higher depending on the constellation of parameters.

3.6 The political equilibrium

In this Section I endogenise the policy. I assume that it is determined in a political process which takes the form of a two stage game (Grossman Helpmann 1994). At the first stage the two lobbies offer the government contribution schedules $\lambda_i(w), w \in W, i = K, U$; at the second stage the government chooses $w \in W$ so

[30]The relevance of such benefits has been discussed in Bulow and Summers (1986) in the context of industrial policy, and in Agell (1999) in the context of labor market policy.

[31]The same idea has been expressed by Acemoglu and Newman (2002). However, they do not build a political economy model nor do they analyze the impact of globalization on institutional change.

as to maximize the weighted sum of contributions and net social welfare:

$$\Gamma(w) \equiv \gamma_K \lambda_K(w) + \gamma_U \lambda_U(w) + [\Omega(w) - \lambda_K(w) - \lambda_U(w)] \qquad (3.6.1)$$

Net social welfare (the term in brackets) receives a weight of 1, contributions - weights of γ_K and γ_U respectively, where I assume $\gamma_K \geq 1$, $\gamma_U \geq 1$. The parameters γ_K and γ_U can be regarded as a measure of the strength of each lobby: the higher its γ, the more effective the lobby is in influencing the policy. For example in the extreme case $\gamma_K = \gamma_U = 1$ both lobbies are powerless and the government is a social welfare maximizer. Another extreme case would be that one of the lobbies has infinite power ($\gamma_i \to \infty$). In this case this lobby could induce the government to set any policy $\hat{w}$ by simply offering a contribution schedule that pays an arbitrarily small amount $\epsilon > 0$ at $\hat{w}$ and zero anywhere. There are different reasons why the two lobbies may not be equally effective in influencing the government. Rama and Tabellini for instance argue that the nature of the contributions (labor offers support demonstrations, while capital offers cash) as well as the cost to organize into an active lobby may differ between capital and labor (Rama and Tabellini 1998, p. 1306).

At the first stage of the game each lobby offers a contribution schedule. Following Grossman and Helpman (1994) and Rama and Tabellini (1998) I restrict attention to the Nash-equilibrium supported by the so called "truthful" contribution schedules. These take the form

$$\lambda_i(w, R_i) \equiv \max\,[U_i(w) - R_i, 0], \quad i = K, U \qquad (3.6.2)$$

i.e. they pay the government, for any w, the excess welfare of lobby i at w relative to a given reservation utility. The equilibrium is a combination of two reservation utilities (R_K^{eq}, R_U^{eq}) and a corresponding policy $w^{eq} = \underset{w \in W}{\text{argmax}} \;\; \Omega(w) + (\gamma_K - 1)\lambda_K(w, R_K^{eq}) + (\gamma_U - 1)\lambda_U(w, R_U^{eq})$ such that no lobby can improve its net welfare by readjusting its reservation utility, given the reservation utility of the other lobby. Net welfare is defined as gross welfare minus contributions

$$U_i^{net}(w) \equiv U_i(w) - \lambda_i(w) \qquad (3.6.3)$$

The two definitions (3.6.2) and (3.6.3) imply:

$$U_i^{net}(w) = \min\,[U_i(w), R_i] \qquad (3.6.4)$$

The objective now is to characterize how the equilibrium policy and reservation utilities depend upon the political parameters γ_K and γ_U. The following Lemmas and Proposition are proven in the appendix.

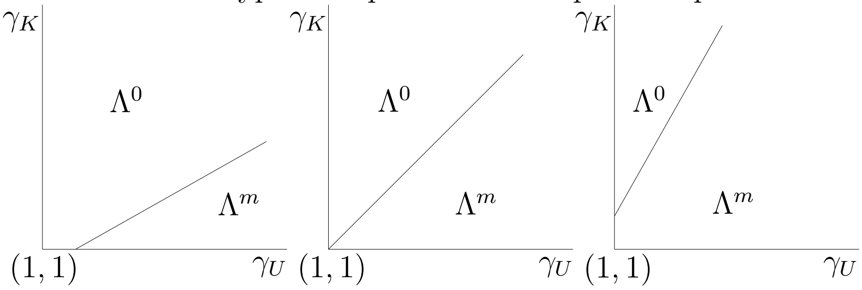
Lemma 1 In equilibrium each lobby gets its reservation utility: $R_i^{eq} = U_i^{net}(w^{eq})$, or equivalently $R_i^{eq} \leq U_i(w^{eq})$.

Lemma 2 The equilibrium policy satisfies
$w^{eq} = \underset{w \in W}{\operatorname{argmax}} \; \gamma_K U_K(w) + \gamma_U U_U(w).$

Proposition There exists a critical ratio γ^*, such that for $\gamma_K/\gamma_U > \gamma^*$ the equilibrium policy is laissez-faire and for $\gamma_K/\gamma_U < \gamma^*$ the equilibrium policy is a binding minimum wage.

Figure 3.6.1 depicts how the (γ_U, γ_K)-space can be divided into two subsets according to the Proposition. The first set denoted Λ^0 is associated with a flexible wage and the second set denoted Λ^m is associated with a binding minimum wage in equilibrium. The precise slope of the borderline $\gamma_K = \gamma^* \gamma_U$ depends upon the economic parameters of the model.

Figure 3.6.1: Different types of equilibria in the political parameters' space



case 1: $\Omega^0 > \Omega^{int}$ case 2: $\Omega^0 = \Omega^{int}$ case 3: $\Omega^0 < \Omega^{int}$

If $\Omega^0 > \Omega^{int}$, i.e. social welfare is maximized by no intervention, then the point (1,1) must lie to the left and above the line $\gamma_K = \gamma^K \gamma_U$ (remember that for $\gamma_K = \gamma_U = 1, w^{eq} = \underset{w \in W}{\operatorname{argmax}} \; \Omega(w)$). Hence in this case $\gamma^* < 1$. If on the other hand $\Omega^0 < \Omega^{int}$, i.e. social welfare is maximized by a binding minimum wage (w^{int}), then the point (1,1) must lie to the right and below the line with slope γ^* and hence $\gamma^* > 1$. Finally, if $\Omega^0 = \Omega^{int}$, then the point (1,1) lies exactly on the borderline, $\gamma^* = 1$. It is clear that when $\Omega^0 = \Omega^{int}$ and $\gamma_K = \gamma_U = 1$ the equilibrium policy is not unique - it may be w_s^0 or w_{int}. In fact, it can be shown that, whatever the slope of the borderline γ^*, when (γ_K, γ_U) lies exactly on that line, the equilibrium policy is not unique - it can be laissez faire or a binding minimum wage.
For those γ_K and γ_U for which the equilibrium policy is a minimum wage its level can be found from

$$G'(w) \equiv \gamma_K U_K'(w) + \gamma_U U_U'(w) = 0, \tag{3.6.5}$$

provided it is strictly in the interior of W (otherwise it is equal to one). I shall assume that the function $G(w) \equiv \gamma_K U_K(w) + \gamma_U U_U(w)$ is globally concave[32] for all $(\gamma_K, \gamma_U) \in \Lambda^m$, which guarantees that the equilibrium policy is unique for $\frac{\gamma_K}{\gamma_U} \neq \gamma^*$. For w^{eq} strictly in the interior of W we obtain the following comparative static results by implicit differentiation of (3.6.5) :

$$\frac{dw^{eq}}{d\gamma_K} = -\frac{U_K^{'}}{G''} < 0 \qquad \frac{dw^{eq}}{d\gamma_U} = -\frac{U_U^{'}}{G''} > 0 \tag{3.6.6}$$

Quite intuitively the minimum wage depends positively (negatively) on the political power of the workers (capital owners). For later reference I state another formulation of equation (3.6.5) which is obtained by using (3.5.11) and (3.5.14)

$$G^{'}(w) = \gamma_U(w - w_{int})\frac{dL_s}{dw} + (\gamma_U - \gamma_K)L_s \tag{3.6.7}$$

3.7 The effects of openness

All results so far have been derived treating the capital stock (number of firms operating in the country) K as given. In this Section I endogenise this variable by assuming that firms can relocate their production activities to exploit cost differentials internationally. I shall denote by $\bar{K}$, as before, the original number of firms (capital endowment) and by K the number of firms operating in the country after it opens to capital mobility.

3.7.1 The effects of capital mobility between a laissez-faire and a regulated economy: the Europe-America case

I start by considering a benchmark model paralleling that of Davis (1998): I analyze the effects of perfect capital mobility between two economies which are identical in all respects except that the one (Europe) has an exogenous binding minimum wage and the other (America) a flexible. The previous Section makes it clear that two identical economies can indeed have such polarly different labor market policies. Simply assume that initially, before opening to international capital mobility, the parameter point (γ_K, γ_U) was to the right and below the borderline with slope γ^* in Europe, while in America it was to the left and above. In fact, as we have seen in the last Section the difference between the political parameters in both countries may be arbitrarily small. Let me look first at what the effects of capital mobility would be, if each country retained its policy. Obviously capital flight from Europe to America would take place until the secondary sector wages in both countries are completely equalized. The reduction of the number of secondary firms operating in Europe would be met by an equiproportionate

[32]It is easy to show that this assumption is satisfied for example with the following production function in the secondary sector: $Y(L,K) \equiv AL - B\frac{L^2}{K} + CK$, where A,B, and C are positive parameters.

reduction of the secondary sector employment in Europe to keep the marginal product of labor in that sector equal to the minimum wage. As we know from Section 3.5 (s. Eq. (3.5.7))the reduction of secondary sector employment would entail an increase in both unemployment and primary-sector employment in Europe. We see thus that the effects of capital mobility here are very similar to the effects of trade in the Davis (1998) model. In both cases the regulation's protective effects (in terms of higher wages for the low-paid workers) spread over to the deregulated country, and in both cases the regulation's costs (in terms of involuntary unemployment) remain borne by the regulated country alone and increase with the opening. This suggests that the minimum wage may become politically unsustainable in Europe after the opening.

Now I turn to the question under what conditions and how the equilibrium policy in Europe is going to change when capital becomes mobile. Unfortunately we cannot analyze the simultaneous determination of policy in both countries. The latter problem is quite complex, because the optimal strategy of each lobby depends then not only upon the strategy of its competing lobby in the home country, but also upon the strategies of the two lobbies in the other country (because the effects of the domestic policy are different depending upon the policy set in the other country). What I do therefore, is analyze the policy determination in Europe by assuming that America keeps its wage flexible and that this is known to all players[33]. The first question now is whether Europe may be driven to remove any regulation and adopt the flexible wage policy. To address this question we have to see how the shape of the reduced-form political support function $G(w)$ is affected by the opening of the economy. This is made easy by the symmetry of the model and the assumption of perfect capital mobility. First, the choice set of the government is as before: w_s^0 corresponds to the policy of no intervention, and any $w \in (w_s^0, 1]$ represents a binding minimum wage.

When the policy in Europe is laissez-faire, capital mobility with identical America has actually no effect - equilibrium is given by Eqs. (3.4.8)-(3.4.10) as before. When the policy in Europe is a binding minimum wage, we have the following

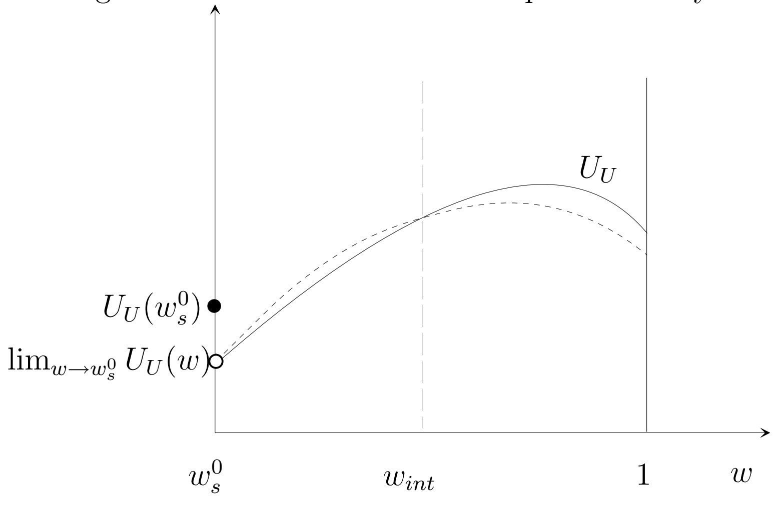
[33]Note that as long as the wage w^A set in America is lower than that in Europe it will not be binding, hence in this case we may treat America as keeping its wage flexible (even if $w^A > w_s^0$). Moreover, given that the only asymmetry in this model is in the ratio $\frac{\gamma_K}{\gamma_U}$, whereby the workers' lobby is relatively stronger in Europe, it seems extremely unlikely that America ends up with a higher wage when the policies are determined simultaneously.

system of equations:

$$
\begin{aligned}
1 &= w + c_0 + c_1 \left[\frac{N}{N - L_P^A}\right] \quad (3.7.1)\\
w &= Y_L'(L_s^A, K^A)\\
N &= L_P^A + L_s^A\\
Ł_P &= \alpha(N - L_s)\\
w &= Y_L'(L_s, K)\\
2\bar{K} &= K + K^A
\end{aligned}
$$

The superscript "A" denotes the American variables when these are distinct from the European ones. The first three equations correspond to the equilibrium conditions in a flexible wage economy (3.4.8)-(3.4.10), the second two equations correspond to the equilibrium conditions in a regulated economy (3.5.7)-(3.5.8), and the last equation says that the sum of capital operating in both countries equals two times the single country's endowment. We can see that the aggregate welfare of the capital owners is the same for any policy because the wage set in Europe automatically prevails in both countries and determines the profits of each single secondary firm regardless of its location decision. This means that the function $U_K(w)$ does not shift relative to its position without capital mobility. The function $U_U(w)$, on the other hand, shifts as depicted in Figure 3.7.1.

Figure 3.7.1: Welfare effects of capital mobility



Clearly at w_s^0 there is no capital flight, and hence $U_U(w_s^0)$ and $\lim\limits_{w\to w_s^0, w>w_s^0} U_U(w)$ are unaffected by capital mobility. For any $w > w_s^0$ however some firms relocate, which means that the aggregate employment in the secondary sector, L_s, obtained at any given wage with capital mobility, is lower than that without capital mobility. Using Eq. (3.5.13) we can conclude that $U_U(w)$ shifts upward for $w \in (w_s^0; w_{int})$, remains unchanged at w_{int}, and shifts downward for $w \in (w_{int}, 1]$.

After what we said above about the openness increasing the costs of regulation it may appear puzzling that for some policies the workers are actually better-off with capital mobility than without it. The explanation is that any policy entails costs (here involuntary unemployment) and benefits (here boosting the employment in the more productive primary sector) and that both of them are affected when the economy opens. It turns out that for policies in the range $w \in (w_s^0; w_{int})$ openness reinforces benefits by more than it does costs. It is now clear that the reduced form political support function $G(w)$ is unchanged at $w_s^0, w \to w_s^0$, and w_{int}, shifts upward for $w \in (w_s^0; w_{int})$ and downward for $w \in (w_{int}, 1]$. From this we can conclude that Europe unambiguously retains its minimum wage, if it was set originally not higher than w_{int}. On the other hand, it may well happen that the opening to capital mobility leads to a complete deregulation in Europe, if originally the minimum wage was set higher than w_{int}. We should note that w_{int} is, among the "interventionist" policies, the most efficient one, i.e. $w_{int} = \underset{w \in W, w \neq w_s^0}{\text{argmax}}\ \Omega(w)$, and that the original equilibrium in Europe is to the left (right) of w_{int} exactly when the union is the relatively weaker (stronger) lobby[34]. I identify therefore the condition that the union be the stronger lobby ($\gamma_U > \gamma_K$) as necessary for a complete deregulation to occur in Europe after the opening. It may be of interest also to know whether Europe can be driven to adopt the flexible-wage policy, even if a minimum wage is more efficient from a social welfare perspective, i.e. if $\Omega^0 < \Omega^{int}$. It turns out that this cannot happen because $\Omega^0 < \Omega^{int}$ implies $G(w_s^0) < G(w_{int})$ for $\gamma_U > \gamma_K$, and as we have seen $G(w)$ is unaffected by capital mobility at both w_s^0 and w_{int}.

As a next step I look at how the minimum wage in Europe is going to be adjusted, if it is retained. To this end I look at how the slope of the political support function at the original equilibrium changes when capital mobility is introduced. Since the function $U_K(w)$ is unaffected for all $w \in W$ all we need to see is how $U_U^{'}(w)$ as given by expression (3.5.14) changes at the original equilibrium. Capital mobility affects the terms L_s and $\frac{dL_s}{dw}$ in this expression. We have already established that L_s is lower at any wage with capital mobility than without. It remains to see how $\frac{dL_s}{dw}$ is affected. This is not obvious because the firm level reduction of employment in response to a small wage increase is the same with and without capital mobility giving rise to two opposite tendencies. On one hand, the number of firms operating in Europe at any wage is smaller with capital mobility, which tends to make the effect of a wage increase on aggregate employment smaller (in absolute

[34]This is because $G^{'}(w_{int}) \lesseqgtr 0$ as $\gamma_U \lesseqgtr \gamma_K$ as implied by Eq. (3.6.7).

value). On the other hand, with capital mobility a small wage increase has the additional effect of inducing further relocation of firms, which tends to make its effect on aggregate employment larger (in absolute value). It turns out that the second effect always dominates, i.e. $\frac{dL_s}{dw}$ is smaller (larger in absolute value) at any wage with capital mobility than without.[35] Using expression (3.5.14) we can see now that the opening to capital mobility may either reduce or increase $U_U^{'}(w)$ for $w \in (w_s^0; w_{int})$, while for $w \in (w_{int}; 1]$ $U_U^{'}$ is unambiguously reduced. We can conclude that, if originally the minimum wage was set below w_{int}, the direction in which it is adjusted is indeterminate and that otherwise it is unambiguously going to be reduced.[36]

Intuitively one may expect that the surge in capital mobility would strengthen the political influence of the capital owners and lead to a reduction or possibly an abolition of the minimum wage under all circumstances. Interestingly, however, the effects of capital mobility here are quite different depending on the relative strength of the politically active groups in Europe. As we have seen, if the union is the stronger lobby, the results are as expected: the minimum wage is unambiguously reduced, and it may even be abolished after the opening. However, if the capital owners are the stronger lobby, then the minimum wage is unambigu-

[35]To see this totally differentiate the system (3.7.2) and solve for $\frac{dL_s}{dw}$ to obtain (for the case of capital mobility)

$$\frac{dL_s}{dw} = \frac{1}{Y_{LL}^{''}(L_s, K)} \frac{Y_{LK}^{''}(L_s, K)}{Y_{LK}^{''}(L_s^A, K^A)} \left[1 - \frac{(L_s^A)^2 Y_{LL}^{''}(L_s^A, K^A)}{c_1 N} \right]$$

Obviously the obtained $\frac{dL_s}{dw}$ is negative. Remember that before we had

$$\left(\frac{dL_s}{dw}\right)^{NCM} = \frac{1}{Y_{LL}^{''}(L_s^{NCM}, \bar{K})}$$

where the superscript "NCM" indicates that the corresponding value is obtained for the case of "no capital mobility". Obviously $\left(\frac{dL_s}{dw}\right)^{NCM}$ is also negative. Now build the ratio

$$\frac{\frac{dL_s}{dw}}{\left(\frac{dL_s}{dw}\right)^{NCM}} = \frac{Y_{LL}^{''}(L_s^{NCM}, \bar{K})}{Y_{LL}^{''}(L_s, K)} \frac{Y_{LK}^{''}(L_s, K)}{Y_{LK}^{''}(L_s^A, K^A)} \left[1 - \frac{(L_s^A)^2 Y_{LL}^{''}(L_s^A, K^A)}{c_1 N} \right]$$

Using the homogeneity of degree -1 of $Y_{LL}^{''}(.)$ and $Y_{LK}^{''}(.)$ and the fact that at any given wage the equilibrium labor/capital ratio is the same with and without capital mobility (i.e. $\frac{L_s^{NCM}}{\bar{K}} = \frac{L_s}{K} = \frac{L_s^A}{K^A}$) we can write $\frac{Y_{LL}^{''}(L_s^{NCM}, \bar{K})}{Y_{LL}^{''}(L_s, K)} = \frac{K}{\bar{K}}$ and $\frac{Y_{LK}^{''}(L_s, K)}{Y_{LK}^{''}(L_s^A, K^A)} = \frac{K^A}{K}$. We see then that the term pre-multiplying the brackets equals $\frac{K^A}{\bar{K}}$ which is larger than one for any $w > w_s^0$. But the term in brackets is also larger than one, which proves that for any $w > w_s^0$ the term $\frac{dL_s}{dw}$ is larger in absolute value with capital mobility than without.

[36]The only possible exception is if initially we have a corner solution at $w = 1$. Even in this case the result that $G^{'}(w)$ falls holds, which means that a reduction of the minimum wage my occur. Note also that we never have a corner solution if $U_U(w)$ reaches its maximum before 1.

ously retained, and it may even be increased after the opening. This suggests that openness tends to act more as a political equalizer, rather than give excessive power to the capital owners. In the following I consider a version of the model, which demonstrates this even more clearly.

3.7.2 The small economy case

The results of the benchmark model considered so far have been derived under the assumption of perfect capital mobility. This had the implication that the wage set in Europe prevailed automatically in both countries. It may be argued that such a one- to-one impact of the European policy on the American wages is exaggerated. That is why I consider now the case of a fixed foreign wage, i.e. I treat Europe as a small economy. As before I assume that originally the equilibrium policy has been determined when the firms were not mobile. I assume also that the original equilibrium policy is a binding minimum wage, which is above the foreign wage, i.e. after the opening, if the wage is not adjusted, Europe would be a capital exporter. This time I perform only a local analysis, i.e. I look at how the slope of the political support function changes at the original equilibrium. To make the problem of policy determination in Europe after the opening interesting we have to consider now an imperfect capital mobility. Specifically, we shall assume that if firm i decides to relocate in the foreign country, then it can use effectively there only θ_i part of its capital. I assume further that the distribution of the firm-specific iceberg costs θ_i, whereby the firms are ordered in increasing order of their $\theta' s$, can be approximated by a continuous function $\theta(K), \quad K \in [0; \bar{K}]$ with $\theta \in (0; 1)$ and $\theta' > 0$. The number of firms K which operate in Europe at any wage can be found then from the arbitrage condition

$$\Pi(w) = \Pi(w^*)\theta(K) \tag{3.7.2}$$

Where $\Pi(w) \equiv \max\limits^{L} Y(L, 1) - wL$ is the return to a unit of capital at wage w and w^* is the foreign wage. The left-hand side in (3.7.2) is the profit of the K^{th} firm if it stays, and the right-hand side is its profit, if it relocates. Clearly at policy w all firms up to the K^{th} one , as obtained from (3.7.2) find it profitable to stay because they have higher relocation costs (lower θ and thus lower profits abroad) while all firms after the K^{th} (their number is $\bar{K} - K$) find it profitable to relocate. The aggregate utility of the capital owners at any wage is found then as

$$U_K(w) = \Pi(w)K + \Pi(w^*) \int\limits_K^{\bar{K}} \theta(K)\, dK \tag{3.7.3}$$

where K is obtained from (3.7.2). The first term in (3.7.3) represents the aggregate profits of those firms which stay in Europe, and the second term is the profits of those which relocate. Denoting the indefinite integral of $\theta(K)$ as $\Theta(K)$

we can write (3.7.3) also as

$$U_K(w) = \Pi(w)K + \Pi(w^*)\Theta(\bar{K}) - \Pi(w^*)\Theta(K) \tag{3.7.4}$$

Totally differentiating this expression and solving for $\frac{dU_K}{dw}$ we obtain

$$U_K^{'}(w) = \Pi^{'}(w)K + [\Pi(w) - \Pi(w^*)\theta(K)]\,\frac{dK}{dw} \tag{3.7.5}$$

Since $\Pi^{'}(w)$ equals minus the optimal plant-level employment at wage w (by the envelope theorem) and K is the number of firms operating in Europe at wage w it is clear that the first term in (3.7.5) equals minus the aggregate employment in the secondary sector in Europe at any given wage. The second term in (3.7.5) is zero by the arbitrage condition (3.7.2). With capital mobility we have therefore, $U_K^{'} = -L_s$, which is higher (lower in absolute value) at any wage than the respective value when there is no capital mobility. This is quite intuitive: a small wage increase reduces the aggregate firms profits by less if some firms can escape the increase by relocating. Now using (3.5.14) and (3.7.5) we find that the slope of the political support function is given by the same expression with and without capital mobility, namely:

$$G^{'}(w) = \gamma_U(w - w_{int})\frac{dL_s}{dw} + (\gamma_K - \gamma_U)L_s \tag{3.7.6}$$

As before, it can be shown that the terms $\frac{dL_s}{dw}$ and L_s in (3.7.6) are both smaller with capital mobility than without. Since L_s is always positive, and $\frac{dL_s}{dw}$ always negative, the increase in capital mobility makes the first term in (3.7.6) larger in absolute value and the second term smaller in absolute value. Since at the original equilibrium the two terms are of opposite sign and add up to zero, then after the opening the whole expression would obtain a sign opposite to that of the second term $(\gamma_K - \gamma_U)L_s$. We can conclude that the policy is going to be adjusted against the interests of the stronger lobby, i.e. if the union is the stronger lobby ($\gamma_K < \gamma_U$), then openness will bring about a wage reduction, and if the capital owners are the stronger lobby ($\gamma_K > \gamma_U$), then openness will give rise to a wage increase. This highlights the politically equalizing role of capital mobility. What is the intuition for this puzzling, at first glance, result? It is that in setting the policy, the government pursues both efficiency and distributional targets. This can be seen in expression (3.7.6) were the first term can be interpreted as reflecting the pure efficiency target (note that by Eq. (3.5.15) $(w - w_{int})\frac{dL_s}{dw}$ is the marginal effect of the policy on aggregate efficiency as measured by Ω), and the second term can be interpreted as reflecting a particular distribution target (note that the larger the difference in the political power of the two groups, the larger this term is in equilibrium, i.e. the more the government redistributes in favor of the interests of the stronger lobby). When the economy opens, the trade-off between the distribution and efficiency targets changes so that it becomes less attractive for the government to deviate from the socially optimal policy in order to accommodate the interests of the stronger lobby.

3.8 Conclusion to Chapter 3

I presented a model of endogenous labor market regulation, which shows how small differences in the relative power of the politically active groups may lead to large differences in labor market policies across countries. It also shows that through capital mobility the labor market policies in other countries can have profound implications for the policy in an open economy. The presented model allows for institutional variety even when relocation of production activities is costless. Thus it does not support the argument that globalization necessarily will lead to large scale deregulation of the labor markets. Rather it supports the view that openness diminishes the political power of national lobbies and leads to more "neutral" policies. Although these results are suggestive, one should refrain from drawing general conclusions. It should be noted that as it is common in political economy models the results are sensitive to the specification of the political process. With the presented analysis I hope to stimulate further work on the political economy of labor market institutions from an international perspective.

3.9 Appendix to Chapter 3

Proof of Lemma 1: Consider a strategy $\hat{R}_i$ that would lead to policy $\hat{w}$ such that $U_i(\hat{w}) < \hat{R}_i$. I show that $\hat{R}_i$ is weakly dominated by any other strategy $\tilde{R}_i$ such that $U_i(\hat{w}) < \tilde{R}_i < \hat{R}_i$. Suppose first that $\tilde{R}_i$ leads to the same policy $\hat{w}$ as $\hat{R}_i$. In this case the net welfare from playing $\tilde{R}_i$ is the same as that from playing $\hat{R}_i$: it is equal to $U_i(\hat{w})$. Suppose on the other hand that $\tilde{R}_i$ leads to a different policy $\tilde{w}$. Clearly in this case the lobby's contribution at $\tilde{w}$ must be positive, implying that the net utility from playing $\tilde{R}_i$ is $\min\,[U_i(\tilde{w}, \tilde{R}_i)] = \tilde{R}_i$ which is larger than that from playing $\hat{R}_i$. Since a lobby can only gain by such a small reduction in its reservation utility it will reduce it until $R_i^{eq} \le U_i(w^{eq})$.

Proof of Lemma 2: (this proof is analogous to the proof of Eq. (11) in Grossman-Helpman, 1994): For the government to choose w^{eq} at the second stage of the game w^{eq} must satisfy $\Omega(w^{eq}) + (\gamma_K - 1)\lambda_K(w^{eq}, R_K^{eq}) + (\gamma_U - 1)\lambda_U(w^{eq}, R_U^{eq}) \ge \Omega(w) + (\gamma_K - 1)\lambda_K(w, R_K^{eq}) + (\gamma_U - 1)\lambda_U(w, R_U^{eq})$ for all $w \in W$, where R_K^{eq} and R_U^{eq} are the equilibrium reservation utilities of the two lobbies. By definition (27) we have $\lambda_i \ge U_i(w) - R_i^{eq}$ for all $w \in W, \quad i = K, U$ and by Lemma 1 we have $\lambda_i(w^{eq}, R_i^{eq}) = U_i(w^{eq}) - R_i, \quad i = K, U$. Therefore $\gamma_K U_K(w^{eq}) + \gamma_U U_U(w^{eq}) \ge \gamma_K U_K(w) + \gamma_U U_U(w)$ for all $w \in W$.

Proof of the Proposition: Define $F(\gamma) \equiv \gamma U_K(w_s^0) + U_U(w_s^0)$ and $G(\gamma) \equiv \max\limits_{w \in W} \gamma U_K(w) + U_{UC}(w)$ where

$$U_{UC}(w) \equiv \begin{cases} \lim\limits_{w \to w_s^0, w > w_s^0} U_U(w) & ,\text{for } w = w_s^0 \\ U_U(w) & ,\text{for } w \neq w_s^0 \end{cases}$$

Clearly $U_{UC}(w)$ is continuous and differentiable for all $w \in W$. The envelope function $G(\gamma)$ is also continuous and differentiable with $G^{'}(\gamma) = U_K(w)$ evaluated at $\underset{w \in W}{\text{argmax}}\ \gamma U_K(w) + U_{UC}(w)$. Note also that $G(\gamma) = \sup_{w \in \left(w_s^0;1\right]} \gamma U_K(w) + U_U(w)$.

Lemma 2 implies that the equilibrium policy is laissez faire if $F\left(\frac{\gamma_K}{\gamma_U}\right) - G\left(\frac{\gamma_K}{\gamma_U}\right) > 0$ and that it is a binding minimum wage if $F\left(\frac{\gamma_K}{\gamma_U}\right) - G\left(\frac{\gamma_K}{\gamma_U}\right) < 0$. Now I show that the function $H(\gamma) \equiv F(\gamma) - G(\gamma)$ equals zero at one point only (γ^*) and that it is negative to the left and positive to the right of that point. First, $H(.)$ is continuous (because F and G are continuous) and nondecreasing (because $G^{'}(\gamma) \leq F^{'}(\gamma) = U_K(w_s^0)$). Moreover $H(0) = U_U(w_s^0) - \max_{w \in W} U_{UC}(w) < 0$ and $H(\gamma) > 0$ when γ sufficiently large. To see that such a sufficiently large γ exists consider $\hat{\gamma} = \max_{w \in W} \frac{U_{UC}^{'}(w)}{-U_K^{'}(w)}$ (remember that $U_K(w) < 0$ for all $w \in W$). We have $\hat{\gamma} \geq \frac{U_{UC}^{'}(w)}{-U_K^{'}(w)}$ for all $w \in W$ which is equivalent to $\hat{\gamma} U_K^{'}(w) + U_{UC}^{'}(w) \leq 0$ for all $w \in W$. But this means that the policy that maximizes $\hat{\gamma} U_K^{'}(w) + U_{UC}^{'}(w)$ is w_s^0. Hence $G(\hat{\gamma}) = \hat{\gamma} U_K(w_s^0) - U_{UC}(w_s^0)$ and $H(\hat{\gamma}) = \hat{\gamma} U_U(w_s^0) - U_{UC}(w_s^0) > 0$. It remains to show that $H(\gamma)$ is strictly increasing when it equals zero. Suppose that it is not, i.e. suppose $H(\tilde{\gamma}) = 0$ and $H^{'}(\tilde{\gamma}) = 0$. $H^{'}(\tilde{\gamma}) = 0$ implies $G^{'}(\tilde{\gamma}) = F^{'}(\tilde{\gamma}) = U_K(w_s^0)$. Hence $G(\tilde{\gamma}) = \tilde{\gamma} U_K(w_s^0) + U_{UC}(w_s^0)$. But then $H(\tilde{\gamma}) = U_U(w_s^0) - U_{UC}(w_s^0) > 0$, which is a contradiction. This completes the proof.

4 A focus on between-group wage inequality: the skilled-unskilled wage differential

4.1 Hypotheses to explain the rising skill premium in the US

While the previous Chapter 3 was concerned with within-group inequality, the following Chapters 4 through 6 focus on the wage gap between skilled and unskilled workers. As documented in Chapter 2 the countries with highest overall inequality increases experienced also sharp increases in between-group inequality, and in particular, in the returns to education. The subsequent analysis focuses mainly on explaining these trends in the US. This focus is motivated by the fact that, first, the US are one of the countries with highest inequality increases (s. Chapter 2), second, because most of the existing literature focuses on the US, and third, because convenient data on the US economy are freely available (s. Chapter 5).

In this Chapter I introduce the supply and demand framework as a method for quantifying the contribution of changes in the supply and demand of skilled relative to unskilled labor and critically evaluate its assumptions, some of which will be needed for the analysis in the subsequent Chapters. I further make an overview of the methods used to discriminate between trade and technical change as competing explanations for the increase in the relative demand for skilled labor. This literature review sets the stage for the analysis in the next Chapter.

The main hypotheses that have been put forward in the literature as explanations for the rising returns to skill since the mid 1970's can be summarized as follows:[37]

1. **Shift in domestic product demand** away from manufacturing to services.

   The hypothesis that this is the driving force for the rise in inequality is referred to as the **"deindustrialization hypothesis"**. It is related, though not identical, to the "globalization hypothesis" (s.below), because many services are non-traded.[38].

[37] See also Bound and Johnson (1992:371), Gottschalk and Smeeding (1997:646-651) and Katz and Autor (1999:1469)

[38] On the "deindustrialization hypothesis" s. Gottschalk and Smeeding (1997:647) and Murphy and Welch (1993)

2. shift in product demand generally toward relatively more skill-intensive goods due to **trade** with low-wage countries.

   The hypothesis that trade is the major factor contributing to the rise in inequality is referred to as the **"globalization hypothesis"**. It is related to the deindustrialization hypothesis in that trade together with a domestic demand shift may have contributed to the shrinkage of the manufacturing sector. The two hypotheses, however, are not identical, because a trade-induced shift toward more skill intensive goods may occur within the manufacturing sector itself or even within specific manufacturing industries.[39]

3. **Skill-Biased-Technological-Change (SBTC)** (primarily associated with the spread of computers) increasing the relative productivity of more skilled workers. For brevity, I shall refer to the view that technical change was the primary reason for the increasing demand for skills as the **"SBTC hypothesis"**. A number of more recent contributions distinguish **organizational change** from technical change and show that it also tends to be skill-biased.[40]

4. Changes in **the relative supply** of skills as reflected by the size of the cohorts entering the labor market.[41]

5. **Institutional factors** such as the erosion of the real minimum wage and the decline in unionization.[42].

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[39] The literature to the globalisation hypothesis is huge. Some references are Freeman (1995), Wood (1994) Lawrence and Slaughter (1993), Howard Sachs and Shatz (1994) , Leamer (1996) Gottshalk and Smeeding, 1997, p. 648. Further work that studies the contribution of trade to rising wage inequality includes Wood (1995, 1998), Borjas and Ramey (1995), Feenstra and Hanson (1996, 1999), Haskel and Slaughter (2000), Hanson and Feenstra (2001), Baldwin and Cain (1997), Slaughter (1998).

[40] This literature is also too abundant to be cited exhaustively. Some contributions supporting the SBTC hypothesis include Mincer (1991), Bound and Johnson (1992), Krueger (1993), Berman, Bound and Griliches (1994), Autor, Katz and Krueger (1998), Machin and Van Reenen (1998), Berman, Bound and Machin (1998), Autor, Levy and Murnane (2003). The literature on organizational change includes Bresnahan, Brynjolfsson and Hitt (2002), Caroli and Van Reenen (2001), and Greenan (2003).

[41] Katz and Murphy (1992), Murphy and Welch (1992), Borjas, Freeman and Katz (1997).

[42] Papers that emphasize the importance of institutional factors include DiNardo, Fortin, Lemieux (1996), Card (1996), Freeman (1996), Fortin and Lemieux (1997), Lee (1999), Card and DiNardo (2002)

4.2 A framework for analyzing shifts in the relative supply and demand for skilled labor

In order to analyze which of the above factors have contributed most to the rising skill premium we need a formal framework. In the empirical literature two broad approaches have emerged. As Katz and Autor (1999) write:

"The first attempts to explain actual relative wage and employment changes using a supply-demand framework and (implicitly) attributes anomalies to institutional factors or unmeasured supply and demand shifts (e.g., Katz and Murphy, 1992; Murphy and Welch, 1992; Autor et al., 1998). The second takes institutional changes as exogenous and first attempts to adjust observed wages for the impact of institutional changes and then analyzes the remaining "adjusted" wage changes using a supply and demand framework (e.g., Bound and Johnson, 1992; DiNardo et al., 1996).", s. Katz and Autor (1999:1466)

As it is clear from this citation the two approaches differ mainly in their treatment of labor market institutions, i.e. the factor 5 listed above. As far as I understand, the first approach does not account explicitly for the role of labor market institutions. It allows to discriminate between the factors 1-4, but it is not suitable for evaluating the relative importance of labor market institutions. This is also the approach followed in this thesis. In what follows I present the pure supply-demand framework.

4.2.1 A model of labor demand

[43]

Typically, the demand for a given type of labor is modelled as a result of cost minimization treating wages as given subject to a concave production function (constant returns to scale are implicitly assumed implying that cost-minimization is equivalent to profit maximization). The different types of labor are defined according to some observable characteristics (education, experience, etc.). The concavity of the production function and the assumed optimization problem imply that the observed employment satisfies

$$N_t = D(W_t, Z_t) \tag{4.2.1}$$

where N_t is a $K \times 1$ vector of labor inputs (Katz and Autor, 1999, refer to it as "relative supply", but actually it is just the observed relative employment), W_t is a $K \times 1$ vector of relative wages, Z_t is an $M \times 1$ vector of demand shifters in

[43] The following section is based on Katz and Autor (1999), but the structure of the exposition and some interpretations are different.

year t. The Z_t vector includes variables that capture changes in product demand, technology and the prices of other inputs. Moreover, the optimization problem implies that D_W, the $K \times K$ matrix of cross-price derivatives, is negative semi-definite.

Note that this framework for modelling labor demand can be applied at different levels of aggregation. On one hand, one could assume an economy-wide, an industry-wide or a plant-wide production function. On the other hand, one can choose the number of different types of labor to distinguish between. The main assumptions underlying the supply and demand framework are:

Assumption 1. A concave production function.

An aggregate production function implying diminishing marginal productivity need not exist. For example, the production function may feature increasing returns to scale. Another well-known example is the diversification cone in a small open 2-by-2 constant returns to scale economy leading to constant marginal productivity of labor. This is a relevant problem when modelling factor demand at an economy- or industry-level, and it is less of a problem when modelling plant-level demand. One argument in defense of the aggregate production function is that the US are not a "small" economy and that there are many possible extensions to the Heckscher-Ohlin model such different number of factors and goods (including non-traded), differentiated products (Johnson and Stafford, 1999) etc., which would lead to substitutability between different inputs (and hence, to diminishing marginal productivity).

Assumption 2. Well-defined labor inputs.

A violation of this assumption may be due to bad aggregation or to imprecise measurement. Consider, first, the problem of aggregation. If we aggregate workers with different education degrees into two categories only, college and non-college workers, based on their years of education, it is inevitable that some specific labor inputs that are complements in reality will enter the aggregate production function as substitutes (e.g. construction engineers and construction workers). An alternative would be to split the workforce into finer categories, i.e. categories based not only on years of education, but also on subject, grades and so on. The problem with allowing for too many types of labor, however, is that it usually increases disproportionately the parameters of the model and makes the estimation difficult. A further important limitation is the availability of such fine-grid data.

A second problem relates to measurement. To illustrate how imprecise measurement may affect lead to the violation of the above assumption, suppose that an aggregate production function with two well-defined inputs, skilled and unskilled labor, denoted s and u, respectively, exists. Instead of the characteristic skill, however, let us assume that what we observe is another characteristic of labor, namely, the attainment of a college versus non-college degree, which is only imperfectly correlated with skill. Let us denote the two realizations of this latter characteristic by c and h, respectively. Assuming that wages equal marginal productivity we can express average wages of college and high school graduates as:

$$w_c = MP_s Prob(s|c) + MP_u Prob(u|c) \tag{4.2.2}$$

$$w_h = MP_s Prob(s|h) + MP_u Prob(u|h) \tag{4.2.3}$$

where MP_s and MP_u denote the marginal productivity of skilled and unskilled labor, respectively, and $Prob(i|j), i = s, h; j = c, h;$ denote the probabilities of a randomly chosen worker to be skilled or unskilled conditional on his education degree. The problem now is that changes in the observed wages w_c and w_h are driven not only by changes in productivity, but also by composition effects (i.e. changes in the joint distribution of skills and education). There exists a large number of studies that try to uncover and estimate composition effects of this type in many applications. Typically this involves analyzing additional worker's characteristics (e.g. test scores) and the use of panel data methods to control for individual unobserved characteristics. However, the supply and demand framework presented here focuses by definition on labor inputs characterized by observables.

Assumption 3. The optimization problem.

Even if an aggregate production function with well-defined and observable labor inputs exists, the assumption of cost-minimization constrained only by technology parameters may be violated. In practice firms face a different kinds of adjustment costs. Sometimes institutional constraints prevent them from making profitable employment cuts. Note that when institutional constraints affect only wages but not employment, i.e. firms are free to substitute different types of labor at the prevailing wages, the above supply and demand framework is still applicable.

4.2.2 A test of stable labor demand

A next step after having defined a framework for studying the increase in the skill-unskilled wage differential is to test whether there has really occurred a shift in the demand for skilled labor as proposed by the four hypotheses. Such a test can be constructed as follows. Differentiating Eq. (4.2.1) yields:

$$dN_t = D_W dW_t + D_Z dZ_t \tag{4.2.4}$$

Pre-multiplying both sides by dW_t', rearranging the terms in the above equation and using the negative semidefiniteness of D_W imply:

$$dW_t' D_W dW_t = dW_t'(dN_t - D_Z dZ_t) \leq 0 \tag{4.2.5}$$

In the so constructed test the null is the steady labor demand hypothesis, i.e. $dZ_t = 0$. This implies that under the null we must have $dW_t' dN_t \leq 0$, i.e. relative wages and relative employments must negatively covary. There is a number of studies that reject the stable labor demand hypothesis based on more or less formal tests based on Eq. 4.2.5. These include:

- **At the economy level**: Katz and Murphy (1992). They perform a formal test based on Eq.4.2.5 and reject the stable demand hypothesis assuming an economy-wide production function and 64 types of labor input (defined by sex, education and experience)
- **At the industry level**: Berman, Bound and Griliches (1994) and Autor, Katz and Krueger (1998). They focus on two types of labor input: production versus non-production workers, whereby the categories "production" and "non-production" are considered proxies for the categories "unskilled" and "skilled" workers, respectively. They do not perform a formal test, but simply show that relative employment of production to non-production workers, and respectively of skilled to unskilled workers, has risen together with relative wages in many industries concluding that the demand for skills at the industry level has not been stable.
- Finally, a number of studies document a positive relationship among relative wages and relative employment **at the plant level** and conclude that demand shifts occurred also at this level. These studies include Bernard and Jensen (1998), Doms et al. (1997) and Dunne et al.(1996).

4.2.3 Quantifying the relative demand shift

Once we have rejected the stable demand hypothesis, a next second step is to try to obtain quantitative estimates of the relative demand shift. This will enable us to understand the relative importance of demand shifts as opposed to supply shifts. It will, furthermore, set the stage for studying empirically the relative importance of the four different factors that were hypothesized to drive the demand shift. In other words, before assessing the contribution of trade and technology, for example, to the shift of relative demand one may first want to know what the magnitude of this shift is.

Obtaining a quantitative estimate of the relative demand shift requires additional assumptions. The most important of these is:

Assumption 4. Functional form

Two widely used functional forms are the CES-production function (usually applied at the economy level) and the Translog cost function (usually applied at the industry level). In what follows I consider an application of the CES-production function with two types of labor inputs, college equivalents (c) and high-school equivalents (h), to model the relative demand for skilled labor at the economy level. The aggregate production function is specified as[44]:

$$Q_t = [\alpha_t(a_t N_{ct})^\rho + (1-\alpha_t)(b_t N_{ht})^\rho]^{1/\rho} \tag{4.2.6}$$

where N_{ct} and N_{ht} are the quantities employed of college and high-school equivalents in period t, and α_t, a_t, b_t and ρ are parameters.
Under the assumption that college and high-school equivalents are paid their marginal products, we can use Eq. 4.2.6 to solve for the ratio of marginal products of the two labor types. This yields a relationship between relative wages in year t, w_{ct}/w_{ht}, and relative employment in year t, N_{ct}/N_{ht}, given by

$$\log(w_{ct}/w_{ht}) = \log(\alpha/[1-\alpha_t] + \rho\log(a_t/b_t) - (1/\sigma)\log(N_{ct}/N_{ht}) \tag{4.2.7}$$

This can be rewritten as

$$\log(w_{ct}/w_{ht}) = (1/\sigma)[D_t - \log(N_{ct}/N_{ht})] \tag{4.2.8}$$

where $D_t = \sigma\log(\frac{\alpha_t}{1-\alpha_t}) + (\sigma-1)\log(\frac{a_t}{b_t})$ is interpreted as a measure of relative demand. Rearranging the above equation gives us the following expression for the relative demand:

$$D_t = \log(w_{ct}N_{ct}/w_{ht}N_{ht}) + (\sigma-1)\log(w_{ct}/w_{ht}) \tag{4.2.9}$$

If we knew the value of σ we could plug in this value in equation 4.2.9 together with the observed values of relative wages and relative employment in order to obtain the unobservable time series of demand. The obtained time series of demand could then be used to analyze the factors driving the relative demand shifts. As an example of this suppose that the obtained time series implies an acceleration of the relative demand favoring college equivalents in the 1970's. One may

[44]This example is from Katz and Autor (1999).

conclude from this that an important factor increasing the relative demand for college equivalents started operating exactly at that time (Acemoglu, 2002). Another approach for analyzing the factors influencing relative demand is comparing the implied time series of demand for different countries (Acemoglu, 2003b).

The estimation of σ in the above example requires further assumptions. These are

Assumption 5. Exogenous labor supply

and

Assumption 6. Instantaneous wage adjustment and full employment

The last assumption means that wages adjust instantaneously to ensure equality of the qualities supplied and demanded. Note that this assumption is more restrictive because it does not allow for institutional constraints on wages, something which was allowed under the assumptions 1-3. Having made these additional assumptions we can replace the unobserved time series for demand with some known function of time (for example, a linear time trend), and estimate equation 4.2.8 directly by OLS. As Katz and Autor (1999) note we should be careful in interpreting such estimates because of the estimation problems arising in time series samples with non-independent observations and because of the strong assumption of exogenous relative supply shifts. Still, they report the results of such an estimation carried out by Katz and Murphy (1992) for the period 1963-1987. The results are reproduced below.

$$\log(w_{ct}/w_{ht}) = -0.709\log(N_{ct}/N_{ht}) + 0.033time + constant, R^2 = 0.52 \quad (4.2.10)$$

The implied estimate of sigma from this equation is 1.41 (1/0.709). Other studies that estimate an aggregate elasticity of substitution for the US include Johnson (1970), Freeman (1986), Hamermesh (1993), Krussell et al. (1997), Heckman et al. (1998), Card and Lemieux (2001). Most of these studies arrive at estimates of sigma between 1 and 3. The apparent consensus that σ is in the range from 1 to 3 has motivated a large literature that analyzes demand shifts using Eq. 4.2.9 and several exogenously specified values of σ (Autor, Katz and Krueger, 1998, Acemoglu 2003b). The advantage of this approach is that one avoids the problematic assumptions 5 and 6.

Remember now from figure 2.4.2 that in the 1971-1979 period the college-high-school wage differential was falling (its change was approximately -1.3 log points a year), while in the 1979-1987 period it was rising (its change was approximately 1.6 percent a year). On the other hand, the relative supply of college to high-school equivalents was rising 5.1 log points a year in the 1971-1979 period and

3.2 log points a year in the 1979-1987 period [45]. Simple calculations based on Eq. 4.2.9 and values of sigma in the 1-3 range suggest that the contribution of supply and demand factors to the observed wage trends during the two periods was quite different.

Consider, for example, a value of $\sigma = 2$. Using Eq. 4.2.9 and the above data for the 1971-1979 period we obtain an annual increase in D_t of 2.5 log points $(2 \times (-1.3) + 5.1)$. For the 1979-1987 period the implied increase in D_t is 6.4 log points. Note that this value of σ implies a substantial acceleration of the relative demand for skilled labor during the eighties (Acemoglu, 2003). We can take these figures now together with the value of sigma and look how close the actual change in the relative wage is relative to the one that would have been obtained, had only supply or demand factors been at work. For the 1971-1979 period the change in the relative supply implies a decrease in the relative wage of -2.55 log points $(5.1/\sigma)$, the change in relative demand implies an increase of 1.25 log points $(2.5/\sigma)$. The actual change of -1.3 points is closer to the value implied by the changes in supply alone suggesting that wage trends during that period were generally dominated by factors related to the relative supply of skilled and unskilled labor. A similar calculation for the 1979-1987 period suggests that factors related to the relative demand for skills must have been particularly important in the 1979-1987 period. This has motivated a large literature seeking to explain what factors could have contributed to the sharp increase in the relative demand for skills during the 1980's. The two most widely considered explanations are skill-biased technical change and trade with newly industrialized countries. In what follows I concentrate on these two alternative explanations. To begin with, I review the literature that seeks to discriminate between them.

4.3 Technical change and international trade as competing explanations for the rising relative demand for skilled labor. Methods for estimating their impact

"The two most widely cited explanations for the rise in inequality are skill-biased technical change and trade with low-wage countries. Of these two, technical change due to the use of computers is often believed to be the dominant explanation."[46]

Within the broad debate on the causes for the recent increase in wage inequality in the US and other developed countries there is a more narrow, but perhaps

[45] These figures are from Katz and Autor, 1999, s. their Table 13.

[46] Feenstra and Hanson (1999:907)

even more intensive debate on whether it is trade or technology that accounts for most of the shift in labor demand. The contributions to this more narrow debate differ widely both in their focus and in the data and methods used. Some papers focus on estimating the contribution of a single factor, either trade or technology; others conside both of them and try to evaluate their relative importance. According to the data used we can classify the work in the field into the following three categories:

1. Work based on individual-level data.
   Individual data are used to compute most measures of inequality so one would expect that such data are also appropriate for explaining changes in these measures. Indeed, the early papers that documented a dramatic increase in skill differentials in the 1980s in the US used these data to seek also for explanations (Bound and Johnson, 1992). The problem with using individual data sets for evaluating the role of trade and technical change, however, is that most data sets lack precise information on the technology faced by the individual at his workplace. One approach to overcoming this problem is using the information on the industry affiliation of the employer and complementing the individual data set with trade and technology measures from industry-level data sources (Fitzenberger, 1998, Bartel and Sicherman, 1999). A comprehensive survey of the work on the role of trade and technical change using individual data is beyond the scope of this study. I would only mention the study by Alan Krueger (1993) "How Computers Changed the Wage Structure: Evidence from Micro Data" because it has certainly had a great influence already at the early stage of the debate. In this study Krueger extends the classical log-wage regression by including as an additional regressor a dummy variable indicating on-the-job computer use. The estimated coefficient on this dummy implies a 10-15 percent wage premium for workers who use a computer on the job and it is statistically significant. Krueger interprets this estimated wage premium as a reward for computer skills. This interpretation implies that one-third to one-half of the conventionally measured return to education is accounted for by the spread of computers in the 1980s. The interpretation of the coefficient on the computer dummy as a return to computer skills has been contested by DiNardo and Pischke (1997). It is also clear that the evidence presented by Krueger (1993) does not allow any conclusion with respect to the role of trade.

2. Work based on plant-level data.
   In contrast to individual data, plant-level data sets generally include information on most variables needed to analyze the driving factors of rising high-skilled labor demand: wages and employment, usage of other inputs,

different technology measures, product information, and even direct exports. Thus, such level data have the advantage that they do not require from the researcher to extract further information on given variables of his interest from other sources with a higher level of aggregation. Their main disadvantage is their restricted access for confidentiality reasons. Since I could not access such data I will restrict myself to only listing a few contributions. Among others, these include Bernard and Jensen (1995) and (1997), Doms, Dunne and Troske (1997), Jensen and Troske (1999), Dunne, Foster, Haltiwanger and Troske (2002).

3. Work based on industry-level data.
   In principle, industry-level data is nothing else but aggregated plant-level data. So, for example, the NBER Manufacturing Productivity Database is compiled on the base of the Annual Survey of Manufacturers. Despite the loss of information because of aggregation, these data are widely used to study the impact of trade and technical change on the demand for skills. They have the advantage of being freely downloadable from Internet[47]. Since this is the type of data used later in my original analysis I review the methods applied to them in some more detail.

4.3.1 The cost share regression

The basic idea of this method is to exploit variation across industries in the rate of skill upgrading on one hand, and in various measures of technological change and trade on the other. The theoretical foundations of this method are discussed in detail in Section 5.1. In this section I will only make a brief review of the results of previous applications. Thereby, I will restrict my attention to the following five studies, which can be considered as the starting point for my original analysis in Chapter 5: Berman, Bound and Griliches (1994),[48] Feenstra and Hanson (1996, 1999), Autor, Katz and Krueger (1998), Machin and Van Reenen (1998), hereafter BBG-93, BBG-94, FH-96, FH-99, AKK , MVR, respectively. They have all studied the relative importance of trade and technical change as competing explanations for the rise in the relative demand for skilled labor in the US using (among other methods) the cost-share regression. They all estimate more or less similar specifications of the following type:

$$\Delta SHARE_i = \beta_0 + \beta_1 \Delta Log(K_i/Y_i) + \beta_2 \Delta Log(Y)_i + \beta_3 TECH_i + \beta_4 TRADE_i + \epsilon_i \quad (4.3.1)$$

where $\Delta SHARE_i$ is the change in the share of skilled (non-production) labor in

[47] The NBER Manufacturing productivity Database is available at $http://www.nber.org/nberces/nbprod96.htm$

[48] On several occasions later I shall refer to the working paper version Berman Bound and Griliches (1993) because it is more detailed.

the wage bill of industry i, K_i and Y_i are the industry's real capital stock and output (shipments), $TECH_i$ is some indicator of technological change based on computer spending or computer use (Berman, Bound and Griliches, 1994, Autor, Katz and Krueger, 1998, Feenstra and Hanson, 1998), research and development expenditures (Berman, Bound and Griliches, 1994, Machin and VanReenan, 1998, AKK, 1998) or total factor productivity (AKK, 1998), and $TRADE_i$ is some proxy for the exposure of the industry to the influence of globalization. For example, Feenstra and Hanson (1996, 1998) and Autor, Katz and Krueger (1998) include a measure of outsourcing defined as the share of imported intermediate goods in total non-energy material costs; FH-96, AKK, MVR consider, on the other hand, the ratios of total imports and/or exports to output.

A finding common to all five studies is that the technology measures perform better in explaining the changes in the cost-share of skilled labor than the trade measures do, i.e. they explain a larger fraction of the mean change in the dependent variable and their coefficients are in most cases statistically significant. In other words, previous applications of this method support the view that technical change has been more important than trade in increasing the demand for skilled labor.

4.3.2 The price regression

The main idea of this method is to seek a link between the changes in goods prices and the changes in factor prices. The most famous example of the presence of such a link is provided by the Stolper-Samuelson theorem. [49] A comprehensive survey of the empirical literature seeking to explore the link between product price changes and the rising US inequality is Slaughter (1998). This method has been first introduced by Leamer (1996). Basically, it consists in obtaining a regression by differentiating a system of zero-profit conditions. [50] Later extensions of this method use different terminology to refer to it, e.g. Feenstra and Hanson (1999) use the term "price" regression, while Slaughter (1998) uses the term "mandated wage" regression. The strengths and limitations of the "mandated wage" regression are well discussed by Slaughter (1998). One of his main findings is that this method accounts well for the link between product and factor prices but that much controversy remains as to what extent the observed product price changes can be attributed to trade and technical change. The results emerging

[49] Interesting generalizations of the concept of factor price dependence are offered by Neary and Schweinberger (1986) and Lloyd and Schweinberger (1997).

[50] This differentiation provides a linear approximation of the relationship between product prices and wages keeping the cost shares of each factor fixed. One problem with applying such an approximation is that a skill biased technical change occurring simultaneously with a change in the price levels would generally induce non-negligible shifts in the cost shares at any factor prices.

from the applications of the "mandated wage" regression are mixed. Leamer (1996) and Baldwin and Cain (1997) find no clear pattern that changes in wage inequality were mandated by product price changes during the 1980s. Feenstra and Hanson (1999), on the other hand, decompose the observed price changes into components attributable to outsourcing and to technical change, and find that both of these components mandated rises in wage inequality during the 1980s, with technical change accounting for a larger fraction of it.

4.3.3 Factor content calculation

The main idea behind the factor content approach is that under certain conditions trade in goods represents trade in the primary factors of production embodied in those goods. A simple example for a set of sufficient conditions for this to hold is that of the factor-price-equalization theorem (s. Vanek 1968). Should we allow for differences in technologies and in the pattern of specialization, it is even more tricky to consider trade in goods as a substitute for trade in factors. A comprehensive treatment of the problems with applying the factor content of trade theory to measuring the contribution of trade to rising wage inequality is beyond the scope of the present study. Some recent references on this issue are Deardorff (2000), Leamer (2000), Deardorff(2000), Panagariya (2000), Davis and Weinstein (2001). Different applications of the factor content approach have lead to controversial results with respect to the contribution of trade to wage inequality (see Gottschalk and Smeeding 1997:648, who provide a review of the results based on the factor content approach). Wood (1994), for example, attributes as much as 50 percent of the decrease in demand for less skilled-workers to international trade, while Krugman (2000) argues that the observed trade volumes are too small to imply large distributional effects of trade.

4.3.4 Decomposition of the change in the aggregate cost-share of skilled labor.

This method is widely applied by the proponents of the SBTC hypothesis (Berman, Bound and Griliches, 1994, Machin and Van Reenen, 1998, Berman, Bound and Machin, 1998). It involves a decomposition of the change in the aggregate cost-share of skilled labor in total labor cost into two components, a component attributable to within-industry shifts and a component attributable to between-industry shifts. If we denote the cost share of skilled labor in industry i by S_i and the share of industry i in aggregate manufacturing employment (of both skilled and unskilled workers) by W_i, the share of skilled labor in the aggregate manufacturing wage bill at each point of time can be expressed as a weighted average of the shares of skilled labor in each industry:

$$S_{agg} = \sum_i W_i S_i \quad (4.3.2)$$

This implies that the change in the aggregate wage-bill share of skilled labor between two periods can be expressed as:

$$\Delta S_{agg} = \sum_i \Delta W_i \overline{S_i} + \sum_i \Delta S_i \overline{W_i} \quad (4.3.3)$$

where a bar denotes the mean of a variable over the start and end-of-period value and Δ denotes its change over the period. The first term in this decomposition is the "between-component" and the second term is the "within-component". Note that they need not be of equal sign. The typical finding is that at several levels of aggregation (2-, 3- and 4- digit industries) both components are positive, but the within-component is clearly larger in magnitude than the between-component. From a Heckscher-Ohlin perspective trade should increase the between-component (by making high-skill intensive sectors expand and low-skill intensive sectors shrink), while SBTC is expected to increase the within- component. The above studies, thus, interpret the results from the decomposition as evidence in favor of SBTC hypothesis.

I find this approach, however, inappropriate to apply when we want to discriminate between *trade in intermediate goods* and technical change as competing explanations for the increase in demand for skills. The reason is that in this case both of them will induce an increase in the skill intensity within an industry, i.e. an increase in the within-component in the above decomposition. For example, if there are activities with different skill intensities with each industry and if the least skill-intensive of these activities are relocated abroad, the documented "within"-industry shifts, should be attributed to outsourcing and not to skill-biased technical change. An important piece of evidence on this point is contained in the study of Bernard and Jensen (1997). Applying a similar decomposition on plant-level data they find that most of the skill upgrading is accounted for by employment shifts between plants, and not by increases in the skill intensity within plants. Moreover, they find that exporting plants account for a large fraction of the between-plant component.

4.3.5 Cross-country correlations in industrial skill upgrading

This is not an independent method. It provides only supplementary evidence based on the Heckscher-Ohlin model. According to this model factor-biased technical change has a limited potential to influence factor prices, if the country in which it takes place is relatively small as compared to its trading partner(s). However, if factor-biased technical change takes place also in the partner countries, then its effect can be substantial (Berman, Bound and Machin (1998), s.

also Berman and Machin (2000a and 200b). These studies find predominantly positive cross-country pairwise correlations in the rate of skill upgrading by industry. This suggests that the increases in the demand for skilled labor tends to be concentrated in the same industries across countries. The argument in favor of the SBTC hypothesis based on this evidence is as follows (Bound and Machin, 1998). They start with the hypothesis that skill-biased technical change is the main factor contributing to inequality in US. This suggests that we should expect skill upgrading in other countries to take place in approximately the same industries as it does in the US. The reason is that technology is expected to spread quickly among the leading industrialized countries.

Note however that the hypothesized correlation between skill-upgrading by industry across countries is a necessary, but not a sufficient condition for the SBTC hypothesis to hold. This correlation may arise for reasons other than a skill-biased technical change as well (for example, one would expect that throughout the advanced countries it is the same industries that outsource). Therefore, if the hypothesized correlations were not found in the data, this would be evidence against the SBTC hypothesis. The fact that they are found, however, cannot be interpreted as confirmation of the SBTC hypothesis.

In concluding this Section we should note that several of the presented methods, s. in particular 4.3.1, and 4.3.4, seem to rely too heavily on the Heckscher-Ohlin framework and insufficiently account for the increased role of trade in intermediate goods and outsourcing. This is a serious drawback, since many authors have emphasized the importance of intermediate goods (s. for example Slaughter, 1998, Section 2, and Aghion, Caroli and Garcia-Penalosa, 1999, Section 3.2.3.). The importance of outsourcing as a special form of trade in intermediate goods is emphasized in the work of Feenstra (s. for example Feenstra, 1998, and Feenstra and Hanson 1996, 2001). Improving on this drawback is the main purpose of the following Chapter. More precisely, I modify the first of the methods discussed above, the cost-share regression, and use it to re-examine the role of international trade and technical change for the rising relative demand for skilled labor, taking particular account of the phenomenon of outsourcing.

5 A reexamination of the role of trade and technical change

Motivated by the literature reviewed in the previous Chapter, I undertake now a re-examination of the role of trade and technical change as factors increasing the relative demand for skilled labor. Since most of the literature has considered these two as competing explanations I adopt the same perspective here, and start the analysis by treating trade and technical changes as two independent phenomena attributable to different exogenous developments. The reduction of transportation costs and all kinds of costs of trading with and producing in newly industrialized countries can be regarded as the exogenous development leading to increased trade. The advances in computer science and information technology can be regarded as the exogenous development stimulating technological change in almost all other industries. I will come back to the issue of interdependence between trade and technical change at the end of this chapter.

5.1 The theoretical foundations of the cost-share regression

Berman, Bound and Griliches (1994) were perhaps the first to introduce the cost-share regression in the debate on the role of trade and technical change. In deriving their specification BBG-93 relied upon the traditional Translog Cost function approach. This approach focuses on estimating the parameters of a fairly general cost-function using a number of restrictions derived from economic theory. The Translog approach was developed long before the role of trade and technical change in increasing the demand for skilled labor became an object of intense research interest. In order to evaluate the application in BBG (and also in later studies, which followed BBG closely in terms of specification) I start by briefly presenting the traditional Translog approach.[51]

5.1.1 The Translog Cost Function framework

Assume that input demand in an industry is given by the solution of

$$\begin{aligned} &\min_{L} \qquad && w.L \\ &s.t. \qquad && f(L, Z) = y \end{aligned} \tag{5.1.1}$$

where Z is a vector of fixed inputs, y is output, $f(.)$ is the production function, w is a vector of factor prices treated parametrically and L is the vector of the

[51]The following exposition is based on Greene (2000), Chapter 15.6., and Feenstra Hanson (2001)

optimally chosen inputs. This problem gives rise to the optimal value function $C(w, L, y)$. The question is now to chose an appropriate functional form for it. To simplify notation let me describe all the arguments of $C(.)$ by a single vector $x = (w, L, y)$ with dimension M. A convenient functional form for $\log C(x)$ is

$$\log C(x) = \alpha_0 + \sum_{i=1}^{M} \alpha_i \log x_i + \frac{1}{2} \sum_{i=1}^{M} \sum_{j=1}^{M} \beta_{ij} \log x_i \log x_j \tag{5.1.2}$$

This can be considered as a second order Taylor approximation of an arbitrary $\log C(x)$, where the expansion point is $\log(x) = 0$ and the derivatives of $\log C(x)$ at that point are identified as coefficients. Note that this interpretation implies equality of the cross-partial derivatives:

$$\beta_{ij} = \beta_{ji} \tag{5.1.3}$$

Specifying a functional form for $\log C(x)$ rather than for $C(x)$ is convenient because it leads directly to equations for the share of $C(x)$ accruing to factor i. In order to see this let us assume that x_1 is the price of the factor of interest. Given the optimization problem (5.1.1) the envelope theorem implies that $\frac{\partial C(x)}{\partial x_1}$ will equal the optimal amount of that factor used in the industry. Now let us multiply this amount by the price x_1 and divide by $C(x)$ to get the desired share:

$$S_1 = \frac{\partial(x)}{\partial x_1} \cdot \frac{x_1}{C(x)} = \frac{\partial \log C(x)}{\partial \log x_1} \tag{5.1.4}$$

Thus share equations can be obtained by directly differentiating (5.1.2) with respect to the prices of the optimally chosen inputs. This gives rise to the system

$$\begin{aligned} S_1 &= \alpha_1 + \beta_{11} \log x_1 + \beta_{12} \log x_2 + \cdots + \beta_{1M} \log x_M \\ S_2 &= \alpha_2 + \beta_{21} \log x_1 + \beta_{22} \log x_2 + \cdots + \beta_{2M} \log x_M \\ &\vdots \\ S_W &= \alpha_W + \beta_{W1} \log x_1 + \beta_{W2} \log x_2 + \cdots + \beta_{WM} \log x_M \end{aligned} \tag{5.1.5}$$

where W denotes the number of optimally chosen inputs. If there are no fixed inputs and there are constant returns to scale then $W = M$, otherwise $W < M$. With W variable factors, Z fixed factors and output as arguments in the translog function there will be a total of $(W + Z + 2)W$ coefficients in the unconstrained system of costs share equations (W equations with W coefficients on variable factors, Z coefficients on fixed factors, output and a constant term in each). A number of restriction can be imposed to reduce the number of parameters.

First, the interpretation of the translog cost function as a second-order Taylor approximation implies the symmetry of the cross price derivatives (5.1.3).

Next, the structure of the optimization problem (5.1.1) implies that the cost function $C(.)$ should be homogeneous of degree one and concave in the prices of the optimally chosen inputs. In terms of $\log C()$ the homogeneity implies

$$\log C(\lambda w, z, y) = \log \lambda + \log C(w, z, y) \tag{5.1.6}$$

Using (5.1.2) and (5.1.3) it is easy to see that this implies the following restriction on the parameters

$$\begin{aligned} \sum_{i=1}^{W} \alpha_i &= 1 && \\ \sum_{i=1}^{W} \beta_{ij} &= 0 && , j = 1, \ldots, M \end{aligned} \tag{5.1.7}$$

i.e. across equations in (5.1.5) the constant terms must sum up to 1 and all of the slope coefficients including those on the fixed factors, if there are such must sum to zero.

Finally, an additional restriction can be obtained by assuming constant returns to scale in the production function $f(.)$. This assumption implies that the cost-share equations should be homogeneous of degree zero in output and in the fixed factors simultaneously. Thus, in the case of no fixed inputs the constant-returns-to-scale assumption is imposed in practice by dropping the log of output in all equations, in the case of some fixed inputs it is imposed by restricting the coefficient on log-output to equal minus the sum of the coefficients on the log of the fixed factors in each cost-share equation.

Usually the restrictions (5.1.3) and (5.1.7) are imposed when estimating the system of cost-share regression, while the concavity of the cost function is checked after the results are obtained[52]. Whether constant-returns-to-scale are imposed is more a matter of taste.[53]

[52]See for example Fizeenberger p.136, Feenstra Hanson (2001) p.22 footnote 163.

[53]For example Berman, Bound and Griliches (1993) impose constant-returns to scale, Fitzenberger (1998) does not and Machin and Van Reenen (1998) report both specifications

Imposing the restrictions (5.1.3), (5.1.7) and constant returns to scale reduces the number of parameters in (5.1.5) to

$$K = \frac{1}{2}(W-1)(W+2Z+2) \tag{5.1.8}$$

In principle, these parameters can be identified using data on a single industry provided we have long enough time series on the input prices, usage of fixed factors and output. Alternatively we can assume identical cost functions across industries which would allow identification based also on cross-sectional variation in the data. It should be also mentioned that after imposing the two restrictions (5.1.3) and (5.1.7) the system of cost-share equations cannot be estimated unless one of the equations is dropped. Appropriate SUR-estimation techniques have to be used in order to ensure invariance of the estimates with respect to which equation is dropped[54].

5.1.2 How can we adapt the Translog approach in order to address the issue?

In this section I discuss how the Translog approach described above can be adapted to asses the impact of trade and technical change on the relative demand for skilled labor. In doing so I critically evaluate the solutions to that problem proposed by the received literature, focusing in particular on the following influential contributions: BBG-93, FH-96, AKK, MVR and FH-99.

A central issue is how the contribution of trade and technology can be measured within the framework presented in the last section. A careful examination of the optimization problem 5.1.1 and the implied cost function 5.1.2 and share equations 5.1.5 reveals that both trade and technology have their place there.

Perhaps the most natural way to account for the role of trade in the Translog cost function framework just presented would be to include imported intermediate goods within the vector of optimally chosen inputs. This would imply estimating cost-share equations that include the corresponding price indeces as regressors. Unfortunately, such data are difficult to obtain. [55] Perhaps for that reason the approach suggested here is not followed in the literature. Instead, Berman, Bound and Griliches (1993) and (1994) do not account for trade at all

[54]See Fitzenberger (1998) p.135, Greene (2000) p.638 and p.642

[55]The only import prices I could find for the US are those at *http://cid.econ.ucdavis.edu/usixd/wp5515d.html*, s. Feenstra (1996). These contain import price indexes for the U.S. at the 3-digit 1972-basis SIC level over the period 1980-1992. However, these are price indeces for total imports and not for imports of intermediate goods.

in their cost-function framework. [56] Feenstra and Hanson (1996, 1998), Autor, Katz and Krueger (1998) extend the cost-share equation in an ad-hoc way by including a measure of outsourcing defined as the share of imported intermediate goods in total non-energy material costs. By using the expression "in an ad-hoc way" here I would like to emphasize the departure this represents from the Translog cost-function approach. There is no justification from economic theory why this measure of outsourcing should affect the dependent variable in the cost-share regression linearly. Other measures of trade that have also been included in an ad-hoc way in the cost-share regression are the shares of imports and/or exports in total output or sales, s. Autor, Katz and Krueger (1998), Machin and Van Reenen (1998).

Technological change is conceptually difficult to account for in a highly structural approach such as the one described in the previous Section. In fact, technology is implicit in the production function $f(.)$ and is parametrized in its dual - the cost function $c(.)$. Thus, the parameters of the cost function are the true technology measures in this framework. Allowing for a general form of technical change means allowing for instability of the parameters over time. This is not the approach followed in the literature. The specifications in all of the five studies considered are based implicitly on the assumption that all the parameters of the cost function (except the constant terms in the cost share equations, s. 5.1.5) are stable over time. Note that this by definition rules out many forms of technical change. As in the case with trade, technical change is accounted for by including observable variables that are supposed to indicate technical change. Typically, these include measures based on computer spending or computer use (Berman, Bound and Griliches, 1994, Autor, Katz and Krueger, 1998, Feenstra and Hanson, 1998), research and development (Berman, Bound and Griliches, 1994, Machin and VanReenan, 1998, AKK, 1998) and total factor productivity (AKK, 1998).

I next turn to the issue of how many factors to consider in the optimization problem (5.1.1) and which of them to treat as optimally chosen. First, let us note that all factors, those optimally chosen as well as those that are treated as fixed in the optimization problem, appear somehow in the share equations (5.1.5). The difference is that the optimally chosen factors are represented in the cost-share equations by their prices while the fixed-factors by their levels (when capital is treated as fixed factor and is measured by the capital stock its full utilization in production is implicitly assumed). This requires different type of data - for the fixed factors we need the amounts used, while for the optimally

[56] They address the role of trade extensively in the previous sections of their papers, which are based on two of the methods I described in Chapter 4 - The decomposition of the aggregate change in the wage bill share and the factor content approach.

chosen factors we need the user costs. Moreover, from the point of view of the empirical implementation treating a given factor as optimally chosen rather than fixed is costly, in the sense that it uses more of freedom (using Eq. (5.1.8 we find): $\frac{\partial K}{\partial Z} = W - 1 < \frac{\partial K}{\partial W} = W + Z + 1/2$. These are perhaps the reasons all of the five studies outlined above treat capital and output as fixed factors in the optimization problem 5.1.1. This implies that the log of real output and capital should appear as regressors in the cost-share equation (data on real output and capital can be easily obtained from the NBER Productivity Database (Bartelsman and Gray, 1996) at the 4-digit SIC level. In my opinion the treatment of capital and output as quasi-fixed factors, although convenient in terms of implementation, may be inappropriate given the special purpose of the whole exercise - namely to discriminate between trade (in particular outsourcing, which is done to a large extent by multinational firms) and technical change as factors contributing to increasing relative demand for skilled labor. I discuss this point in detail in the next Section, where special account is made of the activities of multinational enterprises.

As to the optimally chosen inputs the studies outlined above typically consider just two - skilled and unskilled labor. This implies that the system (5.1.5) reduces to a single equation which can be estimated by ordinary least squares, hence the name "cost-share regression". [57] In most of the specifications reported in the the cost-share of "skilled labor" is measured as the cost-share of non-production workers from the NBER Productivity Database (Bartelsman and Gray, 1996) or the United Nation Industrial Statistics Database, i.e. for the purposes of the cost-share regression "skill" is measured by the occupational categories "non-production/production" rather than the more widely accepted educational categories "college/non-college". It is clear that replacing the cost-share of college-educated workers with the cost-share of non-production workers leads to a measurement error. This replacement is made in practice for data availability reasons and is defended by arguing that in data sets which allow a comparison, the two measures of skill are highly correlated, i.e. the measurement error is small (s. Machin and Van Reenen p.1255, footnote 9). What is needed for consistent estimates in the cost-share regression however is not that this measurement error is small, but that it does not vary systematically across industries. To my knowledge this has not been shown. Cost-share regressions with the change in the "college wage-bill share" as a dependent variable have also been estimated in the studies considered (in particular Autor, Katz and Krueger, 1998, Machin, Van Reenen, 1998) but not in specifications including outsourcing

[57] As it is clear from the exposition in the previous Section in the case of only two optimally chosen inputs the resulting cost-share equations for skilled and unskilled labor are linearly dependent - the one can be obtained from the other using the restrictions. The literature typically estimates the equation for the share of skilled labor in first differences.

measures (when outsourcing is included as an explanatory variable the dependent variable is always the change in the non-production wage bill share). The only reported comparable results using either dependent variable alternatively is contained in Table 3 of Machin and Van Reenen (1998). It is suspicious that in three of five countries the coefficients on Research and Development intensity are very sensitive to the choice of the dependent variable (for U.K. and Japan they are twice as large when the "non-production wage-bill share" is used instead of the "high education employment share", for Sweden they are smaller by more than 30 percent. I should note that the problems with measuring "skill" outlined here are relevant also to my original application of the cost-share regression in this Chapter. Due to lack of data I have no alternative than using "proguction/non-production" labor as proxy for "skilled/unskilled" labor as this has been done in the previous literature.

We should note also one important departure from the traditional Translog approach common to the five studies considered - they typically drop the log of the relative wage although according to the exposition in the previous Section this term should enter the cost-share equation. BBG-93 motivated this with the likely endogeneity of wages and with the argument that the "quality adjusted" wages should not vary across industries and the later studies followed the same approach. [58]

To sum up, the Translog approach has not been followed very strictly in the five studies considered. Already BBG-93, undertook a significant departure from it by dropping the relative wages in the cost-share regression and by including technological change proxies in an ad-hoc way. Later applications went one step further in including measures of trade in an ad-hoc way. In fact, the use of the cost-share regression in FH-96, AKK, FH-99, is much in the spirit of an explorative analysis of the data without seeking any particular justification in economic theory. While all these studies refer to the work of BBG, in none of them is the cost-share regression explicitly founded in the cost-function framework.[59] In this chapter I go one step further and estimate specifications including only trade and technology measures on the right-hand side. The motivation for such a specification is explained in Section 5.4 and in the next subsection 5.1.3.

[58]Other researchers have dealt with this problem using instrumental variables for the wages which allowed them to follow the theoretical framework more closely, e.g. Fitzenberger (1998), Chapter 5. However, in his application of the Translog approach Fitzenberger (1998) does not focus on estimating the effect of trade versus that of technical change which is the central issue here

[59]S. in particular FH-96:240-241, FH-99: 927-929, AKK: 1199-1202. FH-99 for example include the change in output and capital intensity simply as "control variables" (s. FH-99:928, first paragraph above.)

5.1.3 On the role of outsourcing or is it appropriate to treat capital and output as quasi-fixed factors in the cost-share regression equation?

At the end of Chapter four I referred to the literature emphasizing trade in intermediate goods and, in particular, outsourcing as a potentially important relative demand shifter. The purpose of the following section is to clarify the concept of outsourcing and to discuss whether the specifications discussed in the last section allow us to account for this phenomenon.

The term "outsourcing" is used broadly both in the popular press and in academic writings. Its uses and various definitions are reviewed in Lübker (2005). One of the broadest, measurement-oriented definitions is given by Feenstra and Hanson (1996): "we have argued that outsourcing, by which we mean the import of intermediate inputs by domestic firms, has contributed to an increase in the relative demand for skilled labor in the United States", Feenstra and Hanson (1996), p.240. I will give a definition that comes close to that bellow. It should be noted however, that the term "outsourcing" is often used in a more narrow sense. Grossman and Helpman (2002), for example, use the following definition:

"To us, outsourcing means more than just the purchase of raw materials and standardized intermediate goods. It means finding a partner with which a firm can establish a bilateral relationship and having the partner undertake relationship-specific investments so that it becomes able to produce goods or services that fit the firm's particular needs. Often, but not always, the bilateral relationship is governed by a contract, but even in those cases the legal document does not ensure that the partners will conduct the promised activities with the same care that the firm would use itself if it were to perform the tasks."
For the purposes of the present thesis **outsourcing represents substitution of imported foreign-produced intermediate goods for domestic production**. This substitution can take three forms:

1. As emphasized in the definition of Grossman and Helpman (2002) foreign producers may be in a contractual relationship with the outsourcing company. The impetus for obtaining some intermediate goods from abroad rather than producing them at home is given by the sourcing company in response to exogenous factors such as reduction of transportation costs, reduction of legal and administrative restrictions, improvement of infrastructure in host countries, etc. Note that we would normally expect the intermediate goods to be produced in the home country initially. Thus, normally, "outsourcing" involves three elements: closing of a plant (or production line) in the home country; opening of an equiv-

alent plant (or production line) abroad; imports of the foreign-produced parts. These three elements are sufficient to conclude that there is "substitution of imported foreign-produced intermediate goods for domestic production". In some cases, however, we may not observe all the three elements and there might be still good reasons to believe that foreign production has been substituted for domestic production. Consider for example a firm that is growing. For each additional production unit it faces a choice of location. When for a given plant or production line the firm considers domestic versus foreign production, and finally opts for the latter, than we may take this as outsourcing although one of the above elements (closing of a domestic plant) would be missing. The important point is that, absent the competition form abroad, the new production line would have been opened in the home country.

2. Outsourcing can take the same form as above, except that the foreign producer may be a branch of the outsourcing company rather than a partner. The motives for engaging in outsourcing are the same: parts of the production process are more efficiently performed in the host country than in the home one.

What is common between the above two forms of outsourcing is that the initiative comes from a company originally producing in the home country. The relocation of production may require a substantial investment in the initial phase. Set-up costs play an important role in the firm's decision whether to outsource. When it comes to outsourcing of one of the above two forms we would expect also some transfer of knowledge to take place from the outsourcing company to its branch or its subcontractor. Furthermore, the intermediate good would be often so specific that it could not be used by any other firm than the outsourcing company in question. Thus, the above two forms result from non-market interaction (the foreign producer is to some extent dependent on the sourcing company). In the literature the term "outsourcing" is usually associated with one of these two forms. In addition, I will consider a third form of outsourcing.

3. The substitution of imported foreign-produced intermediate goods for domestic production can occur also due to international competition. For example, several domestic and foreign producers may compete on a well established market for some intermediate goods. Over time, market forces may drive out domestic producers to the benefit of foreign producers. Note that the exogenous factors leading to outsourcing of this form are very much the same as those leading to outsourcing of the first two forms: reduction of transportation costs, reduction of legal and administrative restrictions, improvement of infrastructure in host countries, etc.

The above definition is operationalized by two measures of outsourcing to be derived in more detail in Section 5.2 and 5.4. First, I consider all increases in the imports of intermediate goods to represent outsourcing (s. also Eq. 5.4.3). Second, I consider only that part of the increase in the imports of intermediate goods that occurs beyond the change proportional to the change in domestic output (s. also Eq. 5.4.7).

The above discussion suggests that big firms, which are able to control their foreign suppliers either directly through ownership, or indirectly by being a monopoly buyer of highly specialized inputs, account for a potentially important fraction of actual outsourcing. Coming back to the Translog cost function approach this suggests a new perspective on the firms optimization problem. Namely, the optimization problem 5.1.1 which is at the heart of all previous applications of the cost-share regression, including those in Feenstra and Hanson (1996),(1998) and (2001), appears inadequate because it treats output and capital as quasi-fixed factors. In my opinion, if a multinational firm faces some constraint, it is rather on its total sales and not on the value of shipments accruing to one particular country. This suggests to postulate global (as opposed to local or national) production functions. More precisely, the country-specific output and capital stock should be treated as choice variables in the firm's optimization problem regardless of how long the time horizon is. This is because in reality home production workers can be substituted for foreign production workers more quickly than for home non-production workers. To put the argument formally consider the following model.

A multinational firm produces a final good using two intermediate goods - M^1, produced in the developed world (the home country) and M^2, produced in newly industrialized countries (I shall use the superscripts 1 and 2 to denote the two regions (countries) throughout this section). In each country the intermediate goods are produced with unskilled (production) labor (L), skilled (non-production) labor (H) and capital (K) according to concave and linearly homogeneous production functions, $g^1(.)$ and $g^2(.)$. The intermediate goods are firm-specific - they are not produced or used by other firms and have no market prices. They are bundled together into a final good according to a linearly homogeneous and concave global production function f(.) - we may think of this bundling activity as representing the headquarter services (product design, marketing, etc.) I assume that this bundling activity uses also skilled (non-production) labor (H) and capital (C), each with a fixed input coefficient per unit of the final good[60]. Assuming that all of the skilled labor and high-tech capital used in the bundling activity is hired in the developed world we may write the firms unit-costs minimization

[60]this is a simplifying assumption. One could obtain the same results below with reasonable assumptions on the substitutability/complementarity between the inputs used in the bundling activity

problem as follows[61]:

$$\min_{a_L^1, a_L^2, a_K^1, a_K^2} \qquad C \equiv w^1 a_L^1 + r^1 a_K^1 + w^2 a_L^2 + r^2 a_K^2$$

subject to

$$\left| \begin{array}{l} f(a_{M^1}, \theta a_{M^2}, \overline{a_H}, \overline{a_K}) = 1 \\ a_{M^1} = g^1(a_L^1, a_H^1, a_K^1) \\ a_{M^2} = g^2(a_L^2, a_H^2, a_K^2) \end{array} \right.$$

where a denotes input coefficients whereby countries are indexed with the superscripts 1 and 2, and inputs are indexed with L, K, H, M^1, and M^2. $\overline{a_H}$ and $\overline{a_K}$ are the fixed per-unit input requirements in the bundling activity and the parameter $\theta \in (0;1)$ captures all kind of costs related to the use of good M^2 in the global production function $f()$. These include transport costs, costs of collecting information, administrative costs, insurance costs related to the risk of changes in the legal system or direct expropriation, costs due to lacking infrastructure in newly industrialized countries and so on.[62] Note that a fall in these costs corresponds to a rise in θ. Furthermore, it is interesting to note that a rise in θ could alternatively be interpreted as a factor-augmenting technical change. This illustrates that outsourcing and technical change are intrinsically related.

Since unskilled labor is used only in the production of the intermediate good, while skilled labor and capital are used in both the intermediate goods production and the bundling activity the total amounts of the primary factors of production used by the multinational in the developed country are $a_L^1 Y$, $(\overline{a_H} + a_H^1)Y$ and $(\overline{a_K} + a_K^1)Y$ respectively, where Y denotes the units produced of the final good.

In the presented framework globalization, or more precisely the catch-up process of newly industrialized countries, can be modelled as a fall in the broad range of costs captured by the parameter θ. Consider now the partial equilibrium effects (i.e. at constant factor prices) of an exogenous rise in θ on relative factor usage by the multinational in the developed country. Obviously the relative use of K, L and H in producing the intermediate good would be unchanged. The firm

[61] Once the costs per unit of the final good are determined in the optimization problem (5.1.9) the total amount of the final good supplied by the multinational is determined by profit maximization, whereby I will assume that the firm faces downward-sloping demand

[62] I do not consider analogous costs on M^1 for the following reasons. First, to the extent that θ captures transport costs it may be argued that the developed world consumes the largest part of the final output. Second, to the extent that θ captures investment to compensate lacking infrastructure, administrative barriers and systematic risks - these costs have fallen relatively in newly-industrialized countries.

would substitute M^2 for M^1 in the production of the final good. Thus per unit of the final good its demand for all primary factors L, K and H in the developed country would fall, and it would fall disproportionately for the unskilled labor (L) not used in the bundling activity.[63] It follows that the ratio of unskilled to skilled labor demanded by the firm in the developed country would rise.

In order to derive the effects of a rise in θ on absolute factor usage in the developed country we have to consider first how the output of the final good, Y, would change. The rise in θ implies a fall in the per unit costs of the final good (we still keep the prices of the primary factors fixed). Assuming a diminishing marginal revenue function this leads to an output expansion, the magnitude of which depends upon the demand elasticity. Note however, that Y, the output of the final good, is not the concept we observe in the data - what we observe is industry value added and industry value of shipments. Among the previous applications of the cost-share regression Machin and Van Reenen (1998) use value added, while BBG-93, FH-96, FH-99, AKK use value of shipments. The model presented here suggests that outsourcing would most likely cause both of these measures to fall as explained below.

With respect to the change in value added and total usage of primary factors in the developed country we can identify two opposing effects: on one hand, keeping y (output of the final good) fixed is substituted M^2 for M^1which tends to reduce value added in the developed country. On the other hand, outsourcing lowers the total costs per unit of the final good and allows the multinational to expand its sales of the final good. This tends to raise value added in the developed country. Whether value added would rise or fall as whole depends upon the size of these two effects. If the substitution effect dominates the expansion effect, which appears to be a reasonable assumption then outsourcing would be associated with falling value added in the developed country.[64]

With respect to the change in value of shipments we have basically the same

[63]We could obtain the same result without excluding unskilled labor from the bundling activity. It would be enough to assume that the bundling activity is less unskilled intensive than the production of the intermediate good.

[64]The price and output adjustment in response of a cost reduction depend upon the nature of the competition with other firms. Under some forms of interaction (implicit agreements) the cost-reduction may not pass through to the price of the final good at all in which case the expansion effect would be zero. Even if the cost-reduction passes through this may have only a limited effect on the quantity depending on the elasticity of demand. Moreover, regardless of how strong the expansion in the final good's output is, the substitution effect will dominate, if the bundling activity is relatively small (in terms of primary factor usage) as compared to the production of the intermediate good. All this makes it reasonable to assume that the substitution effect would dominate as a whole.

two effects. The reason is that value of shipments in the NBER Manufacturing Productivity Database is obtained as the sum of net selling values, f.o.b. plant, which "can include large amounts of duplication across industries or even across plants within the same industry", s. Bartelsman and Gray (1996: 21). Suppose now that the production of the intermediate good M^1 does not take place in the same plant as the bundling activity y, which again appears to be a reasonable assumption. Value of shipments before the incidence of outsourcing would include the sales of the final good plus the the sales of the plants producing M^1. This illustrates that we would observe again a substitution effect - the sales of M^1 decrease, and an expansion effect - the sales of y increase. As before, I am inclined to believe that as a whole outsourcing would tend to reduce value of shipments.

The above exposition makes it clear that under plausible assumptions the growth rate of both, value added and value of shipments, is inversely related to the extent of outsourcing. This suggests that the change in the log of output which has been traditionally included in the cost-share regression, may actually pick up part of the effect of outsourcing. In this respect it is interesting to remember that the change in the log of output is estimated to have a negative and statistically significant partial effect on the dependent variable in virtually all previous applications of the cost-share regression. In Machin and Van Reenen (1998) the latter is given by the coefficient on $\Delta Log(Y)$ which is estimated to be negative; in BBG-93, FH-96, AKK and FH-99 it is given by the difference between the coefficients on $\Delta Log(Y)$ and $\Delta Log(K/Y)$ which is also estimated to be negative.[65]
An unintended feature of this simple model is that outsourcing should be associated with falling capital intensity (i.e. use of capital per unit of output). We know from previous applications of the cost-share regression that rising capital intensity is associated with rising non-production wage-bill and employment shares. Note however that there are many possible extensions of the model that would imply rising capital intensity as a result of outsourcing.

All results so far have been derived keeping factor prices fixed. In fact, if one decides to close the model with goods and factor market equilibrium conditions, then the rise in θ would have an impact on factor prices and the final effect on M^1 and M^2 may not be exactly as in the partial equilibrium analysis above. In my opinion, however, it is exactly the optimization problem of the single firm that gives us the appropriate perspective on the cost-share regression. General equilibrium effects work through changes in the prices. But factor prices would change for all firms (industries) in a similar way. The cost-share regression, by

[65] An alternative explanation is that production employment is fully affected by output shocks while non-production labor remains to some extent insulated from them, s. BBG-93 and Section 5.4 here

contrast, relies upon variation across industries. Even though industries would generally respond differently to common trends in wages the generated variation across industries will probably be smaller than the variation caused by the differences in the extent of outsourcing across industries. Some industries are naturally prone to outsourcing (electrical machinery, transportation equipment), while others (fresh food) are not. When transport costs fall and newly industrialized countries build up their infrastructure, reduce administrative barriers and so on, then the firms in some industries would react much stronger than the firms in other industries. In terms of the presented model we may say that firms (or industries) differ in their ability to substitute between M^1 and M^2. As a response to a common rise in θ the industries with higher substitutability between M^1 and M^2 will outsource more. This will generate variation in the rate of skill upgrading matched by corresponding variation in the rate of output growth across industries.

Finally, I would like to mention two further problems that one should bear in mind when comparing the predictions of this model with actual data. The first problem relates to the classification of industries. Since the output of both good M^1 and good y are recorded and added to obtain total industry output it is of critical importance that the two goods are assigned to the same industry. In practice this may not be the case (actually we should think of M^1 as also being an aggregate of many goods). The next problem relates to the pricing of goods in intra firm transactions. In order to uncover the relationships predicted by the model in the data the prices applied to the intra-firm transactions should equal the cost of producing them and all of the firms profits should accrue to the headquarters activity. In practice the multinational firm may price the goods so as to shift profit across plants and minimize taxes. This would distort the observed values of trade and output in a way which is difficult to predict.

I conclude that the changes in the domestically produced output and the domestically used capital have no place in the cost-share regression when the purpose is to estimate the impact of outsourcing on relative demand for skilled (non-production) labor. The reason is that they are simultaneously determined, i.e. they are caused by the same exogenous factors. In attempting to estimate the impact of the latter factors we should better include only one variable that captures their incidence and not several at a time. The above argument is valid under fairly general circumstances. It rests upon the view that multinational enterprises produce globally and that they represent a sufficiently large part of the economy to affect the relative wage. By dropping the change in output and capital from the specifications we practically fully abandon the Translog approach presented in the beginning of this Chapter. A new foundation for the estimated specifications is presented in section 5.4.

5.2 Data description

5.2.1 The NBER Manufacturing Productivity Database

The NBER Manufacturing Productivity Database (Bartelsman and Gray, 1996) is the main database used in this Chapter. It provides data on value of shipments (with a corresponding deflator), real capital stock, employment[66] and wages of production and non-production workers, energy and non-energy material cost with corresponding deflators, investment (with a deflator) and other variables at the 4-digit SIC level (Standard Industrial Classification). This database is currently available at $http://www.nber.org/nberces/nbprod96.htm$ in a SIC 1972 version and a SIC 1987 version. I use the 1972 version since the data on computer investment and imports of intermediate goods (to be described below) are based on it. The NBER MPD is continuously updated and it is recommended that researchers always use the last update. I follow this recommendation here with only one exception - in the next Section I attempt to reproduce the results in BBG-93 using an older version - the one used by AKK. One noticeable update since AKK is that at some point of time the original 450 industries were reduced to 448 by merging SIC 3671, 3672, and 3672 into one industry with sic code 3671.

5.2.2 Computer investment and imports of intermediate goods

These data are not available on the web. I am very grateful to David Autor for providing me with them. In addition, he provided me with his version of the NBER MPD which I use in Section 5.3. Computer investment as a share of total investment, hereafter CI/I, was compiled originally by BBG-93 based on the responses of establishments to a question in the 1977, 1982 and 1987 Census of Manufactures. Imports of intermediate goods were constructed originally by Feenstra and Hanson (1996). AKK used their broad measure of outsourcing, hereafter $outsfh$ which is defined as the ratio of (estimated) imported intermediate goods to total non-energy material costs. I obtain the value of imported intermediate goods, hereafter *intimp*, by multiplying the latter measure with non-energy material costs from the NBER MPD. The broad Feenstra-Hanson outsourcing measure is available only for 1972, 1979, 1987 and 1990. Accordingly, I could obtain intermediate imports (*intimp*) only for those years. When merging industries (for example SIC 3671, 3672, and 3672) I obtain CI/I and $outsfh$ for the group as weighted averages using investment and non-energy material costs respectively as weights.

[66] In operating plants only, s. Bartelsman and Gray, 1996, p.20. It excludes employment in auxiliary or administrative units (central offices) which, according to BBG-93 account for 7 percent of total manufacturing employment all of which is classified as non-production, s. BBG-93, p.4.

5.2.3 Exports

The data on exports were used to construct export shares - the ratio of exports to value of shipments. The data on exports by 4-digit SIC industry come from Robert C. Feenstra, "NBER Trade Database, Disk 3: U.S. Exports, 1972-1994, with State Exports and Other U.S. Data" NBER Working Paper no. 5990, April 1997. They are also available at
$http://cid.econ.ucdavis.edu/usixd/usixd4sic.html$

All the Data described up to here have been widely used in previous work in the field. By contrast, the use of the following data in that particular context represents an innovation. That's why they are described in some more detail.

5.2.4 Factor content of imports from the United Nations General Industrial Statistics Database

The United Nations General Industrial Statistics Database (UNGISD) is perhaps the only dataset providing internationally comparable information on wages and employments by industry separately for production and non-production workers. These data "have been compiled bearing in mind the requirements of international comparability"[67]. I used these data to construct an estimate of the factor content of US imports. More precisely I take the skill intensity of production in a set of typical host countries to be representative of the skill intensity of the activities which are outsorced by each industry over a period. Previous applications of the cost-share regression have focussed on the size of imports neglecting differences across industries in the factor content of their imports. As I shall explain in detail in Section 5.4 it is of critical importance to put the skill intensity of the imported products (these are assumed to be formerly domestically produced) in relation to the skill intensity of domestic production (as measured by the share of non-production workers) in order to accurately account for the relationship between changes in intermediate imports and changes in the wage-bill share of non-production workers (the dependent variable).

A complete description of the UNGISD can be found at
$http://unstats.un.org/unsd/industry/vol1_intro.asp$. All variables in it are based upon the International Standard Industrial Classification, Revision 2. In merging these data with the other data I had to construct a concordance between the 1972 SIC and the ISIC Rev.2. This concordance is presented in Table 5.7.5 in

[67] $http://unstats.un.org/unsd/industry/vol1_intro.asp$

the appendix 5.7. Since the ISIC Rev.2 is a much broader classification containing a total of 28 manufacturing industries most of the US SIC 1972 codes could be unambiguously allocated to a single ISIC Rev.2 code. Only two SIC industries 3398 "Metal heat treating" and 3399 "Primary metal products, not elsewhere classified" could not be allocated to a single ISIC code and were deleted. These industries are not exceptional in any respect and their omission has no significant impact on the results.

I used the data on the wage bill share of non-production workers in three countries - Turkey, Republic of Korea and Portugal - to construct the estimate of the factor content of US imports, hereafter $fwshare$ (foreign wage-bill share accruing to non-production workers). All 4-digit SIC industries classified to a corresponding ISIC Rev.2 code have been assigned the same $fwshare$. The first three columns in Table 5.7.6 give the average wage-bill share of non-production workers for each of these countries during the seventies. The corresponding values for the eighties are presented in Table 5.7.7. In both Tables the forth columns give the wage bill share of non-production workers for the group as a whole (this is $fwshare$ used later to predict the impact of outsourcing in the US), the fifth columns give the corresponding values for the US for comparison.

Although obviously not all US imports of intermediate goods originate from these three countries, the group can be considered representative of those countries that typically host outsorced activities. I selected these countries according to two basic criteria: low-wage countries with reliable data on all 28 industries in both periods. On the first criterion I excluded countries with average annual manufacturing wage exceeding 10 thousand dollars in 1980 (these were mostly the countries that satisfied the second criterion: Japan, Finland, Austria, United Kingdom, Australia, Belgium, Canada, Sweden, Norway and Denmark). On the second criterion I excluded first the countries with obvious inconsistencies in the data such as negative wage figures for some industries and years, wages of non-production workers exceeding total wages for some industries and years, discrepancy between the sum of employment across the 28 industries (if data were available) and total manufacturing employment (ISIC code 3000) by more that 10 percent in some years and so on. Next, I excluded the countries without data on non-production wage-bill shares for all 28 industries. I did so to avoid distorting the ranking of industries which would occur if different samples of countries were used to obtain the factor content of imports for different industries. Finally, I had to exclude some more countries due to implausibly high non-production wage bill shares in some industries. For example, the average non-production wage bill-share in ISIC 351 "Industrial Chemicals" during the eighties was 44.2 percent in the US, while it was 80 percent in Venezuela, and 81 percent in Greece. Obviously one should not attempt to predict the impact of outsourcing in the US by imputing foreign factor content figures such as those of Greece and Venezuela.

Even if the data for these countries are correct, we would not expect the imports from these countries to the US to displace production and non-production wages in such proportions. As a formal criterion then I decided to exclude all countries with non-production wage bill shares in some industry higher than that of the industry with highest share in the US in the respective decade. After dropping Hungary (Comecom countries had relatively little exchange of intermediate goods with the rest of the world prior to the ninties) this left me with the three countries considered.

5.2.5 Imports of parts and components

These data have been recently compiled by Peter Schott (Schott, 2004, "Across-Product versus Within-Product Specialization in International Trade." Quarterly Journal of Economics 119(2).). The data and a detailed description are available at $http://www.som.yale.edu/faculty/pks4/sub_international.htm$. I use these data as an alternative to the Feenstra and Hanson (1996) measure introduced above. The two measures of intermediate manufacturing imports differ significantly from each other. One major difference is that the Feenstra and Hanson (1996) measure includes both finished goods and parts while the Schott (2004) measure includes only parts. Another important difference is that the Feenstra and Hanson measure is an estimate based on total imports by industry and input-output tables, while the Schott measure is obtained by directly summing up selected product-level imports. To obtain the imports of parts at the 4-digit 1987 SIC level, hereafter (*imppts*), Schott aggregated imports of products containing the word "part" (or its variants "parts", "prts", "pts" and "component") in their verbal description. For the period 1972-1988 aggregation proceeded from the 7-digit TSUSA, for the period 1989-2001 aggregation proceeded from the 10-digit Harmonized System. The switch from the TSUSA to the HS in 1989 introduces an important break in the Schott series. This is apparent also by looking at the continuity of positive records across time for each industry. So for example there are very few industries with a break in their positive records on *imppts* prior to the 1988 and after 1989. There are however a relatively large number of industries that stop having positive *imppts* exactly in 1988 and others that start having positive *imppts* exactly in 1989. The main reason for this appears to be the fact that products falling into a code containing the word "part" in its description under TSUSA fall into codes not containing that word under the HS and vice-versa. It should be also noted that single TSUSA and HS codes were added or deleted from the Classification in various years, which also introduces some noise in the data, although this appears to be a minor problem as compared to the structural break in 1989.

The above discussion should have made clear the main limitation of the Schott data as a measure of outsourcing - undoubtedly many parts have entered the US under product codes not containing the word "part". It should be also noted that the Schott data cover only 386 industries. Obviously for the remaining 73 industries under the 1987 SIC classification there was not any corresponding TSUSA or HS code containing the word "part". In addition, for some of the 386 industries there are missing values in some years reflecting the fact that in that particular year there was not any corresponding TSUSA or HS code containing the word "part". There are also many zeros in the data, s. Table 5.2.1. I take these to imply that a code existed, but there were no actual imports recorded for these products. On the other hand, subject to these limitations, the Schott data have the advantage of being the sum of actual imports, not an estimate based on the implicit assumption (s. Feenstra Hanson, 1996, p.241) that the share of imported inputs purchased by each industry from each other industry is proportional to the latter industry's ratio of imports to total consumption.

At this stage a third difference between *intimp* and *imppts* has to be emphasized: *intimp* for each industry is the sum (estimate) of imports of products that do not necessarily belong to the same industry - the criterion for summing the products is their (estimated) end use rather than their industry affiliation. By contrast *imppts* is a sum of imports of products that are directly assigned to the corresponding industry. Although we expect most of the products assigned to a given industry to be used by the same industry this need not be always the case. In fact for three industries *imppts* exceeds the total non-energy material costs in some years, a proof that some of the imported goods are used by other industries. Prior to 1988 there is only one such industry[68] - SIC 3565 "Industrial patterns". The ratio of *imppts* to non-energy material cost for that industry increased continuously from 2.97 in 1972 to 11.77 in 1987. Interestingly that ratio fell to 1.17 in 1989 after the switch toward the Harmonized System. Since obviously a large part of the SIC 3565 imports of parts represent outsourcing by other industries (that cannot be identified) I shall drop this industry in constructing my estimate of outsourcing based on the Schott data in Section 5.5. The industry is included when constructing the analogous estimate based on the Feenstra and Hanson data and in computing the descriptive statistics in this Section.

In merging the Schott data (based on the 1987 SIC version) with the other data (based on the 1972 SIC version) I imputed missing values of *imppts* to all industries without a one-to-one correspondence between the two classifications which further reduced the sample. To identify these industries I used the 1987-1972 SIC concordance attached to the NBER MPD at

[68]In later years the ratio exceeds one in two other industries: SIC 2599 "Furniture and fixtures, not else-where classified" and SIC 3944 "Games, toys, and children's vehicles; except dolls and bicycles"

$http : //www.nber.org/nberces/nbprod96.htm$.[69] Moreover, to avoid the problems with the break in the series on *impppts* from 1988 to 1989 in the empirical analysis in this Chapter I focuss on the periods 1972-1979 and 1979-1987. I do not attempt any further correction for the noise introduced by adding codes to and dropping codes from the TSUSA classification during these periods.

The periods 1972-1979 and 1979-1987 are peak-to-peak in the business cycle and have been considered also by other researchers (Berman, Bound and Griliches, 1993, 1994, consider exactly the same periods, Feenstra and Hanson, 1996, consider the 1972-1979 period, Bernard and Jensen, 1997, consider the 1979-1987 period). Conveniently, the Feenstra and Hanson data (*intimp*) are also available exactly at the years marking these two periods. Only one occasion in Section 5.3 in reproducing the results of AKK I consider the periods 1969-1979 and 1979-1989.

In what follows I present some descriptive statistics obtained after merging the data as explained above. Figure 5.2.1 illustrates the evolution of the aggregate imports of parts (*impppts*) and intermediate goods (*intimp*) in the sample over the periods considered. The values of both measures have been converted to 1987 basis using the implicit deflator for non-energy material cost from the NBER MPD. I constructed that as recommended by Bartelsman and Gray (1996: 21).[70]

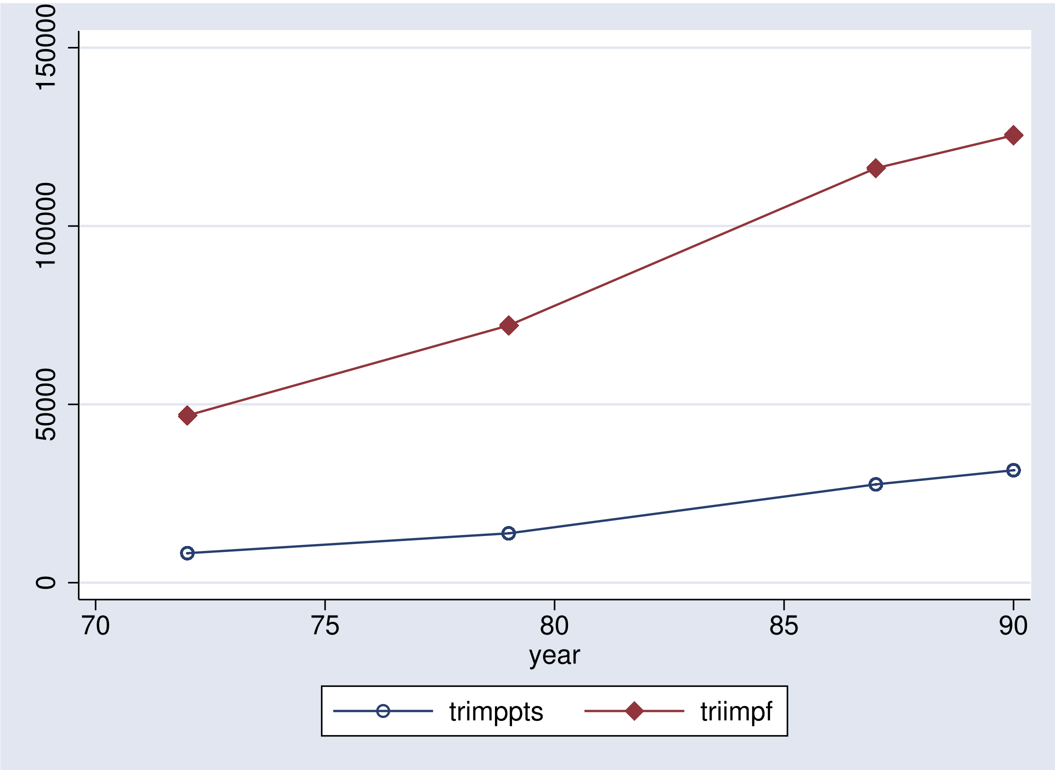
Both measures indicate a significant increase in the intermediate imports over the period - from 1972 to 1987 the imports of intermediate goods increased in real terms around 2.5 times while the imports of parts more than tripled. As to the levels of the two measures in the figure we see that the total imports of parts amount to 17 - 24 percent of the total imports of intermediate goods. According to Feenstra and Hanson (1996) parts and components should account for roughly 70 percent of their estimated intermediate imports with the remaining 30 percent accounted for by contract work (finished products).[71] The main reason for the discrepancy is that many parts and components, as already noted, have entered

[69]There are 99 industries that changed definition from SIC 1972 to SIC 1987. Two alternative solutions that would avoid loosing industries due to the difference in classifications would be to use the weights in the concordance to allocate computer investment across 1987 SIC industries or to allocate the imports of parts from Schott (2004) across 1972 SIC industries. However, the latter weights are based on the 1987 value of shipments for plants under the two different SIC versions. The proportions in which imports of parts and computer investment are distributed under the two versions need not be the same neither in 1987 nor in previous years.

[70]The NBER MPD contains explicit deflators for material cost *pimat* and for energy expenditure *pien*. Real non-energy material cost can be constructed as (matcost/pimat)-(energy/pien). The ratio of nominal (matcost-energy) to real non-energy inputs gives then the deflator for non-energy inputs, hereafter *pineinp*.

[71]S. Feenstra Hanson, 1996, p.242.

Figure 5.2.1: Total imports of intermediate goods

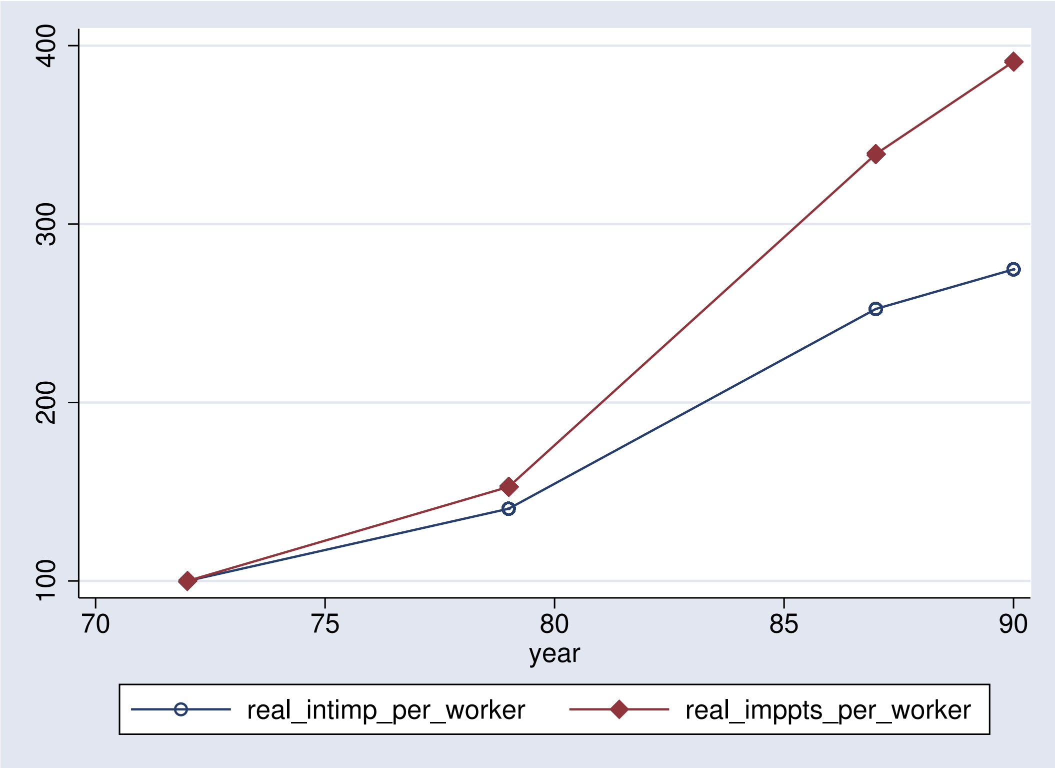


Notes: trimppts = Total Imports of Parts (Schott) in 1987 millions of dollars. triimpf = Total Imports of Intermediate Goods (Feenstra-Hanson) in 1987 millions of dollars. Sample: 448 manufacturing industries. The totals are obtained by summing up over all industries treating missing values of *imppts* as zeros. 1987 dollar values are obtained using the implicit deflator for non-energy material cost from The NBER Manufacturing Productivity Database. It equals 1 in 1987 for all industries.

the US under TSUSA and HS codes not containing the word "part" and accordingly are not captured in the Schott data. Another factor that also contributes to the discrepancy is that I imputed missing values to industries that changed definitions from SIC 1972 to Sic 1987, thus the totals of *imppts* are obtained by summing over fewer industries.

One aspect which is not so well apparent in figure 5.2.1 is the acceleration of both measures during the eighties. This acceleration in the growth rates of intermediate imports appears even more pronounced if one takes into account the evolution of employment: total manufacturing employment increased from 18.03 millions to 19.24 millions during the period 1972-1979 in order to fall back to 17.72 millions in 1987. To illustrate this I divided the totals presented in Figure 5.2.1 by the total manufacturing employment in each year and plotted the obtained ratios as indeces in Figure 5.2.2.

Figure 5.2.2: Imports of intermediate imports per worker



Notes: real-imppts-per-worker = index of *trimppts*/(total manufacturing employment)
real-intimp-per-worker = index of *triimpf*/(total manufacturing employment)
triimpf and *trimppts* are defined in the Notes to figure 5.2.1
Sample: 448 manufacturing industries.

Finally, Table 5.2.1 reports correlations between the imports of parts and components (Schott) as a share of non-energy material purchases and the imports of intermediate goods (Feenstra-Hanson) as a share of non-energy material purchases. After everything said above it should not be surprising that these correlations are generally small.

Interestingly, however, they are much smaller for the levels than for the changes. This is reassuring given my intention to use the change in the imports of intermediate goods from the start to the end of the period in order to construct an estimate of the share of domestic production (with implications for wages and employment) that is relocated abroad during the period. I shall use both measures in parallel in the empirical analysis. Although they are defined differently they are both very closely related to outsourcing, and each has its advantages as a measure of outsourcing. Interestingly, I obtain very similar results when using either measure. In light of the low correlation between them I interpret this as a strong robustness check on my results.

Table 5.2.1: Correlations between the Feenstra-Hanson and the Schott measures of intermediate imports in real terms.

	1972 – 1979		1979 – 1987	
	(1)	(2)	(3)	(4)
levels	0.12	0.17	0.07	0.01
changes	0.31	0.36	0.20	0.27
obs.	281	106	284	113

Notes: The Feenstra-Hanson and Schott measures in real terms are *intimp/neinp* and *imppts/neinp* respectively. *Levels* are taken at the end of the period. *neinp* = expenditure on non-energy materials from the NBER Manufacturing Productivity Database, it is constructed as *matcost* – *energy*, s. variable definitions in Bartelsman and Gray (1996); *intimp* and *imppts* have been defined in the text. Sample: manufacturing industries with data on *imppts* and one-to-one correspondence between their 1972 and 1987 SIC codes. Columns (2) and (4) exclude industries with "zero" value of *imppts* in both the start and the end year of the period. SIC 3565 has been excluded in all columns. All correlations are weighted by the average industry share of the total manufacturing wage bill at the start and the end of the period.

5.3 Notes on the measurement of technology and some robustness checks on the results from the literature

Technology is notoriously difficult to measure. Gottschalk and Smeeding (1997) p.649 put it as follows: "... technological change is simply a label of our ignorance. Because changes in technology are difficult to observe directly, its importance is often inferred by ruling out other factors." Card and DiNardo (2002) make a similar point in the second section entitled "technology or tautology". In fact, what means technology? In the theoretical literature the term "technology" is often used as a synonym of "production function(s)". This is an abstract concept which is not directly observed in the data.[72] In principle one could attempt to estimate changes in the production functions, but this is more difficult than estimating stable production functions. As already discussed, this is not the approach followed by researchers applying the cost-share regression. Perhaps attempting to avoid the above critique they infer technical change from observed variables which are assumed to be good indicators of it. By "indicator" I mean here something which accompanies technical change, but in contrast to it is itself observable. While this approach avoids the above critique it depends critically

[72]As a joke consider designing a business survey which asks the managers what production function their plant uses. The possible answers might be: a)Cobb-Douglass with parameter values...,b)CES with parameter values:... c)Other, specify.

upon the existence of reliable indicators. Let me use a metaphor to illustrate the point: air coming out of the water can be taken as an "indicator" of the presence of divers, although it might be also fishes that cause them. The quality of our indicator depends upon wether we can rule out that it reflects other phenomena. In the metaphoric example above, if we can rule out the presence of fishes, than the air coming out of the water may be considered a good indicator of divers. In the context of the cost-share regression we have to rule out the possibility that our "technology measures" indicate something else.

As already noted the indicators of technological change in the previous studies (s. 5.1.2) include: computer spending or computer use, research and development, and total factor productivity. Among these "RandD" and computers have received most attention.[73] Let us first consider research and development intensity. This variable may be correlated with industry characteristics that are not included in the cost-share regression but are relevant for the change in the demand for skills such as firm size and concentration, degree of competition, etc (to my knowledge this argument has not been put forward in the literature before).[74] Because data on "RandD" are not available at the four-digit industry level (the data I use in this chapter) I do not investigate further the reliablily of "RandD" as an indicator of technical change. I focus instead on the other popular proxy, namely computer use or spending. As we have seen in (4.3.1) computer investment as a share of total investment hereafter CI/I performs very well as a predictor of industry skill upgrading. In virtually all applications of the cost-share regression where it is included it attracts a statistically significant and economically sizeable coefficient. BBG-93, who were the first to use this measure comment on their results as follows:

"While these results are striking, their interpretation is not clear cut. The relationship between computer investment and the non-production share could be mechanical rather than causal. Suppose that it is non-production workers who typically use computers. A rise in the non-production workers' share in total employment might then increase the share of computers in total investments in the same way that it would increase the share of desks in total investments. One check on this possibility is to regress the change in the log of production and non-production employment on the log of capital intensity, the log of output and the share of computers in total investments as of 1987. The coefficient on the

[73]The problem with TFP is that it stays in a definitional relationship with the other variables as noted by BBG-93 and FH-99.

[74]A further reason for not considering RandD as a very good indicator of technical change is that not all RandD expenditures lead to innovations that are implemented, i.e. we measure an "input" while we would prefer to measure an "output" (quote). Finally, not all technical change comes as a result of formal "RandD" - another important channel is learning-by-doing.

computer variable is -0.20 (0.18) in the non-production worker equation and - 0.45 (0.17) in the production worker equation. These estimates imply that a one percent increase in the share of computers in total investments lowers production employment by 0.45 percent while lowering non-production employment by 0.2 percent. Thus, computers would seem to be substitutes (not complements) for both production and non-production labor, but with the larger effect on production labor.", s. Berman, Bound and Griliches (1993), p.27-28.

I tried to check these results using the data I received from David Autor (these cover the same 450 4-digit industries as those considered by BBG-93). Needless to say, I could not reproduce the results of BBG-93 exactly. The difference appears to be due not to the computer investment variable[75] but to the other variables. BBG-93 obtained these directly from the raw Annual Survey of Manufactures, while AKK obtained them from The NBER Productivity Database (Bartelsman and Gray, 1996). I report results using the 1987 computer investment and the 1982 computer investment separately. I start with the results using the computer investment share as of 1982 because these results are closer to those reported by BBG-93. They are presented in Table 5.3.1.

Columns 1 and 2 of Table 5.3.1 repeat the BBG-93 regressions. The results are very similar to those in BBG-93[76] and one may be tempted to interpret them in the same way: computers are substitutes to both production and non-production workers. In columns 3 and 4 I omit just one industry - SIC 3573 "Electronic computing equipment". This has dramatic effect on the coefficient estimates. Computers now appear to be complements to both production and non-production workers. The coefficient on CI/I in the non-production equation is now six times larger than that in the production worker equation although both are insignificant (the corresponding p-values are 0.205 and 0.856 respectively).

In column 5 and column 6 I control for two other inputs that have been omitted by BBG-93 - total material cost and imported intermediate inputs.

[75]In fact, AKK obtained that variable from BBG, so I should be working with the same data on CI/I. I could indeed reproduce Table 13 of BBG-93, which contains means and correlations of CI/I in the years 77,82 and 87, exactly

[76]the coefficients on CI/I here have to be divided by 100 before comparing them with those in BBG-93, because they use in the regressions the variable $100 \times CI/I$

Table 5.3.1: Uncovering the complementarity between computer equipment and non-production workers. Results using computer investment from 1982

	$\Delta LogNPE$	$\Delta LogPE$	$\Delta logNPE$	$\Delta LogPE$	$\Delta logNPE$	$\Delta LogPE$
	(1)	(2)	(3)	(4)	(5)	(6)
CI/I	-13.663	-20.795	5.716	0.915	5.732*	-0.515
	(12.533)	(14.832)	(4.506)	(5.044)	(3.324)	(4.203)
$\Delta Log(K)$	0.400***	0.142	0.246***	-0.031	0.302***	-0.017
	(0.113)	(0.119)	(0.073)	(0.078)	(0.062)	(0.062)
$\Delta Log(Y)$	0.425**	0.519***	0.673***	0.797***	0.367***	0.378***
	(0.136)	(0.152)	(0.040)	(0.032)	(0.094)	(0.088)
$\Delta Log(dmat) \times (1 - D)$					0.381***	0.483***
					(0.093)	(0.087)
$\Delta Log(imat) \times (1 - D)$					0.006	0.008
					(0.024)	(0.021)
$\Delta Log(dmat) \times D$					0.267***	0.446***
					(0.102)	(0.092)
$\Delta Log(imat) \times D$					−0.073	−0.089**
					(0.047)	(0.038)
$Constant$	−1.298***	−2.568***	−1.721***	−3.041***	−1.518***	−2.567***
	(0.341)	(0.364)	(0.221)	(0.188)	(0.249)	(0.210)
R^2	0.587	0.550	0.761	0.797	0.801	0.841
n	450	450	449	449	403	403

Notes: In columns (1), (3) and (5) Dependent Variable is 100x(annual change in the log of nonproduction employment), in columns (2), (4) and (6) Dependent Variable is 100x(annual change in the log of production employment). Heteroscedasticity-robust standard errors are reported in parenthesis in all columns. All regressions are weighted by the average industry share of the total manufacturing wage bill in the two years used in constructing the dependent variable. Δ indicates 100 times the annual change in the variable. The variables are defined as follows:
CI/I=Ratio of computer investment to total investment in 1982.
K=Real capital stock. In the notation of Bartelsman and Gray (1996) this is the variable *cap*.
Y=Real value of shipments. In the notation of Bartelsman and Gray (1996) this is $vship/piship$.
$dmat$= Real Domestic materials. This equals the total real material costs (obtained as $matcost/pimat$ from Bartelsman and Gray, 1996) minus real imported materials (obtained as $intimp/pineinp$, s. Section 5.2 and footnote 70 in it).
$fimat$= Real Imported materials. This equals $intimp/pineinp$.
D= dummy variable that equals one if the the industry's four digit SIC code starts with 35 (Machinery Except Electrical) 36 (Electrical Machinery), 37 (Transportation Equipment) or 38 (Measuring Instruments, Photographic, Medical and Optical Goods, Clocks and Watches) and zero otherwise.
Sources: The whole dataset underlying this Table is as in Autor, Katz and Krueger (1998), Table VIII. I am grateful to David Autor for providing me with it. The data on computer investment and outsourcing come originally from Berman, Bound and Griliches (1994) and Feenstra and Hanson (1996) respectively, s. the notes to table VIII in Autor, Katz and Krueger (1998). Sample: in columns (1) and (2) the sample consists of all 4-digit SIC 1972 manufacturing industries as in Autor, Katz and Krueger (1998). In columns (3) and (4) SIC 3573 has been excluded. In columns (5) and (6) also the industries with zero *intimp* in either 1979 or 1987 have been excluded (logs undefined).

I include also interaction terms of these two variables with a dummy indicating transportation equipment, machinery and instruments and photographic goods (industries with SIC codes starting with 35, 36, 37 and 38 - a total of 109 industries in the sample of 403 industries in columns 5 and 6) because the production process is much more disaggregated in these industries and I expect parts and components to play a somewhat different role there. The number of observations is smaller in columns 5 and 6 because industries with zero imports of intermediate imports in either 1979 or 1987 are deleted by taking logs. Comparing the results to those in columns 3 and 4 we see that the coefficient on CI/I in the non-production equation is almost the same in magnitude but is now statistically significant, the coefficient in the production worker equation is negative. These findings are in sharp contrast with those of Berman, Bound and Griliches (1993). Interestingly the results indicate also a pronounced difference in the relationship between labor demand on one hand and the use of domestic and imported materials on the other. The change in employment of both production and non-production workers is positively related to the change in domestic materials while it is negatively related to the change in imported materials. Imported materials appear to be particularly strong substitutes for both types of labor in the transportation, machinery and instruments industries.

Analogous regressions using CI/I as of 1987 are reported in Table 5.3.2. The results here are even stronger. The coefficient on CI/I in the non-production equation is close to zero already in the first regression with an associated p-value of 0.995 (s. column 1) After dropping SIC 3573 this coefficient becomes positive and significant (s. column 3). The magnitude of the coefficients and all other results are very similar to those in the previous Table 5.3.1.

Based on the results from Tables 5.3.1 and 5.3.2 I conclude that BBG-93 were not right to reject the hypothesis that the relationship between computer investment and the non-production share is mechanical. In this respect it appears useful to recall also the results of DiNardo and Pischke (1997). Using quite different data they find that calculators, telephones, pens or pencils, or the fact that one works while sitting down is associated with similar wage differentials as using a computer at the workplace. They contest the view that using a computer implies higher productivity and suggest that computers, like the other office tools, are simply more likely to be used by workers who posses higher (unobservable) skills. Although stemming from individual data this evidence may have implications for the interpretation of the computer investment variable at the industry level as well. If the corresponding data at the industry level were available, than one may replace CI/I with the share of desks in total investment in the cost-share regression to see wether this would change the results.

Besides the problem of a potentially mechanical correlation between CI/I and

Table 5.3.2: Uncovering the complementarity between computer equipment and non-production workers. Results using computer investment from 1987

	$\Delta LogNPE$	$\Delta LogPE$	$\Delta logNPE$	$\Delta LogPE$	$\Delta logNPE$	$\Delta LogPE$
	(1)	(2)	(3)	(4)	(5)	(6)
CI/I	-0.027	-7.457	5.157**	-1.654	5.280**	-1.705
	(4.265)	(5.011)	(2.469)	(3.182)	(2.209)	(2.627)
$\Delta Log(K)$	0.346***	0.136	0.217***	-0.009	0.276***	-0.004
	(0.111)	(0.119)	(0.076)	(0.083)	(0.063)	(0.066)
$\Delta Log(Y)$	0.393**	0.473**	0.681***	0.796***	0.371***	0.373***
	(0.170)	(0.191)	(0.038)	(0.031)	(0.092)	(0.090)
$\Delta Log(dmat) \times (1-D)$					0.384***	0.486***
					(0.091)	(0.088)
$\Delta Log(imat) \times (1-D)$					0.005	0.008
					(0.024)	(0.021)
$\Delta Log(dmat) \times D$					0.281***	0.447***
					(0.099)	(0.094)
$\Delta Log(imat) \times D$					−0.087**	−0.083**
					(0.044)	(0.037)
Constant	−1.641***	−2.733***	−1.825***	−2.940***	−1.598***	−2.502***
	(0.331)	(0.321)	(0.242)	(0.211)	(0.254)	(0.222)
R^2	0.573	0.529	0.764	0.798	0.804	0.842
n	450	450	449	449	403	403

Notes: In columns (1), (3) and (5) Dependent Variable is 100x(annual change in the log of nonproduction employment), in columns (2), (4) and (6) Dependent Variable is 100x(annual change in the log of production employment). Heteroscedasticity-robust standard errors are reported in parenthesis in all columns. All regressions are weighted by the average industry share of the total manufacturing wage bill in the two years used in constructing the dependent variable. CI/I is the ratio of computer investment to total investment in 1987. All other variables, the data sources and the samples are as in Table 5.3.1.

changes in the non-production wage-bill share I have one additional concern with that variable: other things being equal, industries that outsource more may have lower total investment in the source country (i.e. in our case the US) which would tend to make CI/I for these industries larger. In other words CI/I, may pick up some of the effect outsourcing through its denominator. If this is so, then it would be inappropriate to use this variable in a regression whose main purpose is to discriminate between trade and technical change as explanations for the shift in demand toward more skilled labor.

It should be noted that I am not the first to express scepticism about the use of CI/I in the cost-share regression: Feenstra and Hanson (1999: 927) write "the numerator and denominator of this variable are both investment flows making the ratio difficult to interpret"; in Feenstra and Hanson (2001: 24) they write: "we feel that measuring computers as a share of total capital stock is preferable."

However, they do not give any further argumentation as to why this measure is inappropriate. To my knowledge, the argument expressed here that this measure may capture part of the effect of outsourcing through its denominator is new. This is why it deserves some further attention.[77]

Intuitively, the argument that other things being equal outsourcing should be associated with lower investment in the home country is compelling. It rests on the view that multinational firms facing some global constraint (for example, on their worldwide sales or borrowing) maximize profits by simultaneously choosing the optimal amounts of input and investment in each location. In the previous section I presented a model based on that view. Although it is a static model it might be used to illustrate the point. In that model outsourcing implied an increase in the capital used abroad. To the extent that a firm faces some constraint on its borrowing capacity the investment needed to increase the foreign capital stock may crowd out domestic investment.

It is relatively easy to find a case-by-case evidence supporting the view that investment at home and investment abroad can be considered as substitutes. A quick check on the Internet for example using the words "new", "plant" and "automobile" produces a number of press releases announcing the opening of new automobile plants. These official press-releases provide interesting evidence on the relationship between outsourcing and investment. Consider for example the following :

" Jakarta, September 25, 2003 — P.T. Honda Precision Parts Manufacturing, Honda's parts production subsidiary in Indonesia, held an inauguration ceremony today at its new plant, marking the start of production of automatic transmissions and engine valves for automobiles. The new plant represents a capital investment of approximately USD 64 million and employs approximately 1,000 associates. ...The automatic transmissions and engine valves manufactured at the new plant will be supplied to Honda's automobile plants within the ASEAN region as well as exported to Honda plants in other regions including Europe."(available at $http://world.honda.com/news/2003/c030925.html$)

This may be considered a typical example of outsourcing.[78] In the above example

[77] In what follows I discuss in detail the argument that outsourcing (which requires investment abroad) and total investment in the US (the denominator in CI/I) are substitutes. In principle, a similar relationship may exist also between outsourcing and computer investment (the numerator in CI/I), which is simply a component of total investment. However, there is also a reason to believe that computer investment and outsourcing are complementary: relocation of part of the production activities abroad raises the need for coordination which is achieved in practice with additional computerization.

[78] Strictly speaking we are missing one piece of evidence, namely wether producing the au-

the parts are imported to Europe but it may easily happen that some analogous plants export parts to the US. My basic argument now is that the 64 million capital investment in Indonesia are not without consequences for Honda's investment in other countries, including US.

While official press releases of automobile firms can provide interesting information on investment they say nothing about the negotiations that usually precede the decision to open a new plant in a given location. Such information can be found in the popular press. Consider for example the following citation:

"Ontario workers are well-trained. That simple explanation was cited as a main reason why Toyota turned its back on hundreds of millions of dollars in subsidies offered from several American states in favor of building a second Ontario plant." (by STEVE ERWIN, 10:59 AM EDT Oct 25 at CBC News (Canadian Broadcasting Corporation: Canada's national public broadcaster)
$http://www.cbc.ca/cp/business/050630/b0630102.html$

It appears that the decision how much to invest (and expand worldwide production capacity) is often made separately and in advance of the decision where exactly to open the new plants. During the time between the two decisions further information is gathered and negotiations are lead with the local authorities to select the optimal location. The last example illustrates this. It illustrates also my basic argument: investment in other countries (in this case Canada) is substitute for investment in the US. It does not matter that in this case the investing company is japanese so that strictly speaking the US are not a "source" country. When General Motors decides to open a new plant than it faces basically the same choice of possible locations as does Toyota.

One way to try to separate the effects of the numerator and the denominator in the ratio CI/I with the data described in 5.2 is to estimate the following sequence of linear regression models (actually my strategy is to consider them in reversed order):

$$\Delta Share_i = \beta_{CI} log(CI) + \beta_I log(I) + z_i'\gamma + u_i \tag{5.3.1}$$

where z_i includes all other regressors. By imposing the restriction $\beta_1 = -\beta_2$ the model becomes

$$\Delta Share_i = \beta log(CI/I) + z_i'\gamma + v_i \tag{5.3.2}$$

tomatic transmissions and engine valves in the developed world has been also considered by Honda or alternatively whether these parts used to be produced in the developed world at some point of time.

I expect this to yield similar results as

$$\Delta Share_i = \alpha CI/I + z_i'\gamma + \epsilon_i \tag{5.3.3}$$

which is the model typically estimated in the literature. Two objections against model (5.3.1) may be that it includes investment in nominal rather than real terms, and that it does not control for the size of the industry when a share variable is replaced with variables that are obviously related to the size of the industries. At this stage it may be argued that model 5.3.1 is simply a more general version of model 5.3.2, which obviously does not suffer from the above drawback. Thus, if the latter model is appropriate than the first cannot be inappropriate either. Nevertheless I shall control for size later in this section.[79]

In order to ensure comparability of the results from all equations with previous work on one hand and across the equations here on the other I perform the analysis in four steps. I start with (5.3.3) which I estimate as AKK did in columns (7) and (8) of their Table VIII. As a next step I estimate the same model dropping industries with zero computer investment. This is an intermediate step that should ensure that the results in (5.3.2) are not driven by the change in the sample (note that industries with zero CI/I have to be deleted when taking logs). Then I estimate model (5.3.2) which should be also considered as an intermediate step. The purpose here is to see wether (5.3.2) yields similar results as (5.3.3). Finally, if both yield similar results we can link the results from (5.3.1) to the results in 5.3.3.

The results from applying this strategy are summarized in Table 5.3.3. All variables are defined as in AKK except I which is average investment over the period[80] and CI which is defined as $CI/I \times I$ (s. the notes to Table 5.3.3 for more detail). I restrict attention to the last two decades considered by AKK, i.e. the seventies and the eighties, because data on computer investment and outsourcing are unavailable prior to the seventies.[81] Columns (1) and (5) almost identically reproduce the results in AKK, s. columns (7) and (8) in their Table VIII.

[79]One drawback of both models 5.3.2 and 5.3.1 is that not all regressors are bounded, s. Section 5.4. I shall estimate them in this section despite this fact.

[80]Since investment is in nominal terms the simple averaging over years puts implicitly more weight on later years. However, the results are almost identical when I is investment at the start or the end of the period or in the years in which CI/I was recorded, reflecting the fact that industry investment is very persistent over time.

[81]In their regression for the sixties AKK used data from later periods to obtain the outsourcing and CI/I. It should be also noted that I obtain very similar results when performing the analysis for the periods 1972-1979 and 1979-1987 which are the periods considered later in this study

Table 5.3.3: Change in the nonproduction worker share of the wage bill in four-digit manufacturing industries, 1969-1979 and 1979-1989

	1969-1979				1979-1989			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta Log(K/Y)$	.039***	.030**	.021	.019	.046***	.047***	.040***	.044***
	(.014)	(.014)	(.014)	(.014)	(.010)	(.010)	(.010)	(.010)
$\Delta Log(Y)$	.032**	.046***	.049***	.049***	.015*	.016*	.016**	.019**
	(.014)	(.013)	(.013)	(.012)	(.007)	(.008)	(.008)	(.010)
CI/I	3.222***	3.04**			2.296***	2.315***		
	(.204)	(1.214)			(.893)	(.892)		
$Log(CI/I)$			.072*				.133***	
			(.042)				(.042)	
$Log(CI)$				.067				.126***
				(.048)				(.410)
$Log(I)$				-.091***				-.141***
				(.029)				(.446)
ΔS_x	.033	.001	-.002	-.004	.066*	.065*	.066*	.067**
	(.040)	(.078)	(.083)	(.082)	(.034)	(.034)	(.034)	(.034)
ΔS_o	.047	.000	-.027	-.030	.110	.112	.106	.110
	(.052)	(.087)	(.088)	(.087)	(.145)	(.145)	(.144)	(.139)
Constant	-.095*	-.118**	.284	.382**	.141***	.136***	.711***	.761***
	(.050)	(.057)	(.221)	(.155)	(.044)	(.045)	(.158)	(.184)
R^2	.157	.232	.176	.179	.211	.215	.220	.222
n	448	281	281	281	448	440	440	440

Notes: Dependent Variable is 100x(Annual Change in the Nonproduction Wage-Bill Share). Heteroscedasticity-robust standard errors are reported in parenthesis in all columns. All regressions are weighted by the average industry share of the total manufacturing wage bill in the two years used in constructing the dependent variable. Δ indicates 100 times the annual change in the variable. The variables are defined as follows:
I=average investment over the period computed for each industry as a simple mean over the 10 years (1970 to 1979 and 1980 to 1989 respectively)
CI/I=Ratio of computer investment to total investment. For the 1969-1979 period CI/I is the 1977 computer investment share; for the 1979-1989 period CI/I is the average of the computer investment share in 1982 and 1987.
$CI = (CI/I) \times I$
K/Y=Real capital stock to real shipments ratio.
Y=Real value of shipments.
S_x=Exports/shipments.
S_o= $intimp/neinp$ (imported intermediate goods/total non-energy material purchases).
ΔS_o: For the 1969-1979 period, ΔS_o is 100 times the minimum of one-tenth of the level of S_o in 1972 and the annual change in S_o from 1972-1979; for the 1979-1989 period it is 100 times the annual change in S_o from 1979-1990.
Sources: I obtained the data on computer investment and outsourcing from David Author (s. Autor, Katz and Krueger (1998) and the notes to their table VIII). The data on total imports and exports are from *http://cid.econ.ucdavis.edu/usixd/usixd4sic.html*, s. Feentra (1996). All other variables are from Bartelsman and Gray (1996).

The minor differences are due to the fact that for all other variables except CI/I, computer investment and exports, I use the updated version of the NBER Productivity Database which contains now 448 industries. Dropping industries with zero CI/I has almost no effect in the eighties (there are only 8 such industries) while it changes somewhat the results in the seventies. Still the results in columns (2) and (6) are close enough to the results in columns (1) and (5) so that we can proceed with our stepwise analysis.

Replacing CI/I with $Log(CI/I)$ changes very little in the eighties: The coefficients and standard errors estimates of all other variables remain almost the same between columns (6) and (7). Only the coefficients on the computer investment variable and the intercept change, but this is expected. The weighted mean of CI/I in column (6) is 0.057 and the weighted mean of $Log(CI/I)$ is -3.27. The slope of the logarithmic function at these two points is 17.57 and 26.35, implying that we should expect the coefficient on the computer investment variable to fall about 17 to 26 times when we move from column (6) to column (7). In fact, it falls 17.4 times and remains statistically significant at the 1 percent level. The goodness of fit does not change much either, R^2 is even slightly larger in the specification including $Log(CI/I)$.

For the 1969-1979 period the weighted means of CI/I and $Log(CI/I)$ from columns (2) and (3) are 0.032 and -4.137 respectively. The slope of the logarithmic function at these points is 31.44 and 62.64 respectively implying that we should expect the coefficient on the computer investment variable to fall 30 to 60 times from column (2) to column (3). In fact, it falls 42.22 times and remains statistically significant. As an additional tool that might help discriminate between the two functional forms for both decades I considered component-plus-residual plots. These are presented in figures 5.7.1 - 5.7.4 in the Appendix. Based on these plots it is difficult to reject the logarithmic specification against the linear.[82] I conclude from this that model 5.3.2 can be considered a good starting point for attempting to separate the effect of total investment from the effect of computer investment, and that the conclusions can be carried over to the base specification 5.3.3.

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[82]There appears to be some tendency for the points on the left of figure 5.7.4 (which corresponds to the logarithmic specification for the 1979-1989 period) to deviate above the straight line, which is not apparent in figure 5.7.3 (the linear specification for the same period). However, the problem appears to be due to systematically larger residuals at small values of CI/I which is common to both specifications. The problem is simply masked in figure 5.7.3 due to the clustering of many points within a small interval. To illustrate this argument Figure 5.7.5 plots the residuals from columns (5) against CI/I for observations with small CI/I. Figure 5.7.6 plots the residuals from column (7) for the same industries. The two graphs look very similarly showing that the problem of positive residuals at small CI/I applies to both specifications.

Suppose that CI/I is the appropriate technological change proxy. It follows that increasing both total investment and net investment in computers proportionately we should be moving toward an industry with the same rate of technological change. Accordingly, the expected change in the wage bill share of that industry (keeping the other factors in Z fixed) should remain unchanged. Interestingly, however, the results in columns (4) and (8) indicate that changes in total investment (I), have larger impact on the dependent variable, than changes of equal magnitude in net computer investment (CI). While this may be simply due to chance[83] the fact that the coefficient on total investment in column (4) appears to be more precisely estimated [84] as compared to that on net computer investment is puzzling from the point of view that CI/I is a good indicator of technology and suggests that my concern with the role of the denominator in that ratio may be well grounded.

One possible explanation for that puzzle is that by increasing both the numerator and the denominator of the computer investment share we are most likely moving toward a larger industry. The difference between the estimated effect of net computer investment on one hand and total investment on the other in the unrestricted model may therefore, reflect the impact of simply moving toward an industry of different size. Presumably changes in total investment capture changes in industry size better than changes in net computer investment. If for some reason industry size was a relevant factor for skill upgrading in the seventies then this may explain why $Log(I)$ performs better than $Log(CI)$ in column (4). As a check on this hypothesis, I estimated model (5.3.1) by including also the log of employment at the start of the period. This produced the following results for the seventies:[85]

[83] In fact, in both decades we cannot reject the hypothesis that the two coefficient are of equal magnitude

[84] The 95 percent confidence interval for the coefficient on total investment in column (4) is (-0.148; -0.033); for the coefficient on net computer investment the corresponding confidence interval is (-0.027; 0.161). Note also that the coefficient on net computer investment is insignificant in the seventies. The coefficient on total investment By contrast,is highly statistically significant in both decades.

[85] The corresponding results for the eighties are:

$$\begin{aligned}\Delta SHARE &= \underset{(0.011)}{0.039}\Delta Log(K/I) + \underset{(0.011)}{0.014}\Delta Log(Y) + \underset{(0.045)}{0.142}Log(CI) - \underset{(0.048)}{0.113}Log(I) + \\ &\quad + \underset{(0.032)}{0.066}\Delta S_x + \underset{(0.145)}{0.125}\Delta S_0 - \underset{(0.044)}{0.063}Log(EMP) + \underset{(0.192)}{0.852}, R^2 = 0.227\end{aligned}$$

$$\Delta SHARE = \underset{(0.014)}{0.020}\Delta Log(K/I) + \underset{(0.012)}{0.053}\Delta Log(Y) + \underset{(0.051)}{0.055}Log(CI) - \underset{(0.031)}{0.109}Log(I) \tag{5.3.4}$$
$$-\underset{(0.084)}{0.008}\Delta S_x - \underset{(0.087)}{0.037}\Delta S_0 + \underset{(0.053)}{0.045}Log(EMP) + \underset{(0.224)}{0.270}, R^2 = 0.182$$

The sum of the coefficients on $Log(CI)$, $Log(I)$ and $Log(Emp)$ is close to zero in both decades (it is -0.0085 in the seventies and -0.0336 in the eighties) implying that changes in industry size as captured by proportional changes of all CI, I and Emp in the above specification have no significant effect on the dependent variable.[86]

More importantly, controlling for industry size does not resolve the puzzle encountered in Table 5.3.3 for the seventies period. The difference in the magnitude of the coefficients on $Log(CI)$ and $Log(I)$ in the seventies period is now even larger. Moreover, the coefficient on $Log(I)$ appears to be again more precisely estimated than that on $Log(CI)$ and By contrast,to the latter is highly statistically significant. I experimented also with dropping $Log(CI)$ and $Log(I)$ separately from the regression for the seventies period. When dropping $Log(CI)$ in Eq. 5.3.4 the coefficients on $Log(I)$ and $Log(Emp)$ are -0.097 (0.026) and 0.098 (0.06) respectively. When dropping $Log(I)$ the coefficients on $Log(CI)$ and $Log(Emp)$ are 0.041 (0.052) and -0.47 (0.048) respectively. Interestingly, the coefficient on $Log(Emp)$ adjusts exactly to compensate the coefficient on the other size-dependent variables so as to make the sum of all size-dependent variables included in the regression close to zero. When dropping both $Log(CI)$ and $Log(I)$ the coefficient on $Log(Emp)$ is -0.008 (.032).

The conclusion emerging from all specifications is the same: after controlling for industry size in the seventies period, the variation of total investment across industries appears to contain some useful information, not contained in the variation of net computer investment across industries.[87]. I obtain similar results also when the regressions are not weighted. This fact is difficult to reconcile with the view that the ratio CI/I is a good technological change indicator. From the latter point of view we would expect most of the useful variation in CI/I across industries to be contained in its numerator, whereby the denominator is needed simply to make the measure size-independent.

[86]The hypothesis $\beta_{logci} + \beta_{logi} + \beta_{logemp}$=0 cannot be rejected in either period using a Wald test. The associated p-values are 0.82 in the seventies and 0.14 for the eighties.

[87]Note that the weighted correlation between $Log(CI)$ and $Log(I)$ in the seventies sample is 0.66, i.e. industries that invest more in general invest more also in computers.

In the absence of alternative data in the later analysis I shall use CI/I as indicator of technological change as this has been done in the previous literature. I shall experiment also with a variable which I obtain out of it - computer investment per employee CI/E. I construct this measure by multiplying CI/I with the value of investment in the year in which CI/I was recorded and dividing the result by the value of total employment in the same year. In order to make the coefficients on CI/I and CI/E to some extent comparable in magnitude, before running a regression I shall always scale that variable such that it has the same weighted mean as CI/I in the sample over which the regression is fitted.[88] Note that while the use of CI/E is an attempt to deal with the second of the two problems with CI/I discussed here it does not alleviate at all the first, namely the potentially mechanical correlation between computer investment and the dependent variable arising from the fact that computers are the kind of tools used predominantly by skilled workers. It should be also noted that CI/E is theoretically unbounded which makes its use in the cost-share regression problematic (s. Section 5.4 and footnote 5.4.2). It should be seen merely as an experiment.

5.4 Notes on the measurement of trade and specification

At first glance our available measures of international trade are much better than our available measures of technology. Customs offices collect a rich information on trade flows and there is a long lasting tradition in aggregating this information and making it operational for research. Yet for the purpose of determining its impact on skill demand the measurement of trade has proven to be at least as controversial as the measurement of technology. The controversy relates to what the relevant concept of trade is. Should we look at the prices or at the quantities of internationally traded goods? Should we look at the imports or at the exports? Should we look at trade with all countries or at trade with some particular countries? Should we look at trade in all goods or at trade in intermediate goods only?

Different answers to these questions have lead to different methodological approaches, which I surveyed briefly in Chapter 4. My purpose in this section is not to re-evaluate the theoretical foundations of all these approaches, but rather to derive an appropriate measure of trade to be included on the left hand side of the cost share equation. In addition, I provide an alternative motivation for the estimating equation which should replace the traditional assumption of an identical translog cost function accross industries.

[88] To this end I simply multiply the variable CI/E with a constant term that equals $\overline{CI/I}/\overline{CI/E}$, the ratio of the weighted means of the two variables in the corresponding sample. This scaling has no effect on the corresponding t-statistics and significance levels. The units of measurement of the two variables of course remain different - CI/I is a ratio, CI/E are dollars per worker.

5.4.1 An alternative motivation for the estimating equation

With the cost-share regressions that I report in the next section I do not pretend to quantify the contribution of trade and technical change to the rising skill premium. Rather, I am searching for an answer to the following question: Does trade or technical change explain better skill upgrading by industry? Checking the answer of this question with the cost-share regression requires so few assumptions that one may wonder whether this question is at all useful. In what follows I explain the rationale behind it.

Let us think of trade and technical change as exogenous shocks in line with the philosophy of all studies considering trade and technical change as competing explanations (see the introduction to this Chapter). Let us furthermore think of these shocks as hitting individual firms as illustrated by the following two examples. On one day during the eighties a technician at firm x comes up with the idea of a process innovation which requires some investment in computing equipment and would make five production workers redundant while requiring one additional non-production worker to be hired. This is an example of an SBTC-shock hitting firm x soon. At another day a manager of firm x is unexpectedly invited to a coctail at the embassy of country y at which he learns for the first time about the opportunity to produce there at low cost. This is an example of an outsourcing shock hitting firm x soon. Obviously one single shock to one single firm would not change the relative wage at the economy level, but many shocks to many firms would do that.

Suppose now that we have some measures that proxy the distribution of the two types of shocks accross industries. For example we can consider CI/I as a proxy for technological change shocks. A proxy for the effects of outsourcing will be derived in the next section. It is then natural to use these measures as covariates in a regression where the dependent variable is the change in the wage bill share of skilled labor. From this perspective the cost-share regression can be motivated as a mean to learn something on the role of trade and technical change by looking at the distribution of shocks across firms.

Suppose that a shock cannot affect aggregate skill demand without affecting firm-level skill demand. This will generate variation in the rate of skill upgrading across firms that will to some extend mirror the variation in the number and extend of shocks across firms. Suppose now that for some reason one of the two types of shocks (trade or technology) is irrelevant (skill-neutral). It follows that the incidence (in terms of number and extent) of that type of shocks would not be useful for explaining skill upgrading at the firm level. This provides the motivation for estimating a cost-share equation as in the previous literature, see Eq.4.3.1, except that we do not need to include the change in the log-output and capital intensity.

Note that the above motivation for the cost-share regression does not rely upon any assumption from economic theory. However, we shall need one critical assumption for estimating and interpreting the results: that all factors left in the error term are independent of the regressors.[89] With respect to choosing an efficient estimation procedure I use one more assumption on the size of the firms (the latter is unobservable in the data used here). I assume that all firms in the economy are of similar size with the industry size roughly proportional to the number of firms (these should not necessarily be identified with the corresponding legal units for which the assumption is obviously incorrect, a "firm" here is simply the production unit for which the relationship 4.3.1 holds). Accordingly, in estimating 4.3.1 on industry (i.e. grouped) data I weight all regressions by industry size as this has been done in all previous applications of the cost-share regression[90](see BBG-93, AKK, FH-96, FH-99, MVR).

5.4.2 Constructing a proxy for the effect of outsourcing: ΔS_{fci}

In this section I derive a new measure that should capture the effect of outsourcing. In essence it represents the change in the wage bill-share of skilled labor predicted based on a factor content calculation. The use of the factor content approach in this context represents an innovation: none of the trade measures used previoulsy in the cost-share regression is derived from that principle. In my opinion the factor content approach is particularly appropriate to apply in the context of the cost-share regression for several reasons. First, predicting relative labor demand at the industry level with a factor content calculation requires no assumptions at all. Since we observe many industries we can use the data to see wether our factor content calculation provides an accurate prediction. Second, since we do not attempt to link the relative wages at the economy level to the estimated factor content in any particular industry we need not estimate the size of the factor content effect correctly - it suffices to correctly reproduce its variation across industries. Finally, the way the dependent variable in the cost-share regression is defined simply calls for a factor content calculation.

To explain the last point let me start with the observation that the dependent

[89]Since I report estimates including different sets of regressors this assumption takes a slightly different form each time. The factors that are left in the error term in all specifications include the impact of unions on wages and employment at the firm level, the impact of product demand (note that in the short run product demand shocks affect production workers disproportionately), the impact of the minimum wage and other regulations, and many others.

[90]One further argument in favor of weighting is that the data on small industries are more noisy - as BBG (1993: 23) note migration of firms into and out of a given industry over time tends to be concentrated in small industries.

variable is bounded by definition. It follows that an x-variable can affect it linearly only if it is bounded too or if it is involved in a restriction with other x-variables implying that their joint effect is bounded.[91] This requires a careful choice of trade measures to be included on the left-hand side. The ratio of imports to value added used sometimes is obviously problematic. To avoid this problem AKK-98 define (see the notes to their Table VIII) the import share variable as imports/(imports+shipments). By contrast, they define the export share as exports/shipments, although theoretically the latter is not bounded. Obviously the presumption here is that transportation costs limit the possibility of reexport, so that the exported goods are to a large extent domestically produced.

Bounded-ness is one important aspect in choosing an appropriate trade measure but it is not all. Consider the change in the share of imported intermediate goods in total non-energy material goods - the measure proposed by Feenstra and Hanson (1996). It is defined as (the industry index is omitted)

$$\Delta S_o = c(\frac{intimp_1}{neinp_1} - \frac{intimp_0}{intimp_0}) \tag{5.4.1}$$

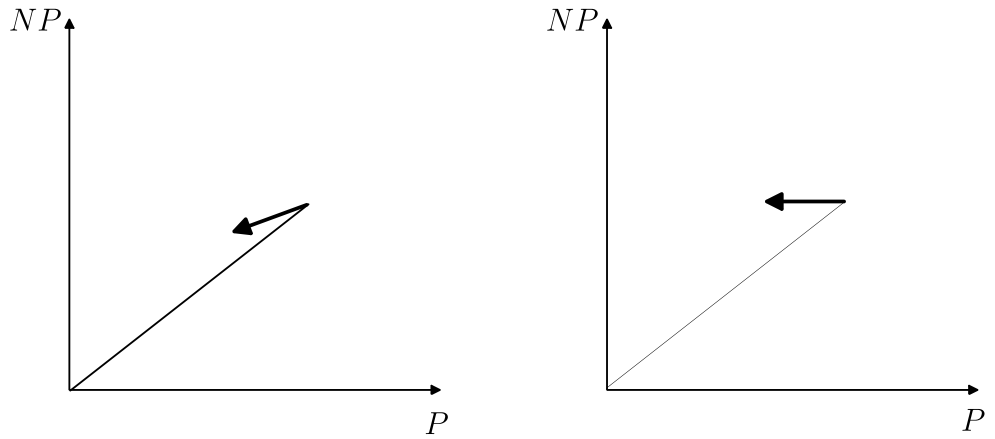
where the subscripts 0 and 1 on the right-hand side denote start-of period and end-of period values respectively and c is a scale factor defined here as $100 \times 1/$(the length of the period in years).[92] While this measure is obviously bounded it is not at all clear that it should affect the dependent variable linearly. Let us for a moment abstract from the influence of all other factors and suppose that the final product demand and the organization of production in an industry remains constant over time. The only thing that changes is that some of the plants producing intermediate inputs are relocated in newly industrialized countries.[93] In our data this would show up as follows: i) reduction of the value of shipments and primary factor usage (plants or particular production lines close down), ii)

[91] Note that this has implications also for the distribution of the error term. Strictly speaking it can not be normally distributed since it is also bounded. However, with a correspondingly low variance the mass of the normal outside the bounds is negligible so that the true distribution of the error term could be close to it.

[92] S. the notes to Table 5.2.1 for a definition of *neinp*; *intimp* has been defined in the text of Section 5.2

[93] For example we may think of the production process as consisting of many separable stages, each requiring fixed amounts of production and non-production labor in different proportions or, alternatively, each paying fixed wage shares to non-production and production workers. Note that any aggregate wage-bill/employment ratio can be represented as a sum of the wage-bills/employment in many small plants each employing a different Cobb-Doulgas/Leontieff technology. By constant organization of production I mean here that these small plants (or divisions, or production stages, or production lines, or tasks) do not change in size, they are simply shifted across borders such as they are.

Figure 5.4.1: Different effects of outsourcing depending on the skill intensity of the relocated production activities



Notes: the small thick arrows indicate employment displaced by imports

increase in the imports of intermediate goods equal to the value of shipments of the relocated plants. In order not to clutter up the formula with deflators let us abstract from the impact of inflation for a moment and treat nominal values as real. Since the total amount of non-energy inputs used in the US does not change in our example ($neinp_1 = neinp_2$) the Feenstra-Hanson measure predicts an impact on the dependent variable proportional to the increase in real intermediate imports (the industry index is omitted):

$$\Delta S_o = c(\frac{intimp_1 - intimp_0}{neinp_0}) = c\frac{\Delta intimp}{neinp_0} \tag{5.4.2}$$

Thus, the shifting of each additional small production line abroad as reflected by $\Delta intimp$ in our example should have the same effect on the aggregate share of non-production labor. Moreover, the effect is modelled to depend only upon the size of the relocated production, not upon its skill intensity. Figure 5.4.1 illustrates that in our example we should expect the same $\Delta intimp$ to have a different impact on the dependent variable depending upon how non-production intensive the displaced production is.

In this figure the solid lines going trough the origin represent the initial use of non-production and production workers, the small thick arrows represents employment displaced by imports of intermediate goods. The length of this arrow is the same in both the left and the right panel of the Figure indicating that a plant of similar size has been relocated abroad in both cases. Obviously the changes in the non-production-production ratio (and also in the non-production employment share) in both cases is different. Note that the changes in the latter share are closely related to changes in the non-production wage-bill share[94], thus we expect the effect on the latter to be different as well. The key insight from Figure 5.4.1 is that we should take into account not only the size, but also the factor content of the additional (i.e. the increase from start to end of a period) imports of intermediate goods when predicting their impact on the dependent variable. In what follows I am going to use the variable $fwshare$ introduced in Section 5.2 as an estimate of the non-production intensity of US production displaced by imports of intermediate goods.[95]

Finally, we should note that in addition to the size and factor content of imports, also the skill intensity of the domestic production at the start of the period matters as illustrated in Figure 5.4.2. The left and right panel in this figure depict two industries of approximately equal size (as captured by the equal length of the line through the origin) which experienced increases in the imports of intermediate goods of approximately equal size and equal factor content (the small thick arrows are parallel and of equal length). Obviously in both cases the implied change in the ratio non-production - production employment is different and we expect the same to be true for the wage-bill ratio and for the corresponding shares. Having said all this I propose to use a new functional form linking changes in intermediate imports to the dependent variable as follows.

First, construct an estimate of the share of production that is relocated abroad during a period by putting the increase in intermediate imports (I will experiment with $m = intimp$ and $m = imppts$ and report results in both cases) in relation to the value of shipments ($vship$) as of the beginning of the period (the industry index is omitted):

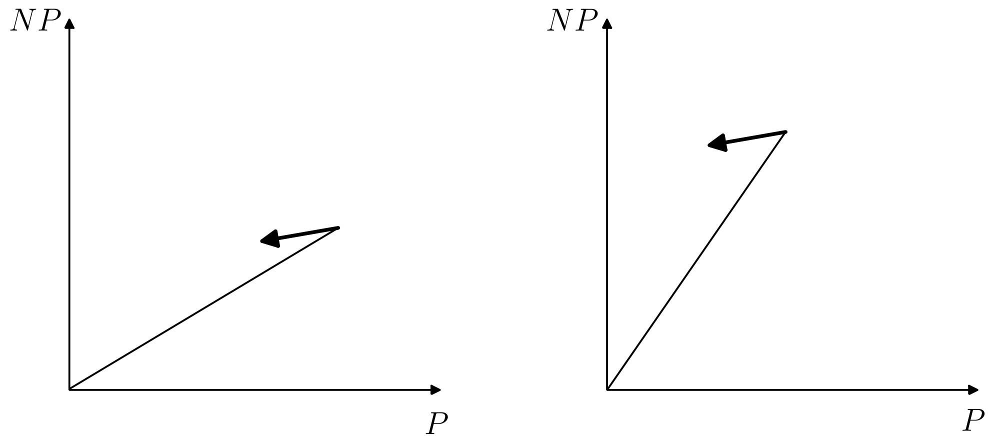
$$O_{sh} = \frac{m^1 \frac{pineinp^0}{pineinp^1} - m^0}{vship^0} \tag{5.4.3}$$

I use the superscripts 0 and 1 to denote start-of-period and end-of-period values respectively. In order to ensure that both the numerator and the denominator of

[94]In fact BBG-93 and MVR consider them alternatively as dependent variables in the cost-share regression and obtain very similar results in both cases

[95]Under the assumption that each small plant that is relocated abroad can be characterized by a Cobb-Douglas technology the aggregate non-production wage bill-share accruing to all relocated plants in their new location will be exactly the same as the wage bill-share accruing to these plants while operating in the US. Note that for this we do not require each single plant to use the same C-D technology.

Figure 5.4.2: Different effects of outsourcing depending on the initial aggregate skill intensity of the industry



Notes: the small thick arrows indicate employment displaced by imports

the ratio are measured in start-of-period dollars I use the deflator for non-energy inputs *pineinp* which has been introduced in Section 5.2 (s. footnote 70 for the exact definition). Expression 5.4.3 is motivated by the example above - we take the increase in intermediate imports to reflect relocation of plants with size (in terms of sales) exactly corresponding to the size of the additional imports. Based on this estimate I construct the implied changes in the industry non-production (subscript n) and production (subscript p) wage bills as follows (the industry index is again omitted):

$$\widehat{\Delta W_n} = -O_{sh} \times (wagebill_0) \times fwshare \tag{5.4.4}$$
$$\widehat{\Delta W_p} = -O_{sh} \times (wagebill_0) \times (1 - fwshare) \tag{5.4.5}$$

The implied total industry wage bill change, which is obtained by summing up the last two expressions, is constructed proportional to the implied domestic value of shipments change. As to the composition of the replaced wage-bill I impute the foreign shares constructed in Section 5.2. The minus sign reflects the fact that increases in the intermediate imports (positive O_{sh}) are taken to imply reductions in the domestic wage bill and value of shipment.[96] Finally, I construct the implied

[96]Intermediate imports increased for most industries during the periods considered, but there are also some industries for which intermediate imports fell. It is debatable wether we should

change in the non-production wage bill share (the dependent variable) as follows (the industry index is omitted):

$$\Delta S_{fci} = c(\frac{W_n^0 + \widehat{\Delta W_n}}{W_n^0 + \widehat{\Delta W_n} + W_p^0 + \widehat{\Delta W_p}} - \frac{W_n^0}{W_n^0 + W_p^0}) \tag{5.4.6}$$

where the scale factor c is defined as before, W_n^0 and W_p^0 are the industry start-of-period non-production and production wage bills respectively, and the subscript fci indicates that the variable represents the change in the non-production wage-bill share predicted from the *factor content of* (intermediate) *imports.*[97]The way the variable is constructed implies that we expect its coefficient to be equal to one.

I conclude this section by discussing the limitations of ΔS_{fci} as a measure of the impact of outsourcing. One possible concern with this measure is that it is a function of the level of the wage bill-share while the dependent variable represents the change in the latter. However, the way the wage bill share enters the formula is rather neutral. Note that if intermediate imports do not change in real terms over the period ΔS_{fci} is zero, regardless of the values of all other variables in the formula. ΔS_{fci} is zero also if the imputed foreign factor content $fwshare$ coincides with the initial domestic wage-bill share, regardless of the values of the other variables. The sign of ΔS_{fci} is directly related to each of the following two factors: 1) the sign of O_{sh} which depends only upon the change in intermediate imports, and 2) wether $fwshare$ is smaller or larger then the initial domestic wage share. Furthermore, ΔS_{fci} depends monotonically (although not linearly) upon the change in intermediate imports.

If the performance of ΔS_{fci} in the regression was driven by the fact that it includes the level of the wage-bill share we would expect the variable to retain its explanatory power even with the wrong values of O_{sh}. As a practical check on this hypothesis I experimented with randomly reallocating O_{sh} (after it has been correctly computed for each industry) across industries and then matching it with the correct wage-bill and $fwshare$ data to construct ΔS_{fci}. After repeating this

accord special treatment to these industries. On one hand, the fact that intermediate imports in an industry fall by a certain amount represents a useful information that we would like to use somehow. On the other hand, our formula implicitly treats the falling imports as reflecting relocation of production activities back to the US which is somewhat problematic. I experimented with redefining O_{sh} as follows: $O_{sh} = max\{0, (m^1 \frac{pineinp^0}{pineinp^1} - m^0)/vship^0\}$. This formulation predicts zero change in the dependent variable for all industries with falling imports of intermediate goods. In all cases were the results very robust to this transformation, perhaps reflecting the fact that there are only few industries with falling intermediate imports. These results are reported in section 5.7.1 in the appendix.

[97]Large values of O_{sh} implying that one or both of the predicted wage-bills in Eq. 5.4.4 is negative do not occur in the sample, s. 5.5.1 and 5.5.2

experiment many times I was not able to detect any pattern in the results. In the regressions including ΔS_{fci} constructed in this way its coefficient estimate varied unpredictably in sign and magnitude and was in most cases insignificant. All this should be convincing enough to take the presence of the level of the wage-bill share at the beginning of the period in the formula for ΔS_{fci} as not being a serious problem.

Another possible concern with ΔS_{fci} is that we take the whole change in the imports of intermediate goods over the period to reflect relocation of production activities abroad, while there might be also other factors causing the imports of intermediate goods to change - most notably, we would expect output shocks to cause roughly proportional changes in all inputs, including imported intermediates. I explain below how the formula can be modified in order to minimize the impact of output shocks on the estimated O_{sh}. The results are robust to this modification. Ignoring the role of output shocks and treating the entire change in intermediate inputs as reflecting relocation of production in the base specification can be justified as follows.

First, over the 1979-1987 period which I focus on later, changes in output and total materials used were generally small as compared to the corresponding changes in the imports of intermediate goods. Based on the sample of 444 industries used in the regressions later (s. Section 5.5.1) the mean annual growth rate of real output and real material costs over that period was 1.12 and 1.16 percent respectively, while the mean growth rate of real intermediate imports was 5.9 percent and that of employment -1.52 percent.[98] This descriptive evidence alone suggests that we should regard the bulk of the increase in intermediate imports over the period as directly substituting domestic production.

Second, we would expect most output shocks to have a proportional effect on all inputs. Thus, failing to account for these shocks would cause simply noise in our measure of oursorcing ΔS_{fci} without necessarily introducing a bias. Correlation between ΔS_{fci} and the error term would arise only if there are some factors not controlled for in the regression which cause industries to expand or shrink while at the same time they have a non-neutral effect on the different types of inputs.

[98]These figures are based on the mean of a variable $\Delta Log(var)$ defined as 100 times the annual change in the log of var, where var is alternatively real output ($vship/piship$), real material costs ($matcost/pimat$), real intermediate imports ($intim/pineinp$) or number of employees. The mean growth in output can be read off also in Table 5.7.3. We should note that different quantiles of the distributions of $\Delta Log(var)$ show similar differences as the means. For example, the median $\Delta Log(var)$, when var is alternatively real output, real material costs, real intermediate imports and employment is 1.09, 1.33, 6.14 and -1.34 respectively. The 25-quantiles of these variables are -1.23, -1.36, 2.68 and -3.66 respectively. The 75-quantiles are 3.72, 3.96, 10.01 and 0.98 respectively.

In this respect it is useful to remember that the estimated partial effect of output changes on the dependent variable is negative throughout specifications (s. Section 5.1.3). Since output is itself endogenous this suggests to watch out for those factors that might cause falling output and at the same time increases in the non-production wage-bill share. The main such factor is outsourcing itself. Technical change is another factor that might cause output changes while at the same time having non-neutral effect on relative input demand, but we would expect technical change to cause industries to expand, not to shrink. This suggests that the output effects of technological change shocks might be small (s. references on SBTC). Moreover, the coefficient estimates on ΔS_{fci} are robust to controlling for technical change as captured by the variables CI/I and CI/E, thus, it is rather unlikely that ΔS_{fci} captures the effect of technical change somehow.

We should note that consumption demand shocks could also have a non-neutral effect on relative input demand - as noted by BBG-93 production employment tends to fluctuate cyclically, closely following the fluctuations in output, while non-production employment tends to be more stable over time. It may be argued, however, that the non-neutral effect of consumption demand shocks on relative labor demand is a short run-phenomenon and that over an entire business cycle production and non-production employment should be proportionately affected by changes in the demand for the industry's products.[99]

Finally, as an attempt to eliminate the impact of exogenous output shocks from our measure of outsourcing, ΔS_{fci}, I experimented by redefining O_{sh} as follows (the industry index is omitted).

$$O_{sh} = \frac{m^1 - m^0 * g}{Y^0} \tag{5.4.7}$$

where now m is real imports of intermediate goods ($intimp/pineinp$) or ($impputs/pineinp$), Y is real shipments and the subscripts 0 and 1 indicate, as before, start-of-period and end-of-period values respectively. With $g = 1$ this formula is almost identical to 5.4.3 - the only difference is that in 5.4.3 all variables are in start-of-period dollars, while in 5.4.7 all variables are in real terms (i.e. in 1987 dollars, since all deflators in the NBER MPD are set to equal one in 1987). In fact, the correlation between O_{sh} obtained using formula 5.4.3 and O_{sh} obtained using formula 5.4.7 with $g = 1$ is 0.99 in the sample of 444 industries used later in the regressions for the 1979-1987 period, s. 5.5.1. Thus the main difference between the two formulations is the term g. I take now g to be the ratio of end-of-period to start-of-period real material costs ($g = \frac{matcost_1/pimat_1}{matcost0/pimat_0}$). With this formulation we are implicitly decomposing the change in the (real) imports of intermediate goods

[99]Note furthermore that the coefficient on ΔS_{fci} is positive and significant also in specifications including the change in industry output (s. columns (6) and (8) in table 5.5.1)

over the period into two components - the first component is the change that we would obtain if intermediate imports were to change exactly proportionately to total material costs. The second component is the additional change, starting from the level that would obtain with the first component alone. In formula 5.4.7 we take only the second component to represent direct substitution of domestic production and implicitly attribute the first component to output shocks.[100]

A comparison between O_{sh} and the corresponding ΔS_{fci} obtained using either of the equations 5.4.3 and 5.4.7 respectively produced the following results. In the sample of 444 industries based on the Feenstra-Hanson data (s. 5.5.1) the correlation between the two O_{sh} for the 1979-1987 period was 0.74, that between the corresponding ΔS_{fci} was 0.81. In the sample of 284 industries based on the Schott data (s. 5.5.2) the correlation between the two O_{sh} in the same period was 0.95, that between the corresponding ΔS_{fci} was 0.94. I looked also at the correlation between the residuals from all the regressions based on Eq. 5.4.3 on one hand (these are reported in Tables 5.5.1 and 5.5.2), and the difference between the values of ΔS_{fci} obtained using equations 5.4.3 and 5.4.7 on the other hand (the latter difference can be considered as the measurement error in ΔS_{fci} in the corresponding regressions if 5.4.7 is the correct specification). In all cases was that correlation small with values around 0.04-0.05.[101] More importantly, the regression results obtained with ΔS_{fci} based on equations 5.4.3 and 5.4.7 are very similar as we shall see in the next section.

At the beginning of this section I raised a number of issues related to the choice of an appropriate trade concept to be linked with wage inequality. After having addressed the issue of prices versus quantities in some detail up to here it is time now to say something on wether it is useful to focuss on trade with a particular group of countries and on the role of exports. Figures 5.4.3 and 5.4.4 provide the basis for this discussion. In these figures we depict countries as circles. We focuss on the production process of a single good and represent it as consisting of different stages labelled A, B, C and D. We may think of these stages as being ordered according to their relative skill intensity. We assume that the processes A, B, C and D are separable and that the resulting output is transferable across locations in the form of intermediate products. We take process A to be the

[100]The imports of intermediate goods represent a small fraction of total material costs. For example, in the sample of 444 industries based on the Feenstra-Hanson data, s. Section 5.5.1, the average share of imported intermediates ($intimp/matcost$) is 10.60 percent, in the sample of 284 industries using the Schott data, s. Section 5.5.2 the average share of imported intermediates ($imppts/matcost$) is 5.19 percent. I obtain similar results when g is the growth of output instead of material costs ($g = \frac{vship_1/piship_1}{vship0/piship_0}$).

[101]It was largest for the residuals from column (5) in Table 5.5.2 with 0.06 and smallest for the residuals from column (8) in Table 5.5.1 with 0.01

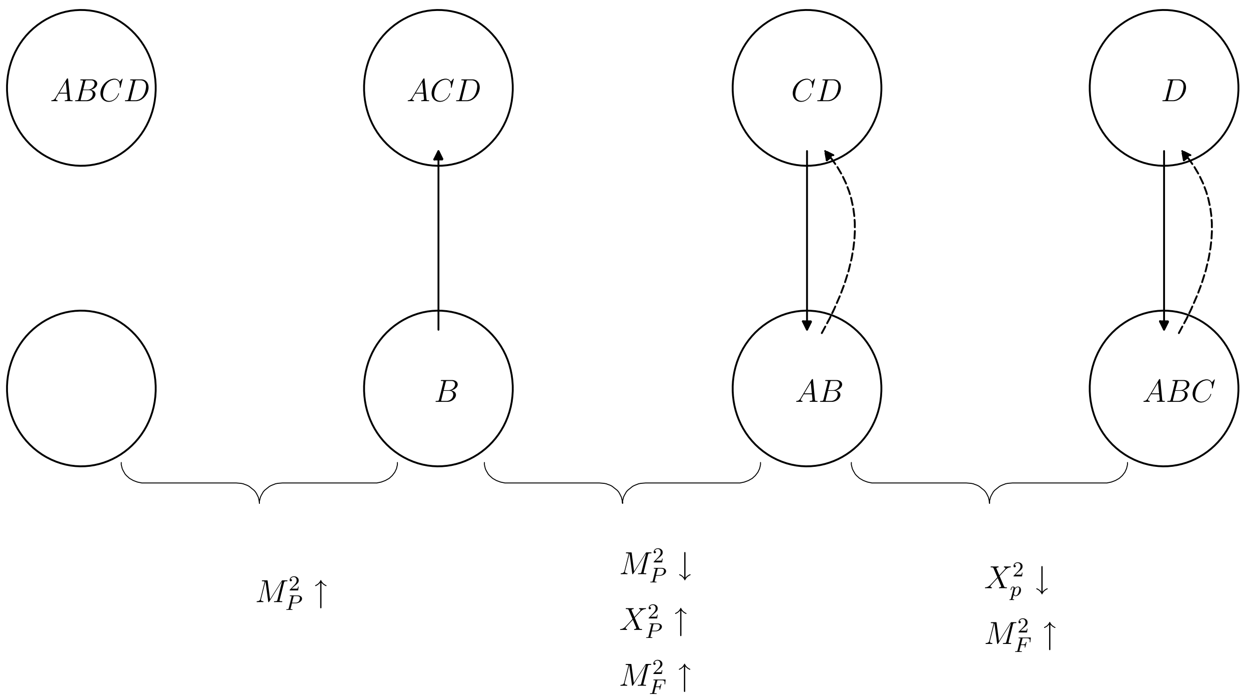
assembly into a finished product although in practice this need not be the least skill-intensive process.

In figure 5.4.3 we have two countries and four situations. I refer to the move from each situation to the next as a stage. Initially the whole production process takes place in the developed country (the upper (northern) circle). In the first stage (i.e. with the move from the first to the second situation) process B is transferred to a newly industrialized country. Since B is relatively unskill-intensive this is associated with a rise in the relative skill intensity of domestic production, a fall in the domestically produced output, and an increase in the imports of intermediate goods. This is basically what we have modelled with ΔS_{fci}. This is the simplest and most transparent representation of outsourcing, but it is by no means the single form it can take.

From the second to the third situation the assembly process is moved to the newly industrialized country. This means that the output of C and D has to be first exported and then reimported coupled with the output of A and B. Thus, in this case outsourcing entails an increase in the exports of intermediate goods, rather than in the imports. Actually the imports of intermediate products might even fall because the assembled product may move into the category "final goods" and reenter the country as such. This is what we assumed implicitly in drawing the lines indicating trade flows and the comments associated with the moves across situations in the figure. We should note however that the output obtained from the assembly process may be also an intermediate. Remember that the Feenstra-Hanson measure includes also finished goods. The Schott measure includes only parts and components, but many of these are complex enough to be assembled at some stage out of smaller parts and components. If the output obtained with the assembly process is also an intermediate then the imports of intermediate goods would rise as a whole in this stage.

It should be also noted that the prediction of rising exports and imports associated with the move of C and D to the newly industrialized country and back hinges on the assumption that the output associated with these goods is material. In fact, the output of stages C and/or D may partially consist of intellectual property - marketing ideas and strategies, product design and technology descriptions, and so on. In this case we would not observe changes in trade flows associated with the export and reimport of the C and D products. Although intellectual property is certainly important there is evidence that non-negligible amounts of material products are exported and then reimported back after being partially processed abroad. As BBG note for the case of the US this are mainly the products entering under items 806 and 807, schedule 8 of the Tariff Sched-

Figure 5.4.3: Implications of outsourcing for the observed trade flows, two partner countries.



Notes: Solid arrows indicate trade in parts and components. Dashed arrows indicate trade in finished products. Superscripts indicate trade partners: 1 = home country (developed); 2 = foreign country (newly industrialized). Subscripts: P = parts; F = finished products; M = imports; X = exports. "Imports" and "exports" are defined from the point of view of the "home" country 1.

ule of the United States.[102] In 1987 the value of such products entering the US amounted to 68.6 billion dollars (BBG 1993:20). This suggests to consider the increase in the exports of intermediate goods as a potentially important indicator of outsourcing. In this respect it is useful to remind the results of Bernard and Jensen (1997). Although they do not explicitly distinguish between intermediate and final goods they find that "increases in employment at exporting plants contribute heavily to the observed increase in relative demand for skilled labor in manufacturing during the period", Bernard and Jensen (1997:3, abstract).

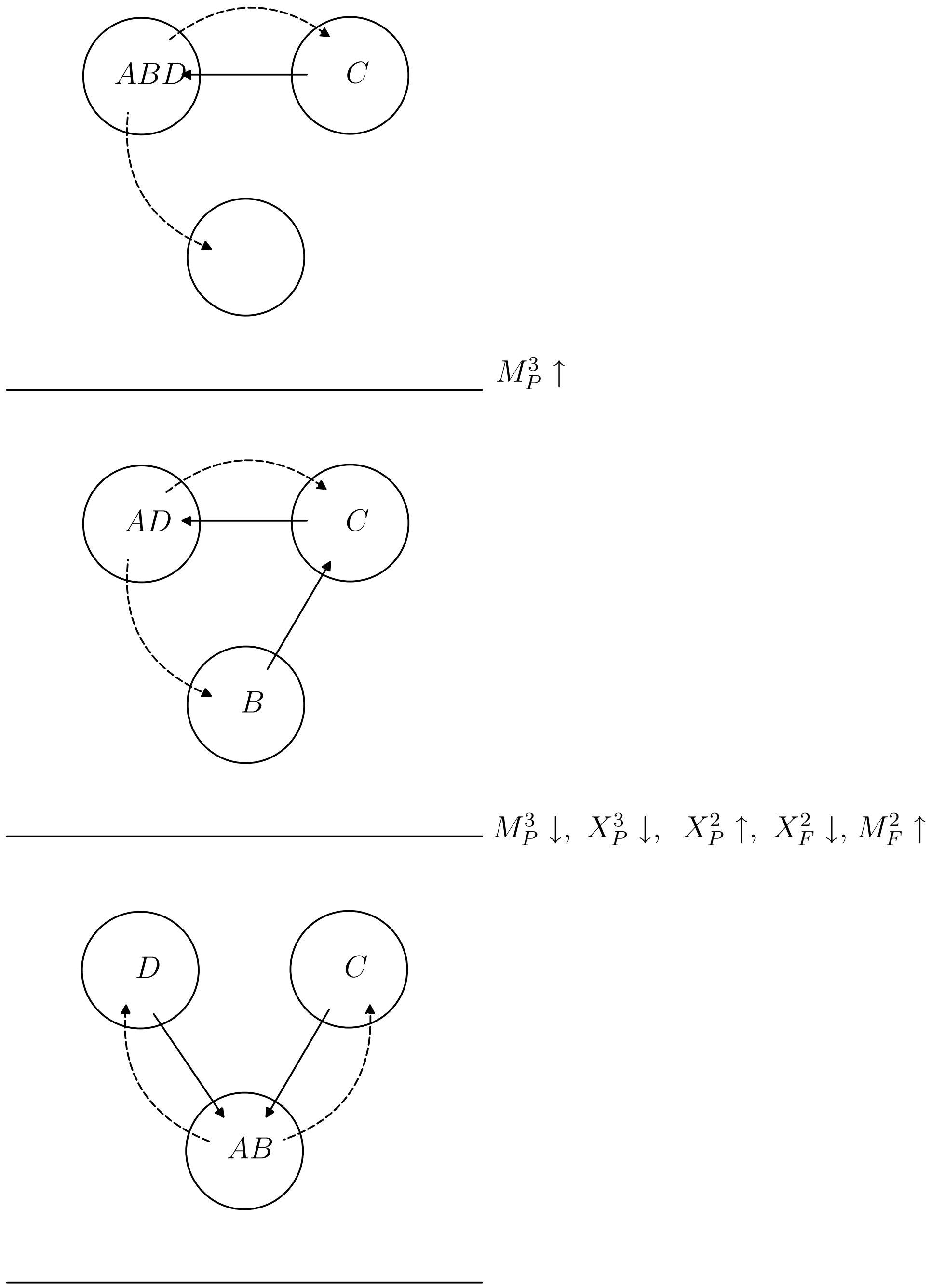
From the third to the fourth situation also process C is moved to the newly industrialized country. This time the exports fall. In practice we would expect the changes associated with all of the stages in figure 5.4.3 to occur simultaneously in an industry, carried out by different firms. The issue is further complicated if one takes into account that the processes can be allocated to more than two countries. In figure 5.4.4 we have added one more developed country, where process C is performed initially. Consider now a relocation of process B to the newly industrialized country as in the first stage of figure 5.4.3 assuming that C is a further-processing of the product obtained from B. The implications for all the observable variables are exactly the same as in figure 5.4.3 except that the increased imports of intermediate goods originate now from a developed country, not a newly industrialized. The second stage in figure 5.4.4 associated with the relocation of the assembly process into the newly industrialized country has the most complex consequences for the observed trade flows across the three countries. These are summarized to the left of the line dividing the two situations in figure 5.4.4 from the point of view of the home (north-west) country under the assumption that the finished product obtained after the assembly process is consumed in all three countries and that the amounts consumed do not change.

Finally, it should be noted hat trade costs limit the possibility of a given good to cross borders many times. This is the central idea behind the gravity approach. It predicts that the trade flows between "close locations" will be most intensive.[103] Figures 5.4.3 and 5.4.4 are suggestive, but by no means exhaustive in illustrating the possible implications of outsourcing for the observed trade flows. It is easy to sketch a variety of situations involving different allocations of production processes across countries and derive from this a variety of complex changes in trade flows as a result of the relocation of a single process. Still, I believe that most of the outsourcing from the point of view of a source country can be tracked as an increase in the imports of intermediate goods as suggested in the first stage

[102] Currently this is provision 9802 of the Harmonized System code, s. Feenstra, Hanson and Swensson (2000)

[103] For a recent application of the gravity approach and estimates of trade costs see Anderson and Wincoop (2004).

Figure 5.4.4: Implications of outsourcing for the observed trade flows, three partner countries.



Notes: Solid arrows indicate trade in parts and components. Dashed arrows indicate trade in finished products. Superscripts indicate trade partners: 1 = home country (developed); 2 = foreign country (newly industrialized); 3= foreign country (developed). Subscripts: P = parts; F = finished products; M = imports; X = exports. "Imports" and "exports" are defined from the point of view of the "home" country 1.

of figure 5.4.3. In addition, the results in Bernard and Jensen (1997) and the high imports under the offshore assembly program 9802 (formerly items 806 and 807, schedule 8 of the Tariff Schedule of the United States) suggest that increasing exports may also be taken as an important indicator of outsourcing. Since data on the exports of intermediate goods are not available I shall include the change in the industry export share as an additional regressor. This variable has been introduced by Autor, Katz and Krueger (1998). It is defined as the ratio of exports to value of shipments. While this measure is affected also by other factors we would expect outsourcing to have a particularly strong effect since it would simultaneously increase the exports and decrease the domestic sales of an industry. Because of the possibility of reexport illustrated in figure 5.4.4 and data limitations I did not attempt to differentiate trade flows by partner country in the analysis here.

5.5 Estimation results, interpretation and sensitivity analysis

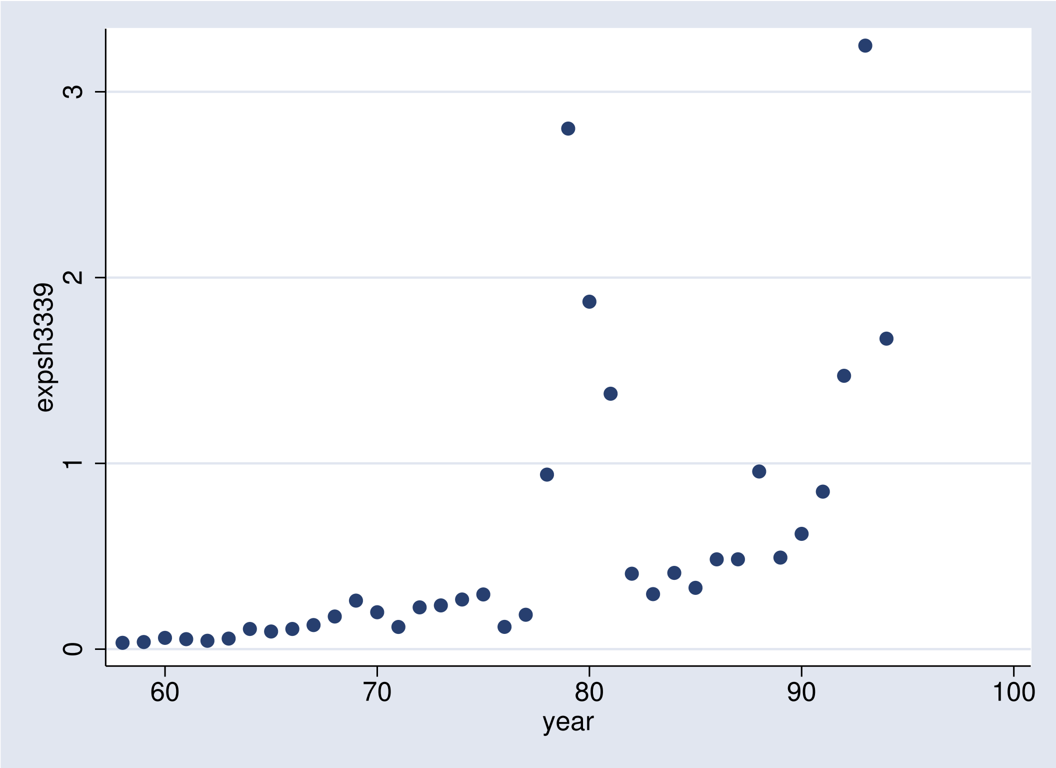
5.5.1 Summary statistics on the sample obtained with the Feenstra-Hanson data

As explained in Section 5.2 data on *imppts* are available for a restricted number of industries, implying that my analysis will be based upon different samples. When using the Feenstra-Hanson data (*intimp*) in constructing ΔS_{fci} the sample consists of all manufacturing industries in the current SIC 1972 Version of the NBER MPD, except four - SIC 3398, SIC 3399, SIC 3573 and SIC 3339. Thus, for each period, the sample consists of 444 industries.[104]

The first three industries are dropped due to data limitations. SIC 3398 and SIC 3399 were lost in matching $fwshare$ with the other data as explained in 5.2. SIC 3339 "Primary smelting and refining of nonferrous metals, not elsewhere classified" is omitted due to its badly measured export share - the value of ΔS_x for this industry is 36.81 in the 1972-1979 period and -28.98 in the 1979-1987 period (there are no other industries with such extreme values as can be seen in Tables 5.7.1 and 5.7.3). Figure 5.5.1 plots the export share of this industry for all available years. Obviously there are some years (among these 1979 that marks the break between the two periods considered) in which unusually high amounts of goods produced by other industries have been exported under the category "not elsewhere classified". It should be noted that the omission of SIC 3339 has an

[104] I obtain very different results for the two periods as we shall see in a moment. Accordingly, I do not estimate pooled specifications across periods as AKK did (s. columns 1-5 in their Table VIII).

Figure 5.5.1: The badly measured export share of SIC 3339

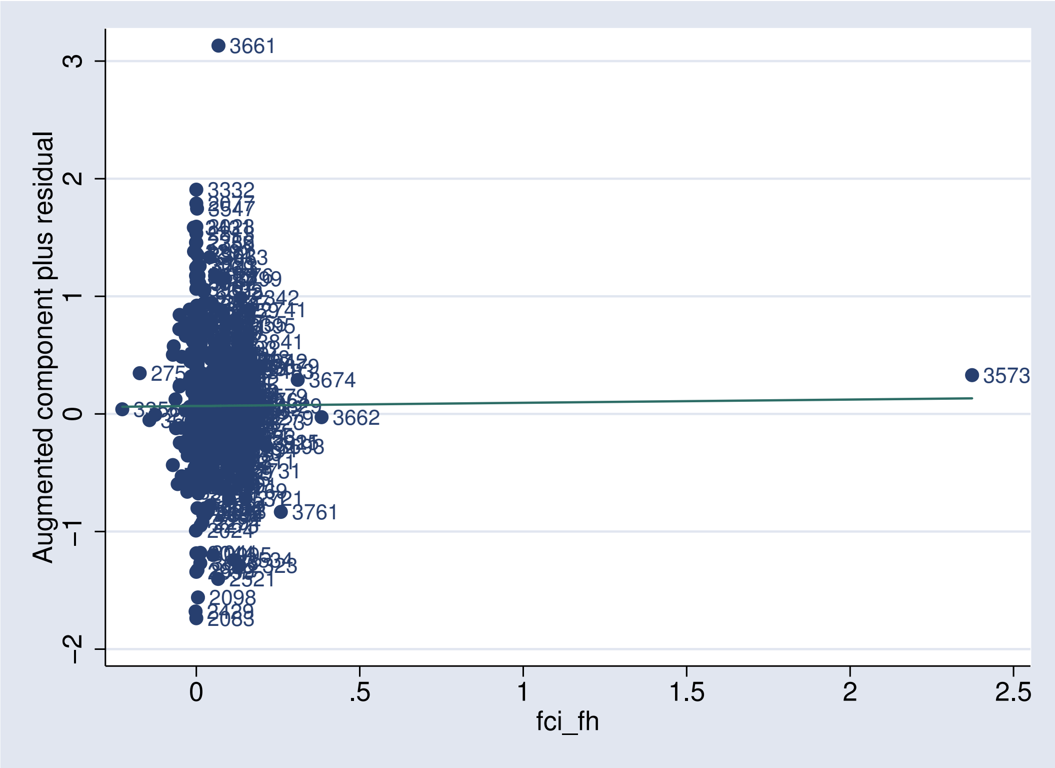


important effect on the coefficient estimates on ΔS_x, but almost no effect on all other results.

Unlike the previous three, the forth industry SIC 3573 "Electronic Computing Equipment" is a highly influential observation. We have already seen how its omission affected the results in Tables 5.3.1 and 5.3.2. In fact, this industry has extreme values on almost all of the variables used in the cost-share regression. For example in the 1979-1987 period this industry has the highest change in output, $\Delta Log(Y) = 27.04$, the lowest change in capital intensity, $\Delta Log(K/Y) = -15.61$, the highest computer investment per employee, $CI/E = 1.46$, the second highest computer investment share, $CI/I = 0.21$, the highest estimated outsorced share, $O_{sh} = 0.33$, and the highest skill upgrading implied by the factor content of intermediate imports, $\Delta S_{fci} = 2.37$. In addition of representing the top or the bottom of the corresponding distributions these values are often quite far away from the next top or bottom values. Figure 5.5.2 illustrates this for the case of ΔS_{fci}, the other values can be compared with those in Tables 5.7.1 and 5.7.3.

The mere fact that SIC 3573 "Electronic Computing Equipment" is an outlier does not necessarily mean that we should drop it from the sample. In fact, obser-

Figure 5.5.2: The outlier-ness of SIC 3573



Notes: The figure represents an adjusted components-plus-residual plot (s. "regression diagnostocs" in Stata Base Reference Manual) from a regression as in column (5) of Table 5.5.1 including also SIC 3573 and SIC 3339 - a total of 446 observations. ΔS_{fci} is on the horizontal axis.

vations with extreme x's may be viewed as particularly useful.[105] However, SIC 3573 is such an extreme outlier that we have a good reason to suspect that its values have not been generated by the same model as those of all other industries. In particular, I do not expect the simple model of plants relocation upon which $\Delta S_{fci} = 2.37$ is based to provide a good approximation for the effect of outsourcing in that industry, because of its extraordinary growth in output. It should be noted that BBG also considered excluding that industry. As they write (s. BBG, 1993, p.23, footnote 24): *"The computer investment industry shows a growth in output unmatched by any growth in inputs. One plausible explanation for this phenomenon is that input and output deflators have not been correctly matched."* They report their results to be robust to the omission of that industry and finally keep it in the sample (op.cit.). As I have shown in Section 5.3 this is not true for all of their results. In light of all this I have decided to drop SIC 3573 from

[105]as Wooldridge, 2003,p.56, puts it "more variability in the independent variable is preferred". Although this statement is made in the context of exogenous regressors and homoscedasticity it is intuitively appealing in more general cases.

the sample. Tables 5.7.1 and 5.7.3 present summary statistics on the samples obtained in this way for the 1972-1979 and the 1979-1987 periods respectively.

5.5.2 Summary statistics on the sample obtained with the Schott data

As explained in Section 5.2 when using the Schott data (*intimp*) the sample consists of all industries except those with missing values on *impppts*, those without one-to-one correspondence in their 1972 and 1987 SIC codes, and those missing in the SIC72-ISIC2 concordance (s. Table 5.7.5).[106] In addition, when using the Schott data, I drop SIC 3565 "Industrial Patterns". As explained in Section 5.2 this is the only industry for which, during the periods considered, the imports of parts *impppts* exceed total non-energy material purchases - an obvious indication that a large part of the imported parts are used by other industries. This is also the only industry for which the estimated O_{sh} is so large that the implied end-of-period wage bills in Eq. 5.4.4, $W_n^0 - \Delta W_n$ and $W_p^0 - \Delta W_p$, happen to be negative. Tables 5.7.2 and 5.7.4 present summary statistics on the samples obtained in this way for the 1972-1979 and the 1979-1987 periods respectively.

[106] In fact SIC 3573 and SIC 3339 are dropped already on these criteria, so there is no need to delete them extra here.

5.5.3 Initial results for the periods 1972-1979 and 1979-1987. Comparison with previous work

Although, in my opinion, the change in the log of output and capital should not be included in the regressions for the reasons explained in Section 5.1.3 I start reporting some results including them. The specifications in Table 5.5.1 are very close to those in AKK, Table VIII, columns (7) and (8). The main difference is that the Feenstra-Hanson measure of outsourcing is replaced everywhere with my new measure ΔS_{fci}, and that I experiment also with including computer investment per employee, CI/E, instead of the computer investment share, CI/I. Two further reasons for the results reported here to differ from those in AKK, are that the samples and the periods considered are not exactly the same. The most interesting facts in Table 5.5.1 can be summarized as follows.

1) Contrary to the impression conveyed by Table VIII of AKK, Table 5.5.1 reveals that there are very important differences across the periods. The key factor allowing to uncover these differences here is the redefinition of the periods[107], and not the the use of the new measure of outsourcing or the differences in the sample. In particular, the large differences in the coefficient estimates on the computer variables across the two periods remain when ΔS_o is used instead of ΔS_{fci} and/or when SIC 3573 and/or SIC 3339 are kept in the sample. In all these cases is the estimated impact of computers close to the corresponding values in Table 5.5.1 - i.e. it is much larger in the seventies as compared to the eighties.

2)The estimated impact of computers is smaller when computer investment is measured per employee as compared to the case when it is measured as a share of investment.[108] This appears to be a fairly general pattern across periods, samples and specifications considered. We shall uncover it also in most of the results reported later. At this stage it should be noted that the differences between the results obtained using CI/I and CI/E are much more pronounced for the 1972-1979 period than for the 1979-1987 period. This should not be surprising given our results in Section 5.3. In particular, when dropping output and capital from the regressions for the 1972-1979 period CI/E is insignificant using either of the samples in columns (3) and (4), while CI/I remains highly statistically significant with both samples.

[107] As explained the periods here correspond exactly to the business cycles while the analysis in AKK proceeds by decades

[108] Remember that CI/E is included in all regressions scaled in such a way that its weighted mean is the same as that of CI/I in the sample used for the estimation.

Table 5.5.1: Mean regressions including the change in output and capital intensity: 1972-1979 and 1979-1987.

	1972-1979				1979-1987			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CI/I	3.921***	5.453***			1.918	1.152		
	(1.394)	(1.303)			(1.411)	(1.499)		
$(CI/E) \times SF$			3.229*	4.029			1.098	−0.085
			(1.857)	(2.472)			(1.455)	(1.347)
$\Delta S_{fci}(FH)$	−0.038		0.112		0.171		0.330	
	(0.266)		(0.242)		(0.350)		(0.457)	
$\Delta S_{fci}(Schott)$		0.100		0.221		0.444*		0.457*
		(0.390)		(0.390)		(0.243)		(0.248)
ΔS_x	−0.007	0.085	−0.014	0.081	0.108*	0.128**	0.098*	0.117**
	(0.070)	(0.059)	(0.071)	(0.056)	(0.058)	(0.053)	(0.057)	(0.051)
$\Delta Log(K/Y)$	0.037***	0.045***	0.033***	0.039***	0.060***	0.054***	0.059***	0.060***
	(0.012)	(0.015)	(0.012)	(0.014)	(0.012)	(0.013)	(0.012)	(0.014)
$\Delta Log(Y)$	0.020*	0.011	0.011	0.004	0.023**	0.0179	0.022**	0.024**
	(0.012)	(0.011)	(0.012)	(0.013)	(0.010)	(0.011)	(0.010)	(0.012)
Constant	−0.051	−0.100*	−0.013	−0.047	0.260***	0.258***	0.285***	0.291***
	(0.051)	(0.057)	(0.051)	(0.059)	(0.044)	(0.054)	(0.038)	(0.046)
R^2	0.119	0.252	0.079	0.152	0.156	0.194	0.146	0.186
n	444	281	444	281	444	284	444	284

Notes: Dependent Variable is 100x(Annual Change in the Nonproduction Wage-Bill Share). All regressions are weighted by the average industry share of the total manufacturing wage bill in the two years used in constructing the dependent variable. Heteroscedasticity-robust standard errors are reported in parenthesis in all columns. Statistical significance at the 1, 5 and 10-percent level is indicated by three, two and one star(s) respectively after the coefficient estimate. The variables are defined as follows:
CI/I=Ratio of computer investment to total investment. For the 1972-1979 period CI/I is the 1977 computer investment share; for the 1979-1987 period CI/I is the 1982 computer investment share.
CI/E= Nominal computer spending per employee in thousands of dollars. It is obtained as $(CI/I) \times I/E$ where I is nominal investment in the year CI/I refers to and E is number of employees in the same year.
SF is a constant scale factor. It is obtained as the weighted mean of CI/I divided by the weighted mean of CI/E. It equals 0.581 in columns (1) and (3), 0.541 in columns (2) and (4), 0.293 in columns (5) and (7), and 0.289 in columns (6) and (8).
ΔS_{fci} is computed using Eqs. 5.4.3-5.4.6, s. Section 5.4; In columns (1)-(4) the variable is obtained using the Feenstra-Hanson data ($m = intimp$ in Eq. 5.4.3), in columns (5)-(8) it is obtained using the Schott data ($m = imppts$ in Eq. 5.4.3).
ΔS_x = 100× annual change in the exports-to-shipments ratio.
K/Y=Real capital stock to real shipments ratio.
Y=Real value of shipments.
Sources: Bartelsman and Gray (1996), Feenstra (1996), Autor Katz and Krueger (1998), Schott (2004). S. Section 5.2 for more details on the data used, and Sections 5.5.1 and 5.5.2 for the samples definition.

3) In no case are the computer investment variables significant in the 1979-1987 period. The main reason for this finding, which is in sharp contrast with the results in all previous applications is the fact that SIC 3573 is omitted here. A further reason is that computer investment is highly correlated with my new measure of the impact of outsourcing ΔS_{fci}. When SIC 3573 is included in columns (5) and (7) and ΔS_{fci} is replaced with the Feenstra-Hanson measure, ΔS_o, then the computer investment variables, CI/I and CE/E, are significant with coefficient and standard error estimates 1.92 (1.17) and 1.18 (.56) respectively.[109]

4) Quantitatively the constant term explains the largest part of the mean change in the dependent variable in the 1979-1987 period. Its coefficient estimate is about twice as large as in AKK, Table VIII, Column (8).

5) The coefficient on the export share for the eighties period is nearly twice as large as that in AKK, Table VIII, column (8). The coefficient on ΔS_{fci} is positive and significant in the eighties period when the Schott data are used, s. columns (6) and (8). Overall the role of trade during the 1979-1987 period appears stronger in light of Table 5.5.1 as compared to any of the previously known results.[110]

I proceed in the next section with a more detailed analysis focussing on the 1979-1987 period. I estimate various specifications using first Eq. 5.4.3 and then Eq. 5.4.7 in obtaining the measure of outsourcing ΔS_{fci}. With each equation I use the Schott and the Feenstra-Hanson data on intermediate imports interchangeably. I report results using CI/I and CI/E interchangeably as measures of technological change. Finally, I check wether the results are not driven by influential outliers.

I performed a similar analysis for the 1972-1979 period but it did not produce any additional insights. These unreported results confirm what can be seen in Table 5.5.1 already: both outsourcing and the export share have no explanatory power during that period, while the computer investment share (but not computer investment per employee) has.

These results for the 1972-1979 period are in line with those in the previous lit-

[109]When all trade measures are dropped in these columns as in BBG, i.e. the regression includes only computers and the changes in the log of output and capital intensity and the sample consists of 445 industries including SIC 3573, then the coefficients on CI/I and CE/E, each included separately, are 2.23 (1.16) and 1.64 (.52).

[110]The results in Feenstra and Hanson (1996) suggest an even stronger role of trade, but their regressions do not include any measure of technological change. When the computer investment share is included along with their outsourcing measures as in Feenstra and Hanson (1999), Table III, Column 4, the latter are insignificant.

erature. Feenstra and Hanson (1996) and AKK (1998) also find that their trade measures are irrelevant for predicting skill upgrading during that period. BBG and AKK also find that CI/I is a powerful predictor of skill upgrading during the seventies. What is new here is the finding that CI/E is not. Altogether this evidence should, in my opinion, not be interpreted in favor of the hypothesis that skill-biased technical change was a more important relative demand shifter than trade.

First, the analysis in Section 5.4 made it clear that that the performance of CI/I in the regressions for the seventies is due to a large degree to its denominator. This fact is difficult to reconcile with the view that CI/I proxies technological change during that period. One further argument against the latter view is that it is only since the beginning of the 1980's that computers at the workplace started to become widespread. In this respect it is useful to remind some important dates from the history of the computer industry: *"many observers date the beginning of the "computer revolution" to the introduction of the IBM-PC in 1981. This was followed by the IBM-XT (the first PC with built-in disk storage) in 1982 and the IBM-AT in 1984"*, the citation is from Card and DiNardo (2002:738).

A second argument for not putting too much weight on the cost-share regression results for the 1972-1979 period is that the aggregate trends in wage inequality and the relative supply of skilled labor were quite different during that period as compared to the 1979-1987. As we have seen in chapter 4 the skilled-unskilled wage differential was actually falling during the 1972-1979 period (s. also Fig. 2.4.2). These aggregate wage trends can be to a large extent attributed to the rapid increase in the supply of skills during that period. It is only after 1979 that the relative demand for skilled labor appears to have accelerated (s. Section 4.2.3) and became the dominant factor driving the skilled-unskilled wage differential. All this suggests a natural focus on 1979-1987 - the period in which almost the entire increase in the skilled-unskilled wage differential took place.

5.5.4 A more detailed analysis of the 1979-1987 period.

The results of this Section are organized in three Tables. In the first, Table 5.5.2, ΔS_{fci} is computed based on Eq. 5.4.3, in the second two, Tables 5.5.4 and 5.5.4, ΔS_{fci} is computed based on Eq. 5.4.7. Consider first Table 5.5.2. I would like to draw attention to the following facts:

1) The coefficient on ΔS_{fci} is always statistically significant except in column (4). Its magnitude is reasonably close to the theoretically expected value of one.

2) There appear to be some systematic differences between the sample obtained when using the Feenstra-Hanson and the sample obtained when using the Schott

data respectively, s. in particular the coefficient estimates on the export share. I shall discuss this bellow.

I move now on to interpret the results obtained with ΔS_{fci} computed based on Eq. 5.4.3. Since this formula attempts to remove the influence of product demand shocks on ΔS_{fci} it is perhaps more appropriate. These results are organized in two Tables. Table 5.5.4 summarizes the results with the Feenstra-Hanson data. Table 5.5.4 has the same structure, but is based on the Schott data. The following facts deserve attention:

1) The coefficient on ΔS_{fci} is positive and statistically significant in three of the four reported regressions including the changes in log-output and log-capital-intensity. Thus, the conclusions to follow do not hinge on the exclusion of the change in the log of output and capital intensity, s. also Columns (6) and (8) in Table 5.5.1.

2) The coefficient on ΔS_{fci} is positive and statistically significant in all regressions excluding the changes in log-output and log-capital-intensity. Its magnitude is particularly close to one in all regressions using the Schott data in constructing ΔS_{fci}.

3) The coefficient on the computer investment variables is statistically significant in only one case - when using CI/E with the Feenstra-Hanson data and excluding the changes in log-output and log-capital-intensity, s. Column (4) in Table 5.5.4. In one case it attracts a perverse negative sign, s. Column (6) in Table 5.5.4.

4) The change in the export share attracts a positive and statistically significant coefficient in all cases. The magnitude of the coefficient in the specifications excluding the changes in log-output and log-capital-intensity is 3-4 times larger as compared to the estimate of 0.066 obtained by Autor Katz and Krueger (1998) for the analogously defined variable, s. Autor Katz and Krueger (1998) column (8) Table VIII.

Table 5.5.2: Mean regressions, ΔS_{fci} based on Eq. 5.4.3, 1979-1987.

	ΔS_{fci} based on the Feenstra-Hanson data				ΔS_{fci} based on the Schott data			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CI/I			2.429				1.780	
			(1.522)				(1.555)	
$(CI/E) \times SF$				2.656*				1.527
				(1.514)				(1.395)
ΔS_{fci}	0.863**	1.056***	0.530*	0.415	0.664**	0.688**	0.573*	0.542**
	(0.355)	(0.374)	(0.307)	(0.398)	(0.274)	(0.292)	(0.296)	(0.266)
ΔS_x		0.181**	0.194***	0.178**		0.216***	0.235***	0.227***
		(0.075)	(0.076)	(0.072)		(0.083)	(0.081)	(0.080)
Constant	0.398***	0.403***	0.335***	0.330***	0.378***	0.383***	0.320***	0.332***
	(0.038)	(0.038)	(0.049)	(0.042)	(0.039)	(0.039)	(0.054)	(0.049)
R^2	0.024	0.047	0.068	0.068	0.021	0.071	0.096	0.087
n	444	444	444	444	284	284	284	284

Notes: Dependent Variable is 100x(Annual Change in the Nonproduction Wage-Bill Share). All regressions are weighted by the average industry share of the total manufacturing wage bill in the two years used in constructing the dependent variable. Heteroscedasticity robust standard errors are reported in parenthesis in all columns. Statistical significance at the 1, 5 and 10-percent level is indicated by three, two and one star(s) respectively after the coefficient estimate. The variables are defined as follows.
CI/I=Ratio of computer investment to total investment in 1982.
CI/E= Nominal computer spending per employee in thousands of dollars. It is obtained as (the value of CI/I)×(nominal investment in 1982 in millions of dollars)/(number of employees in thousands in 1982).
SF is a constant scale factor. It is obtained as the weighted mean of CI/I divided by the weighted mean of CI/E. It equals 0.293 in the sample using the Feenstra-Hanson data (columns 1-4), and 0.289 in the sample using the Schott data (columns 5-8).
ΔS_{fci} is computed using Eqs. 5.4.3-5.4.6, s. Section 5.4; In columns (1)-(4) the variable is obtained using the Feenstra-Hanson data ($m = intimp$ in Eq. 5.4.3), in columns (5)-(8) it is obtained using the Schott data ($m = imppts$ in Eq. 5.4.3).
$\Delta S_x = 100\times$ the annual change in the exports-to-shipments ratio.
Sources: Bartelsman and Gray (1996), Feenstra (1996), Autor Katz and Krueger (1998), Schott (2004). S. Section 5.2 for more details on the data used, and Sections 5.5.1 and 5.5.2 for the samples definition.

Table 5.5.3: Results with ΔS_{fci} based on Equation 5.4.7 and the Feenstra-Hanson data on intermediate imports, 1979-1987

	(1)	(2)	(3)	(4)	(5)	(6)
CI/I			2.169		1.514	
			(1.511)		(1.424)	
$(CI/E) \times SF$				2.361*		0.876
				(1.344)		(1.331)
S_{fci}	2.619***	2.954***	2.070**	2.055**	1.645	1.917*
	(0.961)	(1.000)	(0.964)	(1.027)	(1.009)	(1.043)
ΔS_x		0.177**	0.197***	0.187***	0.114*	0.106*
		(0.077)	(0.076)	(0.074)	(0.061)	(0.060)
$\Delta Log(K/Y)$					0.057***	0.056***
					(0.011)	(0.012)
$\Delta Log(Y)$					0.019**	0.020**
					(0.009)	(0.009)
Constant	0.388***	0.394***	0.331***	0.324***	0.264***	0.282***
	(0.033)	(0.033)	(0.048)	(0.043)	(0.045)	(0.038)
R^2	0.041	0.063	0.082	0.085	0.167	0.160
n	444	444	444	444	444	444

Notes: Dependent Variable is 100x(Annual Change in the Nonproduction Wage-Bill Share). All regressions are weighted by the average industry share of the total manufacturing wage bill in the two years used in constructing the dependent variable. Heteroscedasticity robust standard errors are reported in parenthesis. Statistical significance at the 1, 5 and 10-percent level is indicated by three, two and one star(s) respectively after the coefficient estimate.
ΔS_{fci} is obtained using Eqs. 5.4.7, 5.4.4, 5.4.6 and the Feenstra-Hanson data on intermediate imports ($m = intimp$ in Eq. 5.4.7). All other variables are as defined in Table 5.5.2.
Sources: Bartelsman and Gray (1996), Feenstra (1996), Autor Katz and Krueger (1998), Schott (2004). S. Section 5.2 for more details on the data used, and Sections 5.5.1 and 5.5.2 for the sample definition.

Table 5.5.4: Results with ΔS_{fci} based on Equation 5.4.7 data on intermediate imports, 1979-1987

	(1)	(2)	(3)	(4)	(5)	(6)
CI/I			1.739		1.172	
			(1.549)		(1.488)	
$(CI/E) \times SF$				1.344		−0.205
				(1.426)		(1.371)
S_{fci}	1.043***	1.040***	0.885**	0.802**	0.621*	0.640*
	(0.353)	(0.358)	(0.390)	(0.388)	(0.348)	(0.377)
ΔS_x		0.213**	0.231***	0.222***	0.127**	0.114**
		(0.084)	(0.081)	(0.080)	(0.053)	(0.051)
$\Delta Log(K/Y)$					0.052***	0.060***
					(0.013)	(0.014)
$\Delta Log(Y)$					0.017	0.024**
					(0.011)	(0.011)
Constant	0.375***	0.380***	0.319***	0.335***	0.259***	0.295***
	(0.039)	(0.039)	(0.054)	(0.048)	(0.054)	(0.046)
R^2	0.029	0.077	0.101	0.089	0.195	0.186
n	284	284	284	284	284	284

Notes: Dependent Variable is 100x(Annual Change in the Nonproduction Wage-Bill Share). All regressions are weighted by the average industry share of the total manufacturing wage bill in the two years used in constructing the dependent variable. Heteroscedasticity robust standard errors are reported in parenthesis. Statistical significance at the 1, 5 and 10-percent level is indicated by three, two and one star(s) respectively after the coefficient estimate.
ΔS_{fci} is obtained using Eqs. 5.4.7, 5.4.4, 5.4.6 and the Schott data on intermediate imports ($m = impptsp$ in Eq. 5.4.7). All other variables are as defined in Table 5.5.2.
Sources: Bartelsman and Gray (1996), Feenstra (1996), Autor Katz and Krueger (1998), Schott (2004). S. Section 5.2 for more details on the data used, and Sections 5.5.1 and 5.5.2 for the sample definition.

At this stage I would like to compare the two samples - the full sample of 444 industries with the Feenstra-Hanson data on one hand (s. Section 5.5.1) and the sub-sample of 284 industries with the Schott data on the other hand (s. Section 5.5.2). These samples differ in two aspects. First, although having the same values for each industry most variables have slightly different means in both samples. Most pronounced are the differences in the mean of ΔS_x and $\Delta Log(Y)$. This raises the question whether there are some systematic differences in the two samples and if yes, how can these be explained? Second, obviously the variable ΔS_{fci} is different. It is based on two completely different data sources.

Consider first the sample selection issue. Two types of industries are deleted to obtain the Schott-sub-sample. First, this are industries that changed codes from 1972 SIC to 1987 SIC. These are perhaps randomly selected. Second, this are industries with missing values for *imppts*, s. Section 5.2.5. Here there is perhaps a systematic component. The fact that within the 7-digit TSUSA product codes assigned to a given 4-digit SIC industry there are such with the word "parts" in its description can be taken as an indication that, other things being equal, this (4-digit SIC) industry is more prone to outsourcing. In this respect it is very interesting to compare the coefficient estimates on the export share in the two samples. Throughout the Tables in this Section the coefficient estimate on ΔS_x is larger in the sample based on the Schott data as compared to the sample based on the Feenstra-Hanson data. Note also that the mean of that variable is higher in the first sample, s. Tables 5.7.3 and 5.7.4. This suggests that exports of parts may represent an important form of outsourcing (s. also figures 5.4.3 and 5.4.4). Unfortunately, using aggregate industry export data rather than data on the exports of intermediate goods we can account for this phenomenon only very crudely. Still, the aggregate data reveal that an increasing export share is associated with higher rates of skill upgrading.

Another interesting difference between the two samples relates to the mean change in the (real) value of shipments: it is 1.13 log points annually in the full sample, s. Table 5.7.3, and only 0.65 log points annually in the sample based on the Schott data, s. Table 5.7.4. This fact again fits nicely the hypothesis that outsourcing is associated with lower output growth (s. Section 5.4 and that the Schott sample might select industries that are more prone to outsourcing.

Consider now the differences in the measure ΔS_{fci} based on the two types of data on intermediate imports. It can be argued that the Schott data provide a better measure of the extent of outsourcing at the industry level, because they measure the imports of products classified strictly to the same 4-digit SIC industry. By contrast,the Feenstra-Hanson data measure the imports of products estimated to be used, but not necessarily currently or previously produced, by a given 4-digit industry. Although in general we would expect increased use of intermediate imports by a given industry to be associated with relocation of production abroad of the same industry we should expect the corresponding relationship to be stronger when only products that can be classified to the same industry according to their product characteristics are considered. In the latter case we can be pretty confident that, if previously domestically produced, these products were produced in establishments assigned to the same 4-digit industry. Thus, I believe that conceptually the Scott data are better suited to construct ΔS_{fci}. Since I use the Feenstra-Hanson data for that purpose as well, I believe that they are also suited but, in addition to the desired information, they contain more noise. In this context it should be not seen as a surprise that the coefficient estimates on ΔS_{fci} come closer to the theoretically expected value of one when using the Schott data.

5.5.5 Sensitivity analysis and evidence on the correlation between the effect of outsourcing, ΔS_{fci}, and computer investment, CI/I

Even though obtained using two different objective functions in computing the coefficient estimates (Least Squares and Least Absolute Deviations), two different weighting schemes (weights proportional to industry size and no weights), two alternative data sources in constructing the measure of outsourcing ΔS_{fci} (*imppts* and *intimp*) and two samples (444 and 284 industries) the results presented so far create a more or less uniform picture for the effects of the trade and technology variables. This fact alone implies already certain "robustness" of these results. Nevertheless I performed a systematic analysis in order to detect observations with potentially strong influence on the estimates on the other hand. To this end I employed the tools recommended in the Stata Base Reference Manual under the heading "regression diagnostics", s. Stata Base Reference Manual. These include various diagnostic plots such as residual-versus-fitted, L-R, Added-variables, Component-plus-residual, Residual-versus-predictor[111], and various statistics which can be obtained with the *predict* command after *regress* such as leverage, studentized residuals, DFITS, Cook's and Welsh distance, Covratio and DFBETAs. It should be noted that some of these statistics are not available after robust estimation (i.e. after linear regression with heteroscedasticity-robust standard errors) and/or after weighted regression in Stata. In the cases in which I considered it meaningful I re-estimated the model such that the desired option became available.

After long experiments with deleting the "suspicious" observations one by one or several at a time I was not able to detect any influential observations deserving elimination from the sample except SIC 3339 and SIC 3573 which have been excluded from the outset, s. Sections 5.5.1 and 5.5.2. A complete description of these experiments would increase unduly the volume of the present study so I report them selectively.

Before reporting these experiments however I should note that deleting "suspicious" observations once they are identified is not always the best strategy. In any case this should be preceded by an analysis of the potential reasons for the observation to deviate from the common patterns. An interesting example in that context is SIC 3661 "Telephone and telegraph apparatus". This is the observation with the highest residual in most regressions when using the Feenstra-Hanson data and Eq. 5.4.3 to construct ΔS_{fci} (this is also the industry with highest value

[111]In addition to being useful for identifying outliers some of these plots allow also to detect potential violations of the basic regression assumptions. Indication of such violations was not discovered.

of the dependent variable as can be seen in Table 5.7.3). At the same time the other industry in the three digit group SIC 3662 "Radio and television transmitting, signaling, and detection equipment and apparatus" is the observation with highest ΔS_{fci}, s. Table 5.7.3. The two observations can be identified also in figure 5.5.2. The facts that on one hand SIC 3661 is the observation with skill-upgrading that we most under-predict, while on the other hand SIC 3662 is the observation for which we predict the highest skill upgrading based on the intermediate imports suggests merging them into a single (3-digit) industry with code 366 rather than deleting one or both of them. The motivation for this arises from the probability that the imports of intermediate goods may have been incorrectly assigned to these two industries - it appears likely that some of the imports to 3661 have been assigned to 3662. When merging these two industries the resulting SIC 366 is no more so outlying - its ΔS_{fci} is 0.26 (By contrast,SIC 3662 has $\Delta S_{fci} = 0.38$).

Still, the merged three digit SIC 366 has one of the highest ΔS_{fci} suggesting that outsourcing may be quite important for that industry. In this respect it is interesting to note that Berman, Bound and Griliches (1993), focussing on the value of total imports, use this industry as an example of high skill upgrading and low imports. After having listed the industries with top contribution to within industry skill upgrading they write: *"while some of the industries represented are large importers (e.g., semiconductors, SIC 3674), other are not (e.g., newspapers, SIC 2711; aircraft, SIC 372; telecommunications, SIC 366)"*, s. Berman, Bound and Griliches (1993:16). It should be noted that the three industries belonging to the three digit SIC 372, SIC 3721 "Aircraft", SIC 3724 "Aircraft engines and engine parts", and SIC 3728 "Aircraft parts and auxiliary equipment, not elsewhere classified" also have all relatively high predicted skill upgrading based on their intermediate imports. With respect to their ΔS_{fci} computed based on Eq. 5.4.3 and using the Feenstra-Hanson data for example these three industries rank respectively 50-th, 90-th and 33-th among the 444 industries in the sample. Based on the Schott data SIC 3728 is the industry with second highest ΔS_{fci}, s. Table 5.7.4.

These examples illustrate how important the focus on intermediate imports versus total imports might be for uncovering the effect of trade on skill upgrading. In addition, putting the skill intensity of domestic production in relation to that of the imported goods is a critical advantage of the measure ΔS_{fci} introduced here. In fact, one of the most interesting findings of my analysis may be considered the fact that ΔS_{fci} is highly correlated with the computer investment measures. Table 5.5.5 summarizes the correlations between computer investment variables used in the regression analysis here on one hand and three measures of outsourcing on the other: ΔS_{fci} computed with the two alternative formulas and the measure of outsourcing introduced by Feenstra and Hanson (1996). It can be seen that the Feenstra-Hanson measure is only weakly correlated with the two indicators of technical change which is line with the treatment of trade and technical change as competing explanations for the increasing demand for skilled labor. By contrast my new measure of outsourcing is highly correlated with both technology measures suggesting that outsourcing and technical change should be seen not as competing, but rather as complementary explanations. I come back to that point in the conclusion to this chapter.

Table 5.5.5: Correlations between computer investment and outsourcing.

	ΔS_{fci} (based on Eq.5.4.3)	ΔS_{fci} (based on Eq.5.4.7)	ΔS_o
CI/I	0.55	0.45	0.09
CI/E	0.62	0.43	0.04

Notes: All correlations are weighted by the average industry share of the total manufacturing wage bill in 1979 and 1987. ΔS_{fci} is obtained using the Feenstra-Hanson data and the formula indicated. ΔS_o is the 1979-1987 change in the Feenstra-Hanson measure of outsourcing, the share of imported intermediate goods in total non-energy material costs (*intimp/neinp*). The variables CI/I and CI/E are as in Table 5.5.2. Sample: 444 industries as described in Section 5.5.1.

One way to control for the influence of outliers is to estimate quantile regressions. Quantile regressions feature certain robustness against observations with large residuals (in particular, "any fit is completely unaffected by any change in the data where the x-values remain the same and the y-values change so as to maintain the *same* signs of the residuals", emphasis in the original, Bloomfield and Steiger, 1983, p. 52). I have reestimated all specifications in Tables 5.5.2, 5.5.4 and 5.5.4 as median regressions and obtained similar coefficients estimates. I do not report these results here because they have no clear-cut interpretation in the present context (the industry data used here represent grouped firm-level data; estimating quantiles on such data is not particularly meaningful). Instead, I report the results from deleting specific potentially influential observations. I focus on observations with extreme values on particular x-variables and such with high leverage. I concentrate on the results of a regression as in column (3) in table 5.5.4 and in table 5.5.4, which may be considered my base specification.

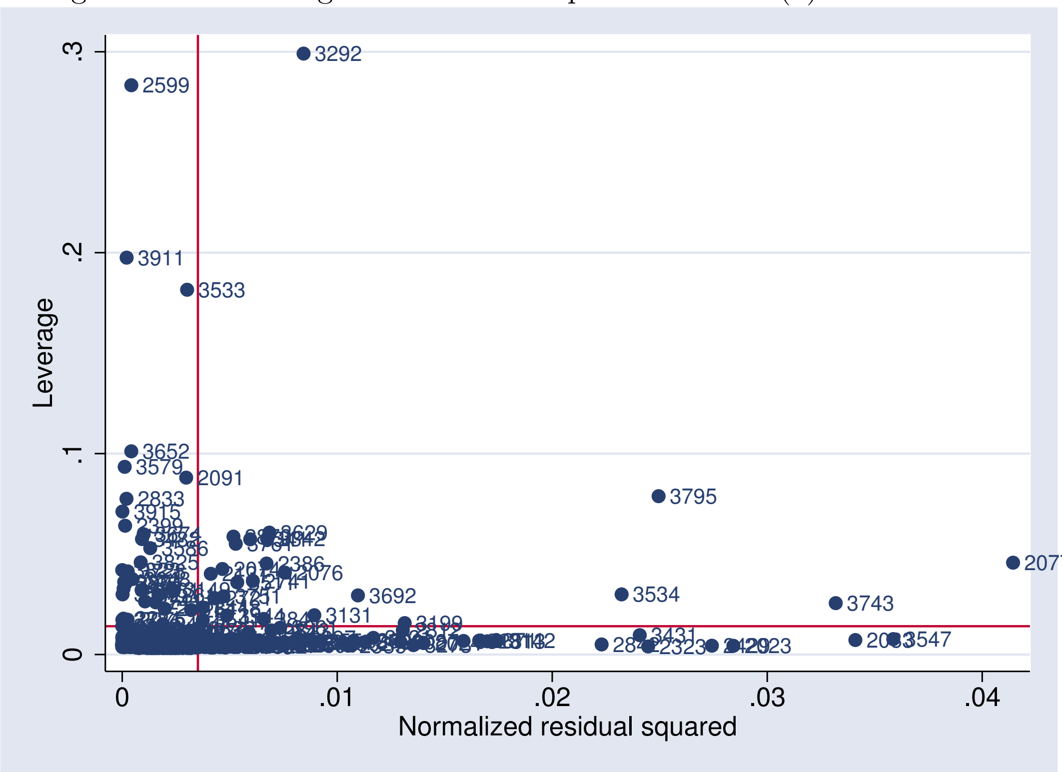
Consider first the regression results with the Schott data. The descriptive statistics allow to immediately identify three outlying observations: SIC 3911 and SIC 3915 with their low ΔS_{fci}'s (which are actually due to their low O_{sh}'s) and SIC 2599 with its high ΔS_{fci} (also due to a high O_{sh}). Dropping these three industries from the sample and re-estimating the regression in column (3) Table 5.5.4 produces the following results:

$$\Delta SHARE \; = \underset{(1.57)}{1.70} \; (CI/I) + \underset{(0.52)}{0.99^{*}} \; (\Delta S_{fci}) + \underset{(0.08)}{0.23^{***}} \; (\Delta S_x) + \underset{(0.05)}{0.32^{***}} \tag{5.5.1}$$

$$R^2 = 0.10, \quad n = 281$$

We see that the results are almost unaffected. The coefficient on ΔS_{fci} is now even closer to the theoretically expected value of one and still statistically significant. The results are almost identical also when dropping each of these industries separately or if resetting all negative O_{sh} to zero (when this is done SIC 3911 and SIC 3915 are no more outlying). Figure

Figure 5.5.3: Leverage versus residual plot to column (3) in Table 5.5.4



Notes: This figure has been generated in Stata using the command *lvr2plot*, s. the chapter "regression diagnostics" in Stata Base Refrence Manual. It should be noted that this command is not allowed after robust estimation (i.e. with heteroskedasticity-robust standard errors) so the regression in Column (3), Table 5.5.4 has been re-estimated without this option (but with weights) and the plot has been obtained based on that regression. The latter regression produces exactly the same coefficient estimates and very similar standard errors as the original regression reported in column (3), Table 5.5.4.

5.5.3 represents a leverage-versus-residual plot for the regression as in column (3) Table 5.5.4 (s. the note to that Table).[112] In addition to SIC 2599, SIC

[112]As suggested for example by Friendly (2005), s. its Section 3.3 "Leverage and Influence diagnostics" the studentized residuals might be more useful on the horizontal axis of such a plot. However, obtaining studentized residuals is not supported in Stata after weighted regression.

3911 which we identified already with the descriptive statistics in 5.7.4 this figure allows to identify SIC 3292, and SIC 3533 as potentially influential with their high leverage. Dropping these industries separately or simultaneously with the others has again a minimal effect on the estimates. For example, dropping the four observations outlying with their leverage and/or ΔS_{fci} SIC 3292, SIC 2599, SIC 3911, SIC 3533 and SIC 3915 and the two observations with simultaneously high leverage and high residuals SIC 3795 and SIC 2077 and re-estimating the regression in column (3) Table 5.5.4 produces the following results:

$$\Delta SHARE = \underset{(1.55)}{1.70}\ (CI/I) + \underset{(0.52)}{1.02^{*}}\ (\Delta S_{fci}) + \underset{(0.10)}{0.25^{**}}\ (\Delta S_x) + \underset{(0.05)}{0.31^{***}} \tag{5.5.2}$$

$$R^2 = 0.09, \quad n = 277$$

Consider now the results obtained with the Feenstra-Hanson data. The descriptive statistics in Table 5.7.3 do not allow to identify any industry that stands apart with respect to any of the x-variables (I report the lowest and the highest three observations for each x, but I looked also at the lowest and the highest ten to obtain a better idea of whether observations actually "stand apart"). SIC 3356 and SIC 2283 are outstanding with their low O_{sh} based on Eq. 5.4.3 but when using Eq. 5.4.7 to compute O_{sh} as in column (3) of Table 5.5.4 only SIC 2283 is outlying. However, we do not seek influential observations among those with low O_{sh} because the results are robust to resetting all negative O_{sh} to zero as already noted. Figure 5.5.4 allows to identify high leverage points that are potentially influential. Two observations stand out with their high leverage - SIC 3636 and SIC 3292. Dropping them separately or individually has no significant effect on the results (neither in terms of magnitude nor significance level of all coefficients). Further, observations with high leverage are SIC 3533, SIC 3942, SIC 3483 (the last two almost coincide on the graph), SIC 2791 and SIC 3769. Dropping all the seven observations with highest leverage produced the following results:

$$\Delta SHARE = \underset{(1.71)}{2.37}\ (CI/I) + \underset{(1.03)}{1.93^{*}}\ (\Delta S_{fci}) + \underset{(0.10)}{0.17^{***}}\ (\Delta S_x) + \underset{(0.05)}{0.32^{***}} \tag{5.5.3}$$

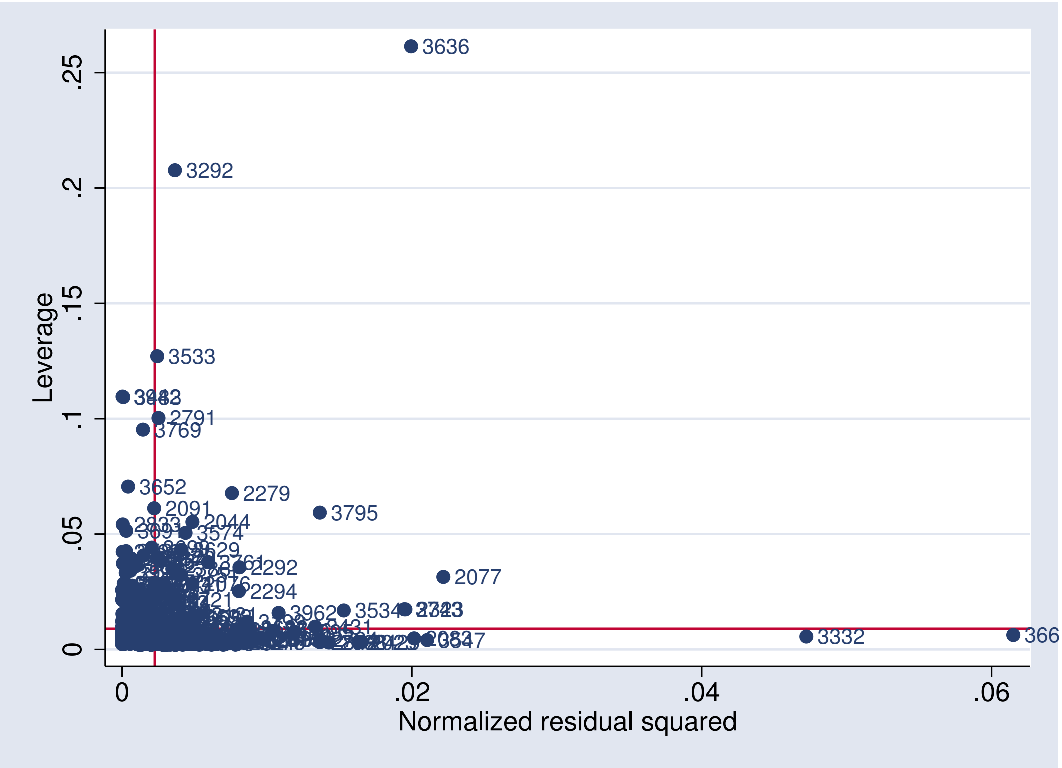
$$R^2 = 0.08, \quad n = 437$$

Dropping these observations individually or successively did not lead to significantly different results either. The plot allows to identify also three observations that have simultaneously relatively high leverage and residual: SIC 2279, SIC 3795 and SIC 207. Dropping these individually or together with the others had no significant effect either. For example, dropping the seven highest leverage point and the last three observations we obtain:

$$\Delta SHARE = \underset{(1.70)}{2.32}\ (CI/I) + \underset{(1.03)}{2.09^{**}}\ (\Delta S_{fci}) + \underset{(0.10)}{0.21^{**}}\ (\Delta S_x) + \underset{(0.05)}{0.32^{***}} \qquad (5.5.4)$$

$$R^2 = 0.08, \quad n = 434$$

Figure 5.5.4: Leverage versus residual plot to column (3) in Table 5.5.4



Notes: This figure has been generated in Stata using the command *lvr2plot*, s. the chapter "regression diagnostics" in Stata Base Reference Manual. It should be noted that this command is not allowed after robust estimation (i.e. with heteroskedasticity-robust standard errors) so the regression in Column (3), Table 5.5.4 has been re-estimated without this option (but with weights) and the plot has been obtained based on that regression. The latter regression produces exactly the same coefficient estimates and very similar standard errors as the original regression reported in column (3), Table 5.5.4.

5.6 Conclusion to Chapter 5

Overall the results presented here suggest that trade has played a significant role in raising the relative demand for skilled labor, and its role has been more important than suggested by previous applications of the cost-share regression. The discussion in sections 5.1 and 5.4, s. also figures 5.4.3 and 5.4.4 made it clear how difficult might be to find a direct link between particular changes in the trade flows and the relative labor demand. In light of this discussion the obtained results should be seen as strong evidence in favor of the role of trade. In fact, the results could hardly be more favorable for the hypothesis that trade matters. The variable constructed as a measure of the change in the non-production wage-bill share implied by the observed changes in intermediate imports attracts a coefficient close (in the base specification very close) to the theoretically expected value of one. Independent of this the export share also has explanatory power throughout specifications.

One possible objection against attributing an important role to trade based on the presented results might be that the mean values of both variables in the samples are low so that actually they "explain" only a small fraction of the mean change in the dependent variable. In Section 5.4, however, I argued against using such calculations to separate the contribution of trade and technical change by assigning each a given percentage value. In addition to the reasons outlined there, one can also point out the fact that such calculations based on the cost-share regression decompose only the within-industry component in skill upgrading, ignoring the between-industry component which arises from the expansion of the skill-intensive industries and the shrinkage of the unskill-intensive industries.

If nevertheless one wants to carry out such a computation using the results presented in this section, then one can multiply the coefficient estimates by the means of each variable reported in Tables 5.7.1-5.7.4 and put the result in relation to the mean change in the dependent variable. The contribution of the computer variables calculated in this way will be in most cases much larger as compared to that of the trade variables. For the reasons explained already, see section 5.4, we cannot conclude from this that technical change was more important than trade in raising the relative demand for skilled labor.

The point becomes particularly evident when focussing on the coefficient on the change in the export share. It is positive and significant throughout specifications indicating that an increasing export share is positively associated with skill upgrading. Since the export share fell on average during the 1979-1987 period, s. 5.7.3 and 5.7.4, multiplying the coefficient by the mean value we obtain a negative contribution of that variable. Obviously it would be wrong to conclude from this that the changes in the exports that occurred throughout the period worked actually to reduce the relative demand for skilled workers in the US and also to reduce the skilled-unskilled wage differential.

In light of all this I find that a fair reading of the results presented here allows to conclude that trade, particularly in the form of intermediate goods, was at least as important as technical change in raising the relative demand for skilled labor. It should be noted that with this I am not arguing against the technical change explanation per se. What I contest here is the view that technical change was the dominant factor with trade playing a rather minor role. In this respect I would like to return to the caveat from the beginning of this chapter.

A number of points indicate that trade and technical change worked together, and that their impacts on labor demand are difficult to separate. The argument is supported not only by the uncovered high correlation between computer investment and our estimates of the effect of outsourcing (s. Table 5.5.5) but also by common sense. In fact, outsourcing represents disintegration of production whereby different stages of the production process are allocated to different countries. Obviously, such a disintegration of production requires rapid and efficient coordination among the units operating in different countries. The possibilities for such a coordination have been greatly enhanced by the advances in information technology. It is thus not exaggerated to say that without the advances in information technology we would not observe outsourcing in the present extent. Similarly, however, it can be argued that the spread of computer technology alone would not have changed the labor market much if taking place in a closed economy. After all, computers do not seem to be direct substitutes for unskilled labor. Moreover, it appears generally difficult to find specific examples of production-labor saving technological advances such as the introduction of new machines or robotization which were introduced at such a large scale as to quantitatively account for the observed decline in the demand for production labor.

Finally, as already noted in the general introduction to the thesis, I would like to stress that the analysis here was purely positive. The view expressed here that trade with newly industrialized countries is a major factor contributing to the increased demand for skilled labor in the developed world should not be taken to imply any policy recommendation.

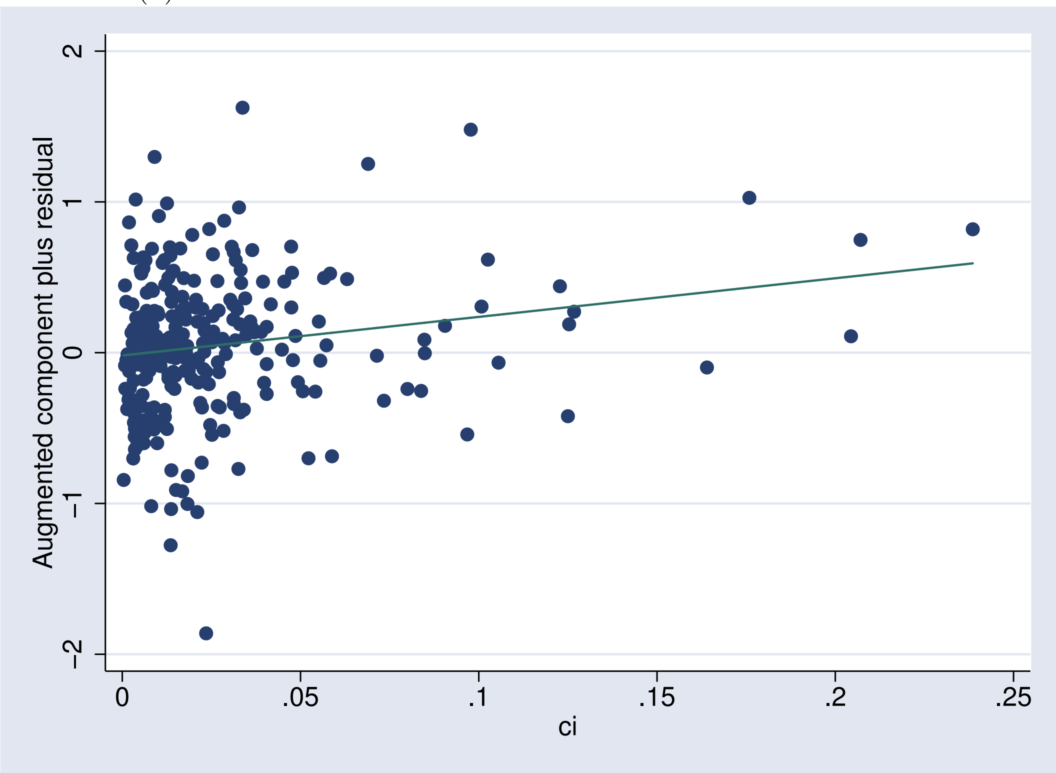
5.7 Appendix to Chapter 5

5.7.1 Sensitivity to observations with negative values of O_sh

As discussed in Section 5.4, s. footnote 96, negative values of O_sh are somewhat problematic since they imply "relocation of production activities back to the US". To address this problem I experimented with resetting all negative values of O_sh to zero and then using these to compute ΔS_{fci} in all Tables.

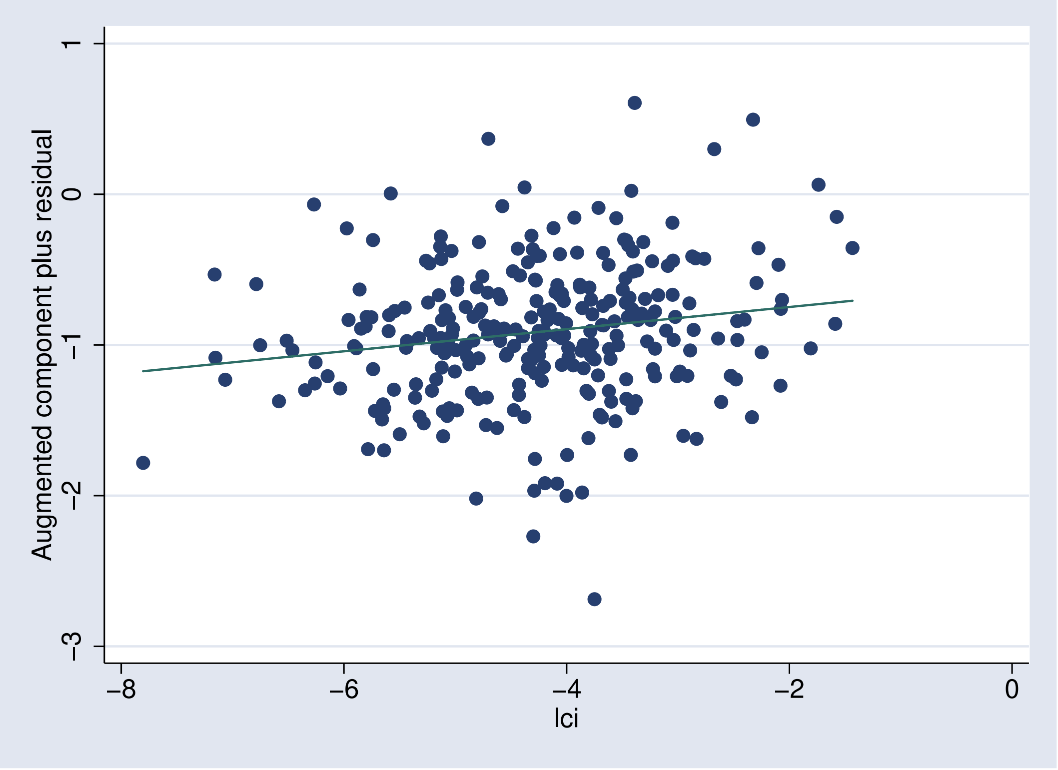
It should be noted that this has almost no impact on the results. The explanation appears to be that there are very few industries with negative O_{sh} of large magnitude. For example, when O_{sh} is computed using Eq. 5.4.7 and the Schott data there are only 14 industries out of 284 with negative O_sh. Among these only 6 have values of O_{sh} smaller than -0.00021, and only two have values smaller than -0.01. When O_sh is computed using Eq. 5.4.7 and the Feenstra-Hanson data out of 444 industries there are only 61 industries with negative O_sh. Among these only 19 have $O_sh < -0.01$ and only six have $O_sh < -0.03$. In the same sample and with the same values of O_sh there are 155 industries with negative ΔS_{fci}. When resetting all the negative O_{sh} to zero the number of negative ΔS_{fci} in the sample is still 153. This makes it clear that the primary reason for the occurrence of negative values of ΔS_{fci} in several industries are not the negative values of O_{sh} but the fact that the estimated non-production-labor-content of imports for these industries higher than that of the domestic production. In light of this descriptive information it is not surprising that replacing the negative O_{sh}'s with zeros leaves the results almost unaffected.

Figure 5.7.1: Adjusted component plus residual plot for CI/I from the regression in Column (2) Table 5.3.3



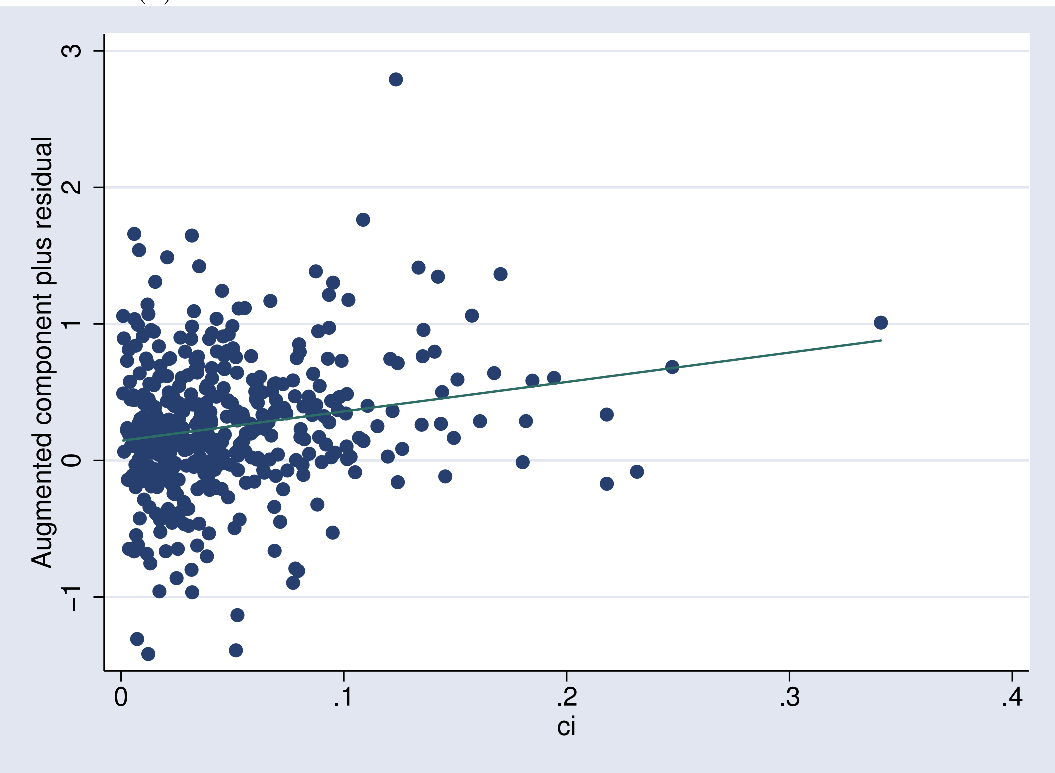
Notes: This plot has been obtained using the command acprplot in Stata, s. Stata Base Reference Manual N-R, Volume 3, p. 368-370, and Mallows (1986).

Figure 5.7.2: Adjusted component plus residual plot for CI/I from the regression in Column (3) Table 5.3.3



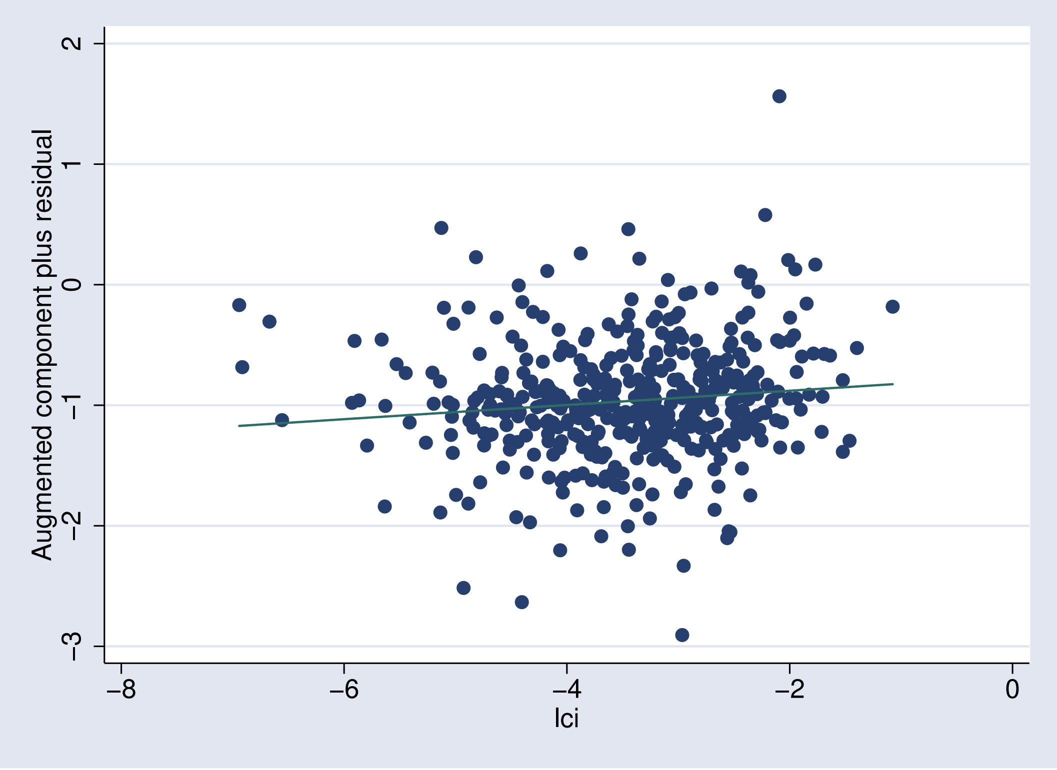
Notes: This plot has been obtained using the command acprplot in Stata, s. Stata Base Reference Manual N-R, Volume 3, p. 368-370, and Mallows (1986).

Figure 5.7.3: Adjusted component plus residual plot for CI/I from the regression in Column (6) Table 5.3.3



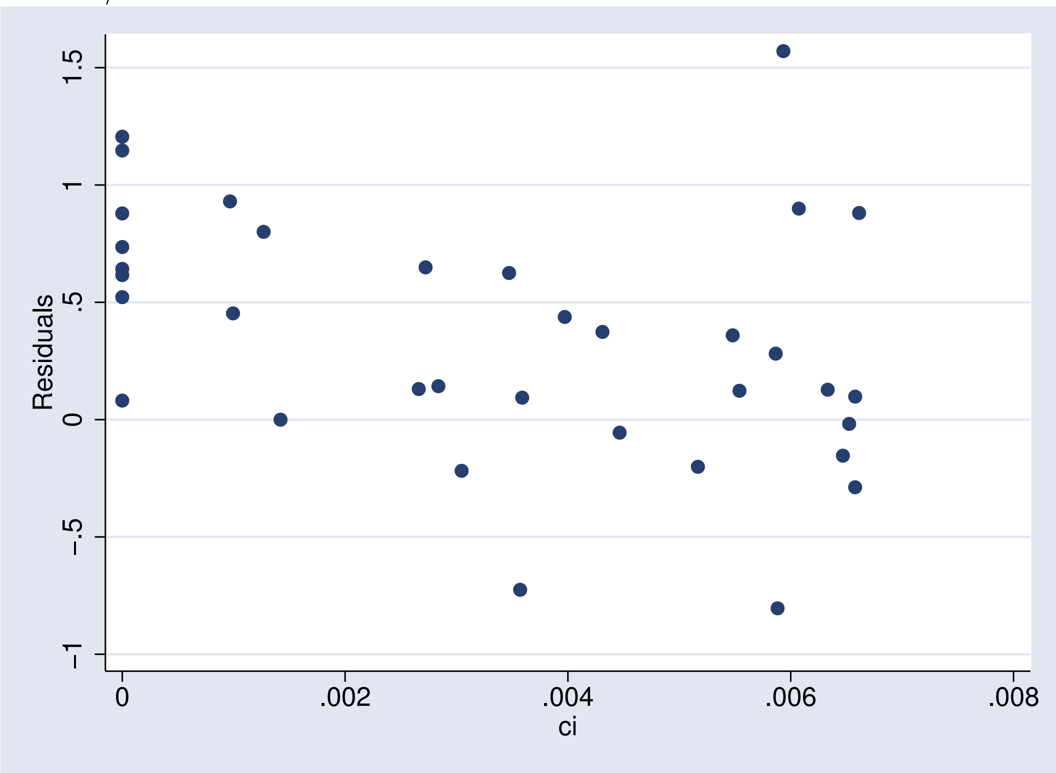
Notes: This plot has been obtained using the command acprplot in Stata, s. Stata Base Reference Manual N-R, Volume 3, p. 368-370, and Mallows (1986).

Figure 5.7.4: Adjusted component plus residual plot for CI/I from the regression in Column (7) Table 5.3.3



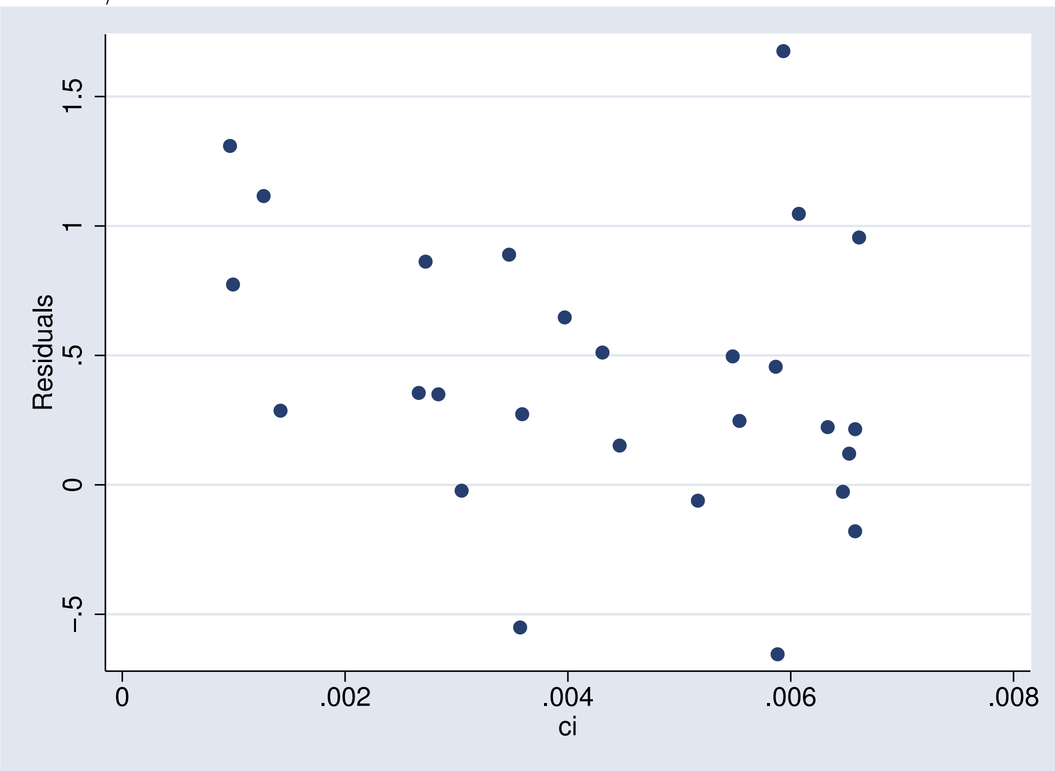
Notes: This plot has been obtained using the command acprplot in Stata, s. Stata Base Reference Manual N-R, Volume 3, p. 368-370, and Mallows (1986).

Figure 5.7.5: The residuals from Column (5) Table 5.3.3 for observations with small CI/I



Notes: This figure plots the residuals from the regression in column (5) Table 5.3.3 against CI/I for observations with CI/I smaller than 0.0067 (corresponds to $Log(CI/I) < -5$).

Figure 5.7.6: The residuals from Column (7) Table 5.3.3 for observations with small CI/I



Notes: This figure plots the residuals from the regression in column (7) Table 5.3.3 against CI/I for observations with CI/I smaller than 0.0067 (corresponds to $Log(CI/I) < -5$).

Table 5.7.1: Summary statistics on the sample obtained with the Feenstra-Hanson data, 1972-1979

Variable	Mean	Median	Stand. Deviat.	min	max
Dependent variable	0.11	0.11	0.43	-1.85	5.03
CI/I	0.02	0.01	0.04	0	0.21
CI/E	0.04	0.02	0.06	0	0.21
O_{sh}	0.02	0.01	0.03	-0.07	0.31
S_{fci}	0.04	0.01	0.10	-0.07	1.24
ΔS_x	0.36	0.22	0.56	-4.46	7.29
$\Delta Log(K/Y)$	0.70	0.65	3.38	-13.68	18.87
$\Delta Log(Y)$	2.66	2.54	3.55	-20.63	18.37

Notes: The mean, median and standard deviation are obtained using the same weights as in the regressions, i.e. the average industry share of the total manufacturing wage bill in 1972 and 1979. Sample: 444 industries at the 4-digit SIC 1972 level, s. Section 5.5.1 for a precise description.

Table 5.7.2: Summary statistics on the sample obtained when using the Schott data, 1972-1979

Variable	Mean	Median	Stand. Deviat.	min	max
Dependent variable	0.10	0.09	0.43	-1.38	2.09
CI/I	0.02	0.01	0.03	0	0.18
CI/E	0.04	0.02	0.06	0	0.44
O_{sh}	0.01	0.00	0.02	-0.08	0.20
S_{fci}	0.09	0.00	0.04	-0.04	0.56
ΔS_x	0.34	0.22	0.54	-4.46	3.47
$\Delta Log(K/Y)$	0.61	0.50	3.51	-9.64	15.47
$\Delta Log(Y)$	2.48	2.11	3.50	-10.41	18.37

Notes: The mean, median and standard deviation are obtained using the same weights as in the regressions, i.e. the average industry share of the total manufacturing wage bill in 1972 and 1979. Sample: 281 industries at the 4-digit SIC 1972 level, s. Section 5.5.2 for a precise description.

Table 5.7.3: Summary statistics on the sample obtained with the Feenstra-Hanson data, 1979-1987

Variable	Mean	Median	Stand. Deviat.	lowest three value	lowest three SIC	highest three value	highest three SIC
Dependent variable	0.43	0.39	0.52	−1.39	2083	2.32	3743
				−1.15	2429	3.09	3332
				−1.11	2098	3.68	3661
CI/I	0.04	0.02	0.04	0	2021	0.19	2342
				0	2045	0.19	3483
				0	2076	0.23	2791
CI/E	0.12	0.07	0.12	0	2021	0.55	2812
				0	2045	0.58	3674
				0	2076	0.61	2611
O_{sh} (based on Eq. 5.4.3)	0.02	0.02	0.03	−0.25	3356	0.11	3679
				−0.24	2283	0.12	3732
				−0.10	2231	0.12	3691
O_{sh} (based on Eq. 5.4.7)	0.02	0.01	0.02	-0.26	2283	0.09	3732
				-0.16	2231	0.10	3942
				-0.10	3356	0.13	3691
S_{fci} (based on Eq. 5.4.3)	0.04	0.01	0.09	−0.23	3356	0.26	3761
				−0.17	2754	0.31	3674
				−0.14	3691	0.38	3662
S_{fci} (based on Eq. 5.4.7)	0.02	0.01	0.04	-0.16	3691	0.18	3574
				-0.10	3832	0.19	2279
				-0.10	3356	0.25	3942
ΔS_x	−0.06	−0.04	0.44	−2.88	3769	3.18	3533
				−2.37	3483	4.10	3292
				−2.10	3795	4.57	3636
$\Delta Log(K/Y)$	1.23	1.06	3.67	−13.71	2279	20.27	3533
				−12.91	3483	21.70	3332
				−10.68	2292	60.79	2794
$\Delta Log(Y)$	1.13	1.09	4.68	−64.74	2794	12.05	3674
				−19.18	3332	12.88	2017
				−18.23	3743	13.07	3483

Notes: The mean, median and standard deviation are obtained using the same weights as in the regressions, i.e. the average industry share of the total manufacturing wage bill in 1979 and 1987. Sample: 444 industries at the 4-digit SIC 1972 level, s. Section 5.5.1 for a precise description.

Table 5.7.4: Summary statistics on the sample obtained with the Schott data, 1979-1987

Variable	Mean	Median	Stand. Deviat.	lowest three value	lowest three SIC	highest three value	highest three SIC
Dependent variable	0.39	0.31	0.44	−1.39	2083	2.01	2023
				−1.15	2429	2.11	3547
				−1.09	2842	2.32	3743
CI/I	0.04	0.02	0.04	0	2021	0.18	3586
				0	2076	0.18	3761
				0	2083	0.19	2342
CI/E	0.13	0.07	0.13	0	2021	0.55	2812
				0	2076	0.58	3674
				0	2083	0.61	2611
O_{sh} (based on Eq. 5.4.3)	0.01	0.00	0.04	−0.21	3915	0.17	3728
				−0.21	3911	0.19	3648
				−0.02	3523	0.42	2599
O_{sh} (based on Eq. 5.4.7)	0.01	0	0.03	-0.22	3911	0.13	3692
				-0.17	3915	0.13	3648
				-0.01	3511	0.29	2599
S_{fci} (based on Eq. 5.4.3)	0.02	0.00	0.10	−0.48	3911	0.41	3579
				−0.31	3915	0.43	3728
				−0.13	3692	1.16	2599
S_{fci} (based on Eq. 5.4.7)	0.02	0	0.07	-0.50	3911	0.30	3674
				-0.26	3915	0.37	3579
				-0.11	3692	0.65	2599
ΔS_x	−0.03	−0.02	0.45	−2.10	3795	2.35	3652
				−1.88	2399	3.18	3533
				−1.72	3341	4.10	3292
$\Delta Log(K/Y)$	1.36	1.09	3.72	−8.30	3446	13.26	3292
				−7.84	2386	18.43	3743
				−7.35	2231	20.27	3533
$\Delta Log(Y)$	0.65	1.09	4.68	−18.23	3743	10.63	2741
				−15.73	3292	11.33	3841
				−14.82	2429	12.05	3674

Notes: The mean, median and standard deviation are obtained using the same weights as in the regressions, i.e. the average industry share of the total manufacturing wage bill in 1979 and 1987. Sample: 284 industries at the 4-digit SIC 1972 level, s. Section 5.5.2 for a precise description.

Table 5.7.5: Concordance between the US Standard Industrial Classification 1972 and the International Standard Industrial Classification Revision 2

ISIC Rev.2 code and description	US SIC 72 code	US SIC 72 description
311: Food products	2011	Meat packing plants
	2013	Sausages and other prepared meat products
	2016	Poultry dressing plants
	2017	Poultry and egg processing
	2021	Creamery butter
	2022	Cheese, natural and processed
	2023	Condensed and evaporated milk
	2024	Ice cream and frozen desserts
	2026	Fluid milk
	2032	Canned specialties
	2033	Canned fruits, vegetables, pre serves, jams, and jellies
	2034	Dried and dehydrated fruits, vegetables and soup mixes
	2035	Pickled fruits and vegetables, vegetable sauces and seasonings, and salad dressings
	2037	Frozen fruits, fruit juices and vegetables
	2038	Frozen specialties
	2041	Flour and other grain mill products
	2043	Cereal breakfast foods
	2044	Rice milling
	2045	Blended and prepared flour
	2046	Wet corn milling
	2047	Dog, cat and other pet food
	2048	Prepared feeds and feed ingredients for animals and fowls, not elsewhere classified
	2051	Bread and other bakery products, except cookies and crackers
	2052	Cookies and crackers
	2061	Cane sugar, except refining only
	2062	Cane sugar refining
	2063	Beet sugar
	2065	Candy and other confectionery products
	2066	Chocolate and cocoa products
	2067	Chewing gum

(1)	(2)	(3)
	2074	Cottonseed oil mills
	2075	Soybean oil mills
	2076	Vegetable oil mills, except corn, cottonseed, and soybean
	2077	Animal and marine fats and oils
	2079	Shortening, table oils, margarine and other edible fats and oils, not elsewhere classified
	2091	Canned and cured fish and sea-foods
	2092	Fresh or frozen packaged fish and seafoods
	2095	Roasted coffee
	2097	Manufactured ice
	2098	Macaroni, spaghetti, vermicelli, and noodles
	2099	Food preparations, net elsewhere classified
313: Beverages	2082	Malt beverages
	2083	Malt
	2084	Wines, brandy, and brandy spirits
	2085	Distilled, rectified, and blended liquors
	2086	Bottled and canned soft drinks and carbonated waters
	2087	Flavoring extracts and flavoring sirups, not elsewhere classified
314: Tobacco	2111	Cigarettes
	2121	Cigars
	2131	Tobacco (chewing and smoking) and snuff
	2141	Tobacco stemming and redrying
321: Textiles	2211	Broad woven fabric mills, cotton
	2221	Broad woven fabric mills, manmade fiber and silk
	2231	Broad woven fabric mills, wool (including dyeing and finishing)
	2241	Narrow fabrics and other small-wares mills: cotton, wool, silk, and man-made fiber
	2251	Women's full length and knee length hosiery
	2252	Hosiery, except women's full length and knee length hosiery
	2253	Knit outerwear mills
	2254	Knit underwear mill's
	2257	Circular knit fabric mills
	2258	Warp knit fabric mill's
	2259	Knitting mills, not elsewhere classified
	2261	Finishers of broad woven fabrics of cotton
	2262	Finishers of broad woven fabrics of man-made fiber

(1)	(2)	(3)
		and silk
	2269	Finishers of textiles, net else-where classified
	2271	Woven carpets and rugs
	2272	Tufted carpets and rugs
	2279	Carpets and rugs, not elsewhere classified
	2281	Yarn spinning mills: cotton, man-made fibers and silk
	2282	Yarn texturizing, throwing, twisting, and winding mills: cotton, man-made fibers, and silk
	2283	Yarn mills, wool, including carpet and rug yarn
	2284	Thread mills
	2291	Felt goods, except woven felts and hats
	2292	Lace goods
	2293	Paddings and upholstery filling
	2294	Processed waste and recovered fibers and flock
	2295	Coated fabrics, not rubberized
	2297	Nonwoven fabrics
	2298	Cordage and twine
	2299	Textile goods, not elsewhere classified
322: Wearing apparel, except footware	2311	Men's, youths', and boys' suits, coats, and overcoats
	2321	Men's, youths', and boys' shirts (except work shirts) and nightwear
	2322	Men's, youths', and boys' underwear
	2323	Men's, youths', and boys' neckwear
	2327	Men's, youths', and boys' separate trousers
	2328	Men's, youths', and boy's' work clothing
	2329	Men's, youths', and boys' clothing, not elsewhere classified
	2331	Women's, misses', and juniors' blouses, waists' and shirts
	2335	Women's, misses', and juniors' dresses
	2337	Women's, misses', and juniors' suits, skirts, and coats
	2339	Women's, misses', and juniors' outerwear, not elsewhere classified
	2341	Women's, misses,, children's, and infants' underwear and nightwear
	2342	Brassieres, girdles, and allied garments
	2351	Millinery
	2352	Hats and caps, except millinery
	2361	Girls', children's, and infants' dresses, blouses, waists, and shirts
	2363	Girls', children's, and infants' coats and suits

(1)	(2)	(3)
	2369	Girls', children's, and infants' outerwear, not elsewhere classified
	2371	Fur goods
	2381	Dress and work gloves, except knit and all-leather
	2384	Robes and dressing gowns
	2385	Raincoats and other water-proof outer garments
	2386	Leather and sheep lined clothing
	2387	Apparel belts
	2389	Apparel and accessories, not elsewhere classified
	2391	Curtains and draperies
	2392	Housefurnishings, except curtains and draperies
	2393	Textile bags
	2394	Canvas and related products
	2395	Pleating, decorative and novelty stitching, and tucking for the trade
	2396	Automotive trimmings, apparel findings, and related byproducts
	2397	Schiffli machine embroideries
	2399	Fabricated textile products, not elsewhere classified
	3151	Leather gloves and mittens
323: Leather products	3111	Leather tanning and finishing
	3161	Luggage
	3171	Women's handbags and purses
	3172	Personal leather goods, except women's handbags
	3199	Leather goods, not elsewhere classified
324: Footware, except rubber or plastic	3131	Boot and shoe cut stock and findings
	3142	House slippers
	3143	Men's footwear, except athletic
	3144	Women's footwear, except athletic
	3149	Footwear, except rubber, not elsewhere classified
331: Wood products, except furniture	2411	Logging camps and logging con-tractors
	2421	Sawmills and planing mills, general
	2426	Hardwood dimension and flooring mills
	2429	Special product sawmills, not elsewhere classified
	2431	Millwork
	2434	Wood kitchen cabinets
	2435	Hardwood veneer and plywood
	2436	Softwood veneer and plywood
	2439	Structural wood members, not elsewhere classified
	2441	Nailed and lock corner wood boxes and shook
	2448	Wood pallets and skids

(1)	(2)	(3)
	2449	Wood containers, not elsewhere classified
	2451	Mobile homes
	2452	Prefabricated wood buildings and components
	2491	Wood preserving
	2492	Particleboard
	2499	Wood products, not elsewhere classified
332: Furniture, except metal	2511	Wood household furniture, except upholstered
	2512	Wood household furniture, up-holstered
	2515	Mattresses and bedsprings
	2517	Wood television, radio, phonograph, and sewing machine
	2519	Household furniture, not elsewhere classified
	2521	Wood office furniture
	2531	Public building and related furniture
	2541	Wood partitions, shelving, lock-era, and office and store fixtures
	2591	Drapery hardware and window blinds and shades
	2599	Furniture and fixtures, not else-where classified
341: Paper and products	2611	Pulp mills
	2621	Paper mills, except building paper mills
	2631	Paperboard mills
	2641	Paper coating and glazing
	2642	Envelopes
	2643	Bags, except textile bags
	2645	Die-cut paper and paperboard and cardboard
	2646	Pressed and molded pulp goods
	2647	Sanitary paper products
	2648	Stationery, tablets and related products
	2649	Converted paper and paperboard. products, not elsewhere classified
	2651	Folding paperboard boxes
	2652	Set-up paperboard boxes
	2653	Corrugated and solid fiber boxes
	2654	Sanitary food containers
	2655	Fiber cans, tubes, drums, and similar products
	2661	Building paper and building board mills
342: Printing and publishing	2711	Newspapers: publishing, publishing and printing
	2721	Periodicals: publishing, publishing and printing
	2731	Books: publishing, publishing and printing
	2732	Book printing
	2741	Miscellaneous publishing

(1)	(2)	(3)
	2751	Commercial printing, letterpress and screen
	2752	Commercial printing, lithographic
	2753	Engraving and plate printing
	2754	Commercial printing, gravure
	2761	Manifold business forms
	2771	Greeting card publishing
	2782	Blankbooks, looseleaf binders and devices
	2789	Bookbinding and related work
	2791	Typesetting
	2793	Photoengraving
	2794	Electrotyping and stereotyping
	2795	Lithographic platemaking and related services
351: Industrial chemicals	2812	Alkalies and chorine
	2813	Industrial gases
	2816	Inorganic pigments
	2819	Industrial inorganic chemicals, not elsewhere classified
	2821	Plastics materials, synthetic resins, and nonvulcanizable elastomers
	2822	Synthetic rubber (vulcanizable elastomers)
	2823	Cellulosic man-made fibers
	2824	Synthetic organic fibers, except cellulosic
	2861	Gum and wood chemicals
	2865	Cyclic (coal tar) crudes, and cyclic intermediates, dyes, and organic pigments (lakes and toners)
	2869	Industrial organic chemicals, not elsewhere classified
	2873	Nitrogenous fertilizers
	2874	Phosphatic fertilizers
	2875	Fertilizers, mixing only
	2879	Pesticides and agricultural chemicals, not elsewhere classified
352: Other chemicals	2831	Biological products
	2833	Medicinal chemicals and botanical products
	2834	Pharmaceutical preparations
	2841	Soap and other detergents, except specialty cleaners
	2842	Specialty cleaning, polishing, and sanitation preparations
	2843	Surface active agents, finishing agents, sulfonated oils and assistants
	2844	Perfumes, cosmetics, and other toilet preparations

(1)	(2)	(3)
	2851	Paints, varnishes, lacquers; enamels, and allied products
	2891	Adhesives and sealants
	2892	Explosives
	2893	Printing ink
	2895	Carbon black
	2899	Chemicals and chemical preparations, not elsewhere classified
353: Petrolium refin	2911	Petroleum refining
354: Miscellaneous petroleum and coal products	2951	Paving mixtures and blocks
	2952	Asphalt felts and coatings
	2992	Lubricating oils and greases
	2999	Products of petroleum and coal, not elsewhere classified
355: Rubber products	3011	Tires and inner tubes
	3021	Rubber and plastics footwear
	3031	Reclaimed rubber
	3041	Rubber and plastics hose and belting
	3069	Fabricated rubber products, not elsewhere classified
356:Plastic products	3079	Miscellaneous plastics products
361: Pottery, china,	3261	Vitreous china plumbing fixtures and china and earthenware fittings and bathroom accessories
earthenware	3262	Vitreous china table and kitchen articles
	3263	Fine earthenware (whiteware) table and kitchen articles
	3264	Porcelain electrical supplies
	3269	Pottery products, not elsewhere classified
362: Glass and products	3211	Fiat glass
	3221	Glass containers
	3229	Pressed and blown glass and glassware, not elsewhere classified
	3231	Glass products, made of purchased glass
369:Other non-metal mineral products	3241	Cement, hydraulic
	3251	Brick and structural clay tile
	3253	Ceramic wall and floor tile
	3255	Clay refractories
	3259	Structural clay products, not elsewhere classified
	3271	Concrete block and brick
	3272	Concrete products, except block and brick
	3273	Ready-mixed concrete
	3274	Lime

(1)	(2)	(3)
	3275	Gypsum products
	3281	Cut stone and stone products
	3291	Abrasive products
	3292	Asbestos products
	3293	Gaskets, packing, and sealing devices
	3295	Minerals and earths, ground or otherwise treated
	3296	Mineral wool
	3297	Nonclay refractories
	3299	Nonmetallic mineral products, not elsewhere classified
unknown whether 371 or 372	3398	Metal heat treating
	3399	Primary metal products, not elsewhere classified
371: Iron and steel	3312	Blast furnaces (including coke ovens), steel works, and rolling mills
	3313	Electrometallurgical products
	3315	Steel wire drawing and steel nails and spikes
	3316	Cold rolled steel sheet, strip, and bars
	3317	Steel pipe and tubes
	3321	Gray iron foundries
	3322	Malleable iron foundries
	3324	Steel investment foundries
	3325	Steel foundries, not elsewhere classified
372: Non-ferrous metals	3331	Primary smelting and refining of copper
	3332	Primary smelting and refining of lead
	3333	Primary smelting and refining of zinc
	3334	Primary production of aluminum
	3339	Primary smelting and refining of nonferrous metals, not elsewhere classified
	3341	Secondary smelting and refining of nonferrous metals
	3351	Rolling, drawing, and extruding of copper
	3353	Aluminum sheet, plate, and foil
	3354	Aluminum extruded products
	3355	Aluminum rolling and drawing, not elsewhere classified
	3356	Rolling, drawing, and extruding ’of nonferrous metals, except copper and aluminum
	3357	Drawing and insulating of non-ferrous wire
	3361	Aluminum foundries (castings)
	3362	Brass, bronze, copper, copper base alloy foundries (castings)

(1)	(2)	(3)
	3369	Nonferrous foundries (castings), not elsewhere classified
381: Fabricated metal products	2514	Metal household furniture
	2522	Metal office furniture
	2542	Metal partitions, shelving, lock-era, and office and store fixtures
	3411	Metal cans
	3412	Metal shipping barrels, drums, kegs, and pails
	3421	Cutlery
	3423	Hand and edge tools, except machine tools and hand saws
	3425	Hand saws and saw blades
	3429	Hardware, not elsewhere classified
	3431	Enameled iron and metal sanitary ware
	3432	Plumbing fixture fittings and trim (brass goods)
	3433	Heating equipment, except electric and warm air furnaces
	3441	Fabricated structural metal
	3442	Metal doors, sash, frames, molding, and trim
	3443	Fabricated plate work (boiler shops)
	3444	Sheet metal work
	3446	Architectural and ornamental metal work
	3448	Prefabricated metal buildings and components
	3449	Miscellaneous metal work
	3451	Screw machine products
	3452	Bolts, nuts, screws, rivets, and washers
	3462	Iron and steel forgings
	3463	Nonferrous forging.
	3465	Automotive stampings
	3466	Crowns and closures
	3469	Metal stampings, not elsewhere classified
	3471	Electroplating, plating, polishing, anodizing and coloring
	3479	Coating, engraving, and allied services, not elsewhere classified
	3482	Small arms ammunition
	3483	Ammunition, except for small arms, not elsewhere classified
	3484	Small arms
	3489	Ordnance and accessories, not elsewhere classified
	3493	Steel springs, except wire

(1)	(2)	(3)
	3494	Valves and pipe fittings, except plumbers' brass goods
	3495	Wire springs
	3496	Miscellaneous fabricated wire products
	3497	Metal foil and leaf
	3498	Fabricated pipe and fabricated pipe fittings
	3499	Fabricated metal products, not elsewhere classified
382: Machinery, except electrical	3511	Steam, gas, and hydraulic turbines, and turbine generator set units
	3519	Internal combustion engines, not elsewhere classified
	3523	Farm machinery and equipment
	3524	Garden tractors and lawn and garden equipment
	3531	Construction machinery and equipment
	3532	Mining machinery and equipment, except oil field machinery and equipment
	3533	Oil field machinery and equipment
	3534	Elevators and moving stairways
	3535	Conveyors and conveying equipment
	3536	Hoists, industrial cranes, and monorail systems
	3537	Industrial trucks, tractors, trailers, and stackers
	3541	Machine tools, metal cutting types
	3542	Machine tools, metal forming types
	3544	Special dies and tools, die sets, jigs and fixtures, and Industrial molds
	3545	Machine tool accessories and measuring devices
	3546	Power driven hand tools
	3547	Roiling mill machinery and equipment
	3549	Metalworking machinery, not elsewhere classified
	3551	Food products machinery
	3552	Textile machinery
	3553	Woodworking machinery
	3554	Paper industries machinery
	3555	Printing trades machinery and equipment
	3559	Special industry machinery, not elsewhere classified
	3561	Pumps and pumping equipment
	3562	Ball and roller bearings
	3563	Air and gas compressors
	3564	Blowers and exhaust and ventilation fans
	3565	Industrial patterns
	3566	Speed changers, Industrial high speed drives, and gears
	3567	Industrial process furnaces and ovens

(1)	(2)	(3)
	3568	Mechanical power transmission equipment, not elsewhere classified
	3569	General industrial machinery and equipment, not elsewhere classified
	3572	Typewriters
	3573	Electronic computing equipment
	3574	Calculating and accounting machines, except electronic computing equipment
	3576	Scales and balances, except laboratory
	3579	Office machines, not elsewhere classified
	3581	Automatic merchandising machines
	3582	Commercial laundry, dry cleaning, and pressing machines
	3585	Air conditioning and warm air heating equipment and commercial and Industrial refrigeration equipment
	3586	Measuring and dispensing pumps
	3589	Service industry machines, not elsewhere classified
	3592	Carburetors, pistons, piston rings and valves
	3599	Machinery, except electrical, not elsewhere classified
383: Machinery, electric	3552	Phonograph records and pre-recorded magnetic tape
	3612	Power, distribution, and specialty transformers
	3613	Switchgear and Switchboard apparatus
	3621	Motors and generators
	3622	industrial controls
	3623	Welding apparatus, electric
	3624	Carbon and graphite products
	3629	Electrical industrial apparatus, not elsewhere classified
	3631	Household cooking equipment
	3632	Household refrigerators and home and farm freezers
	3633	Household laundry equipment
	3634	Electric housewares and fans
	3635	Household vacuum cleaners
	3636	Sewing machines
	3639	Household appliances, not elsewhere classified
	3641	Electric lamps
	3643	Current-carrying wiring devices
	3644	Noncurrent-carrying wiring devices
	3645	Residential electric lighting fixtures
	3646	Commercial, industrial, and institutional electric lighting fixtures

(1)	(2)	(3)
	3647	Vehicular lighting equipment
	3648	lighting equipment, not else-where classified
	3651	Radio and television receiving sets, except communication types
	3661	Telephone and telegraph apparatus
	3662	Radio and television transmitting, signaling, and detection equipment and apparatus
	3671	Radio and television receiving type electron tubes, except cathode ray
	3672	Cathode ray television picture tubes
	3673	Transmitting, industrial, and special purpose electron tubes
	3674	Semiconductors and related devices
	3675	Electronic capacitors
	3676	Resistors, for electronic applications
	3677	Electronic coils, transformers and ether inductors
	3678	Connectors, for electronic applications
	3679	Electronic components, not elsewhere classified
	3691	Storage batteries
	3692	Primary batteries, dry and wet
	3693	Radiographic X-ray, fluoroscopic X-ray, therapeutic X-ray, and other X-ray
	3694	Electrical equipment for internal combustion engines
	3699	Electrical machinery, equipment and supplies, not elsewhere classified
384: Transport equipment	3711	Motor vehicles and passenger car bodies
	3713	Truck and bus bodies
	3714	Motor vehicle parts and accessories
	3715	Truck trailers
	3721	Aircraft
	3724	Aircraft engines and engine parts
	3728	Aircraft parts and auxiliary equipment, not elsewhere classified
	3731	Ship building and repairing
	3732	Boat building and repairing
	3743	Railroad equipment
	3751	Motorcycles, bicycles, and parts
	3761	Guided missiles and space vehicles
	3764	Guided missile and space vehicle propulsion units and propulsion unit parts

(1)	(2)	(3)
	3769	Guided missile and space vehicle parts and auxiliary equipment, not elsewhere classified
	3792	Travel trailers and campers
	3795	Tanks and tank components
	3799	Transportation equipment, not elsewhere classified
385: Professional and scientific equipment	3811	Engineering, laboratory, scientific, and research instruments, and associated equipment
	3822	Automatic controls for regulating residential and commercial environments and appliances
	3823	Industrial instruments for measurement, display, and control of process variables; and related products
	3824	Totalizing fluid meters and counting devices
	3825	Instruments for measuring and testing of electricity and electrical signals
	3829	Measuring and controlling devices, not elsewhere classified
	3832	Optical instruments and lenses
	3841	Surgical and medical instruments and apparatus
	3842	Orthopedic, prosthetic, and surgical appliances and supplies
	3843	Dental equipment and supplies
	3851	Ophthalmic goods
	3861	Photographic equipment and supplies
	3873	Watches, clocks, clockwork operated devices, and parts
390: Other manufactured products	3911	Jewelry, precious metal
	3914	Silverware, plated ware, and stainless steel ware
	3915	Jewelers' findings and materials, and lapidary work
	3931	Musical instruments
	3942	Dolls
	3944	Games, toys, and children's vehicles; except dolls and bicycles
	3949	Sporting and athletic goods, not elsewhere classified
	3951	Pens, mechanical pencils, and parts
	3952	Lead pencils, crayons, and artists' materials
	3953	Marking devices
	3955	Carbon paper and inked ribbons
	3961	Costume jewelry and costume novelties, except precious metal
	3962	Feathers, plumes, and artificial trees and flowers

(1)	(2)	(3)
	3963	Buttons
	3964	Needles, pins, hooks and eyes, and similar notions
	3991	Brooms and brushes
	3993	Signs and advertising displays
	3995	Burial caskets
	3996	Linoleum, asphalted-felt-base, and other hard surface floor coverings; not elsewhere classified
	3999	Manufacturing industries, not elsewhere classified

Table 5.7.6: Estimates of the skill intensity of domestic production and imported products, 1970-1980

ISIC	TURKEY	KOREA	PORTUGAL	FWSHARE	US
311	0.264	0.354	0.251	0.287	0.35
313	0.409	0.482	0.297	0.42	0.525
314	0.13	0.156	0.291	0.141	0.223
321	0.194	0.193	0.169	0.189	0.223
322	0.201	0.2	0.188	0.198	0.239
323	0.086	0.27	0.218	0.227	0.29
324	0.17	0.215	0.152	0.181	0.205
331	0.211	0.228	0.16	0.2	0.221
332	0.156	0.17	0.172	0.169	0.271
341	0.167	0.296	0.226	0.228	0.289
342	0.285	0.398	0.354	0.36	0.461
351	0.37	0.328	0.29	0.339	0.405
352	0.44	0.525	0.522	0.49	0.523
353	0.363	0.476	0.325	0.388	0.347
354	0.331	0.415	0.136	0.381	0.377
355	0.176	0.161	0.246	0.175	0.293
356	0.284	0.269	0.26	0.271	0.329
361	0.276	0.178	0.194	0.226	0.242
362	0.269	0.23	0.172	0.229	0.203
369	0.212	0.266	0.21	0.229	0.305
371	0.199	0.227	0.134	0.201	0.231
372	0.292	0.304	0.19	0.286	0.268
381	0.222	0.255	0.206	0.23	0.321
382	0.234	0.267	0.262	0.25	0.391
383	0.296	0.267	0.276	0.276	0.432
384	0.287	0.277	0.18	0.257	0.339
385	0.165	0.268	0.219	0.255	0.497
390	0.215	0.214	0.311	0.22	0.364

Notes: The numbers represent average non-production wage bill shares in the respective industries and countries over the period. For each country-industry these are computed by summing up the non-production wage bill and the total wage bill over all years in the period where both are available and then building the ratio of the two sums. For Turkey, Korea and Portugal before applying this operation wages were converted from national currencies into to dollars using the Exchange rates US dollars per national currency, period average, IMF, International Financial Statistics, accessible through $http://unstats.un.org/unsd/cdb/$. The $fwshare$ is the average share of non-production workers in the three countries (Portugal, Korea and Turkey) taken as a whole. It is obtained by summing the (dollar) wage bills not only over years, but also over countries and then computing the share. Source: United Nations General Industrial Statistics Dataset.

Table 5.7.7: Estimates of the skill intensity of domestic production and imported products, 1980-1990

ISIC	TURKEY	KOREA	PORTUGAL	FWSHARE	US
311	0.287	0.357	0.252	0.318	0.346
313	0.475	0.49	0.275	0.459	0.526
314	0.117	0.179	0.344	0.145	0.303
321	0.196	0.187	0.156	0.185	0.241
322	0.215	0.192	0.153	0.19	0.274
323	0.113	0.26	0.208	0.246	0.331
324	0.171	0.219	0.146	0.196	0.231
331	0.216	0.235	0.163	0.211	0.244
332	0.234	0.204	0.18	0.202	0.292
341	0.259	0.295	0.224	0.275	0.299
342	0.305	0.469	0.428	0.444	0.517
351	0.332	0.323	0.338	0.327	0.442
352	0.448	0.53	0.512	0.51	0.552
353	0.369	0.366	0.291	0.358	0.378
354	0.364	0.42	.	0.407	0.415
355	0.232	0.157	0.203	0.166	0.302
356	0.325	0.278	0.238	0.278	0.347
361	0.223	0.174	0.164	0.184	0.27
362	0.274	0.224	0.182	0.231	0.227
369	0.27	0.271	0.185	0.257	0.317
371	0.18	0.229	0.242	0.213	0.263
372	0.315	0.273	0.191	0.284	0.3
381	0.231	0.278	0.211	0.262	0.345
382	0.258	0.308	0.286	0.296	0.455
383	0.332	0.3	0.293	0.302	0.497
384	0.286	0.313	0.199	0.296	0.383
385	0.28	0.284	0.177	0.279	0.568
390	0.208	0.22	0.278	0.22	0.406

Notes: The figure for ISIC 354 for Portugal is missing because wages and employment of both production and non-production workers were zero during the period. The numbers represent average non-production wage bill shares in the respective industries and countries over the period. For each country-industry these are computed by summing up the non-production wage bill and the total wage bill over all years in the period where both are available and then building the ratio of the two sums. For Turkey, Korea and Portugal before applying this operation wages were converted from national currencies into to dollars using the Exchange rates US dollars per national currency, period average, IMF, International Financial Statistics, accessible through *http : //unstats.un.org/unsd/cdb/*. The *fwshare* is the average share of non-production workers in the three countries (Portugal, Korea and Turkey) taken as a whole. It is obtained by summing the (dollar) wage bills not only over years, but also over countries and then computing the share. Source: United Nations General Industrial Statistics Dataset.

6 Is the Trade-Hypothesis consistent with the more recent trends in wage inequality?

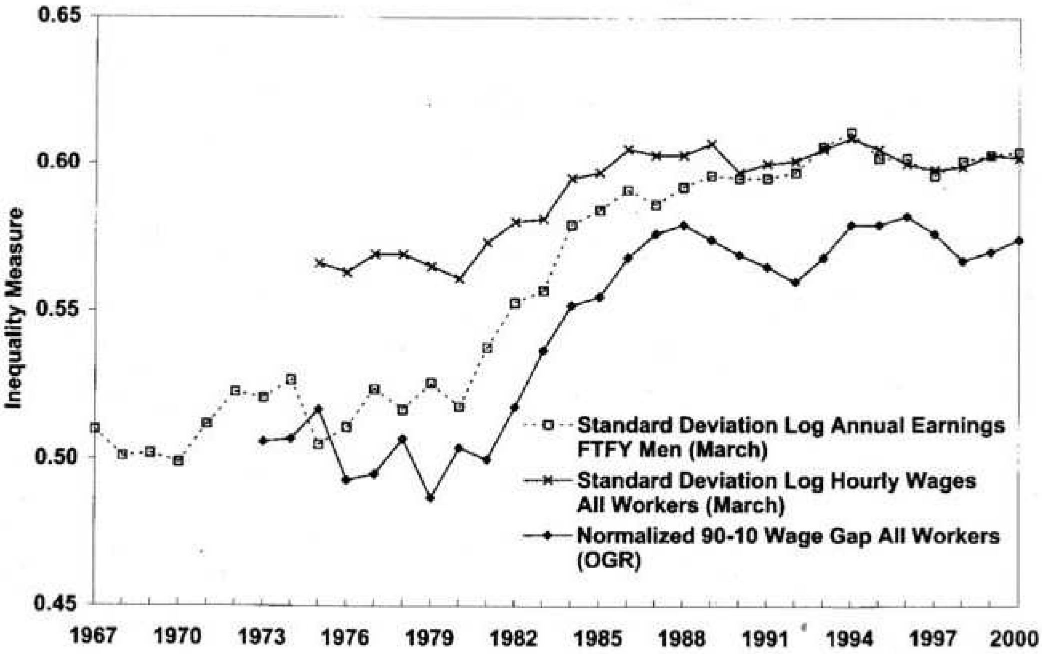
Wage inequality in the US started to increase sharply since the beginning of the eighties, but it appears that by the end of the decade a trend break occurred. Card and DiNardo (2002) present evidence that various measures of inequality remained surprisingly stable since the late eighties as illustrated in Figure 6.0.7 and conclude that the rise in inequality was an "episodic" event. Although Autor, Katz and Kearney (2005a) contest this view, they also find that "the growth of wage inequality in the 1990s was considerably slower than in the 1980s". Figure 2.4.2 in the appendix 2.4 also provides some evidence on this point. Any analysis of the role of trade and technical change as competing explanations for the inequality increases from a present point of view would be incomplete if failing to account for these more recent trends. That's why after having argued in favor of outsourcing as a potentially important explanation for the increasing wage inequality over the 1979-1987 period in the last Chapter, I address here the issue whether this explanation is consistent with the slowdown in wage inequality since the late eighties.

Card and DiNardo (2002) from which Figure 6.0.7 is taken interpret the slowdown in inequality as a problem for the skill-biased technical change explanation:

"A key problem for the SBTC hypothesis is that wage inequality stabilized in the 1990s despite continuing advances in computer technology" (Card and DiNardo (2002:733)

Although Card and DiNardo (2002) do not evaluate the Trade-hypothesis in light of the presented evidence their argument automatically raises the question: Is the slowdown in wage inequality during the 1990s in face of continuing globalization a problem for the Trade-hypothesis? In this Chapter I argue that it is not. The argument is organized in two parts. First, I present evidence that, similarly to some measures of inequality, the imports of intermediate products also slowed down during the 1990's. Second, I present a theoretical model which demonstrates that continuing globalization need not continuously increase the skilled/unskilled relative wage. Rather, the model suggests that in face of continuously falling prices of intermediate goods a turn point in the dynamics of the relative wage is to be expected.

Figure 6.0.7: The time path of wage inequality: alternative measures from Card and DiNardo (2002)



Notes: This Figure is taken from Card and DiNardo (2002:747, Figure 2). FTFY = full-time-full-year occupation. March = Data from the March Current Population Survey. OGR = Outgoing Rotation Group (since Jan 1979 a monthly supplement to the Current Population Survey). S. Card and DiNardo (2002) for more details on the sample and the variables definitions

6.1 Evidence on the time path of intermediate imports

In order to illustrate the dynamics of intermediate imports in this subsection I rely upon two of the data sources used in the previous Chapter: the NBER Manufacturing Productivity Database (Bartelsman and Gray, 1996) and the imports of parts and components from Schott (2004). This time I merge the Schott data with the 1987 SIC version of the NBER in order to avoid loosing industries from the sample and focus on a longer time horizon including the latest years for which data are available. The upper limit in the year coverage of the merged data set is provided by the NBER MPD - it contains data until 1996 (actually the last year in the current version of the database is 1997, but most values for that year are missing). The reason to combine the Schott data with the NBER MPD is to obtain a deflator for intermediate inputs (s. Section 5.2.5) and/or to put the growth in intermediate imports in relation to the growth in other variables. Figure 6.1.1 plots the indeces of total real imports of parts and components and total real value of shipments. The indeces are reset to 100 in 1979 and 1989 to facilitate comparison across the periods 1972-1979, 1979-1989 and 1989-1996 respectively. The index has been reset to 100 exactly in 1979 because this is a break year in the business cycle and in the analysis in the last chapter. The index is reset to 100 again exactly in 1989 because this is the year in which the switch from the TSUSA to the Harmonized System occurred. In this way we obtain three periods of approximately equal length. Since no major changes in classification occurred within each of these periods we would expect the dynamics of both, intermediate imports and total sales, to be correctly reproduced in Figure 6.1.1.

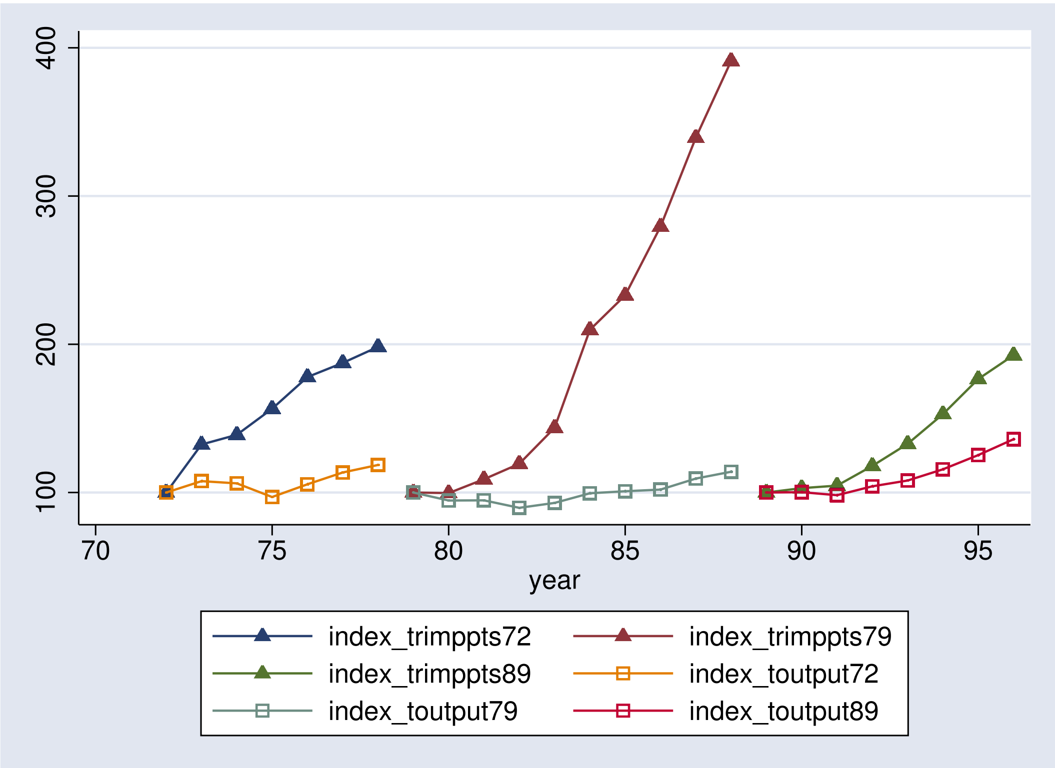


Figure 6.1.1: Indices of real imports of parts and components and real output

Notes: index-trimppts72 = 100x(total real imports of parts)/(the value of total real imports of parts in 1972), index-toutput72 = 100x(total real value of shipments)/(the value in 1972). The other indices are defined analogously, taking 1979 and 1989 as reference respectively. Totals are computed as a sum over all industries in the sample treating missing values as zeros. Nominal imports of parts are converted to real using the deflator for non-energy inputs *pineinp* defined in Section 5.2.5, footnote 70. Sample: 459 manufacturing industries (SIC 1987 version). Sources: Bartelsman and Gray (1996), Schott (2004).

We s. in Figure 6.1.1 that real imports of parts and components increased at a much higher rate during the 1979-1989 period as compared to the other two periods. Interestingly, the growth in the real imports of parts and components during 1989-1996 was no higher than it was during 1972-1979. The slowdown in the growth of imported intermediate products during the 1989-1996 period appears even more pronounced if one takes into account the evolution of total sales. Our discussion in Sections 5.1.3 and 5.4 suggests that it might be informative to put the growth in intermediate imports in relation to the growth in shipments. In particular it suggests that outsourcing is reflected in that part of the increase in the imports of intermediate goods imports which is over-proportional to the growth in output. Figure 6.1.1 shows that during the 1989-1996 period real shipments increased more than during any of the two periods before implying that the growth in intermediate imports relative to shipments was slowest in that period. An alternative way to illustrate the last point is to look at the ratio of total imported parts and components (in nominal terms) to the total value of shipments (also in nominal terms). Figure 6.1.2 plots this ratio without any adjustment (s. the connected points). The structural break associated with the move from the TSUSA to the HS in 1989 is well apparent. Although the levels of the ratio prior to 1989 are not comparable with those after 1989, the yearly changes in the ratio are comparable for all years except when moving from 1988 to 1989.[113] We clearly see a slowdown in the 1989-1996 period.

The data availability in the NBER MPD provides an upper limit on the years considered in figures 6.1.1 and 6.1.2. In order to make use of the latest Schott data, which are available until 2001, I looked also at the share of imported intermediates in total imports. This measure can be constructed using the original Schott data alone. It is plotted in Figure 6.1.3 for the period 1972-2001 without adjustment (s. the connected points). As before, the structural break is well apparent, implying that we cannot compare the levels prior to and after 1989. However, as before, it is reasonable to assume that the dynamics of the measure is correctly reproduced within the 1972-1989 and the 1989-2001 periods. This measure also shows a slowdown during the 1990's and even a turn point around 1993.

What can we make out of figures 6.1.1 to 6.1.3? In any case it would be completely wrong to take the imports of intermediate goods as the cause for the inequality increases, because the first should be regarded as endogenous. It would be also wrong to conclude that globalization, which can be viewed as the exogenous force behind the inequality increase, slowed down in the 1990's. But if intermediate imports and inequality cannot be considered "cause" and "effect", then what's the use of uncovering the coincidence in their timing? In my opinion, there is some use. We can interpret the growth in intermediate imports as an indicator of

[113] The implicit assumption here is that the fraction of the actual imports of parts and components captured under each classification does not change much over time. Note that the same assumption is needed to draw conclusions on the dynamics of *imppts* even when using data based on a single classification throughout a period.

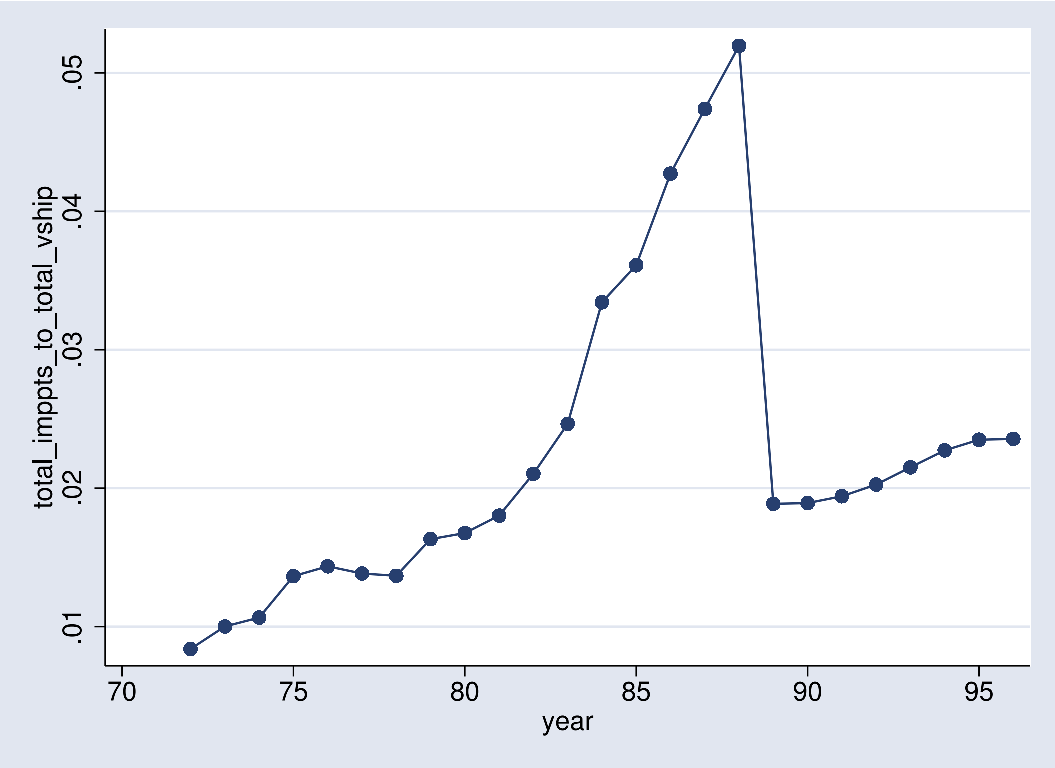


Figure 6.1.2: Imports of parts and components as a share of value of shipments

Notes: total-imppts-to-total-vship=(total imports of parts and components)/(total value of shipments). The totals are computed as a sum over all industries in the sample treating missing values as zeros. Sample: 459 manufacturing industries (SIC 1987 version). Sources: Bartelsman and Gray (1996), Schott (2004).

the intensity with which the endogenous phenomenon "outsourcing"[114] happens. The figures indicate that "outsourcing" was more intensive during 1979-1989 than before and after, whatever the reasons for that development are. In the next subsection I present a model that gives an insight on what these reasons might be.

6.2 The model: assumptions, intuition

In this Section I present a Walrasian general equilibrium model of a small open economy. One should always be careful when modelling the US as a small open economy. This assumption means that the prices of the traded goods are exogenous. At the level of aggregation of that model this is perhaps a reasonable assumption. There are only two traded goods in the model: the country imports

[114]consistent with the exposition in the rest of the thesis outsourcing can be defined here as "relocation of productive activities abroad" or "substitution of domestic (primarily production-)labor services for foreign (production-)labor services"

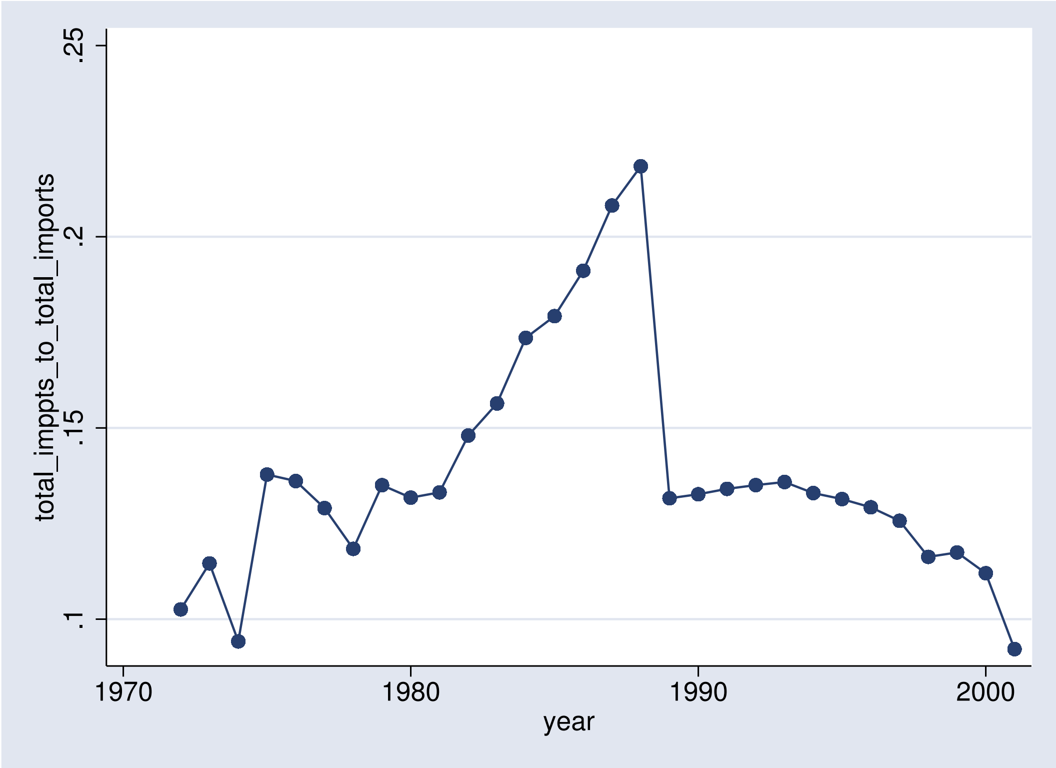


Figure 6.1.3: Imports of parts and components as a share of total imports

Notes:total-imppts-to-total-imports = (total imports of parts and components)/(total imports). The totals are computed as a sum over all industries in the sample. Sample: 386 manufacturing industries (SIC 1987 version). Source: Schott (2004).

intermediate goods (I) and exports sophisticated final goods (X). Globalization is modelled as a continuous fall in the price of the intermediate goods p_I. The fall in the the prices of imported intermediate goods can be attributed to the catch-up process of newly industrialized countries (improvements in the infrastructure, efficiency of the administration, legal system, labor force discipline and basic skills in these countries), the falling transportation costs, and the improved information on the business opportunities in those countries. All these can be viewed as exogenous factors with a potentially strong impact on the price of the intermediate good p_I which motivates the assumption of exogenous goods prices.

The model consists of a system of equilibrium conditions which are assumed to be satisfied in each point of time. The dynamics of the endogenous variables (more precisely we are interested in the wages of skilled and unskilled labor) is derived qualitatively as a function of the dynamics of the exogenous parameter p_I and the system of equations describing the equilibrium in each point of time.

It is assumed that p_I falls continuously over time, while the other parameters (endowments, preferences and technologies) remain constant. The remaining assumptions of the model are as follows.

All standard assumptions of Walrasian general equilibrium models - one price for each good (factor of production), perfect competition, no disequilibrium trade, instantaneous and simultaneous price and quantity adjustment. All production functions feature constant returns to scale. All households have identical and homothetic preferences. There are two primary factors of production - skilled (H) and unskilled (L) labor. There are three goods.

First, there are the non-traded intermediate products and services, Y, which are produced with unskilled labor alone. I assume that good Y is used both in the production of good X as an intermediate and in consumption as a final good. We can think of good Y as embodying unskilled labor services in infrastructure building and maintenance (construction of buildings, including offices, roads, electricity and water supply, repairs and cleaning in offices etc.), hotels, restaurants and mensas (note that these are often paid directly by firms and used by the individuals when at work, i.e. in these cases they should be viewed as intermediate goods as well), taxi services, retail trade and so on.

Second, there are the pure intermediate goods, I, which are also produced with unskilled labor alone and, By contrast,to Y, are traded. We can think of I as the unskilled labor services embodied in all kinds of traded goods such as semiconductors, automobile parts, TV parts, and even sewing and assembly services embodied in reimports of good X. [115] Note that all the goods captured by the aggregate category I are not directly consumable. Even when a consumption good is entirely produced in a newly industrialized country its sale value in the developed world rarely accrues to 100 percent to that country. On one hand, there might be licence payments or other transfer payments arising from the fact that the local producer in the newly industrialized country is using foreign technology, product design or marketing services. On the other hand, there is always some fraction of the sales value accruing to gross- and retail traders in the final destination. All these payments should be viewed as value added in the production of the final consumption good (X in our model) accruing to domestic factors of production. to the extent that these payments tend to constitute a large fraction

[115] Trade models not featuring transport costs or differentiated products allow to determine only net trade. We assume here that the country is a net importer of good X which does not mean that good X never flows in the opposite direction. Suppose for example that an almost finished TV has been produced in the US, is exported to Mexico for final processing (assembly) and then reenters the US as a finished TV. It is reasonable to treat the whole deal az zero net trade in good X and a net import of good I from Mexico to the US with value of the import of I equal to the value added of the assembly operation performed in Mexico.

of the price of the final goods this provides the motivation to assume that good I is a pure intermediate good.

Third, there are the sophisticated final goods, X, produced with high-skilled labor (H), traded intermediates (I), and non-traded intermediates (H). We can think of good X as a broad aggregate including such products as houses, computers, cars, TV's, mobile phones, high-quality clothing and shoes, etc, virtually all consumption goods requiring a non-negligible input of skilled labor. Basic unskill-intensive consumption goods such as sugar, rice and T-shirts for example, are excluded from the model under the implicit assumption that the expenditures on them are small and do not change much over time.

The main result from the model is that a monotonic decrease over time of the price of traded intermediates (I) leads to a hump-shaped time path of the real unskilled wage - initially the unskilled wage falls, but then it starts to increase. The turn point occurs at the time when the traded intermediates I stop to be domestically produced. The intuition for this result can be explained as follows.

The cheaper the imported intermediates become initially, the more they displace unskilled workers employed in the production of similar goods. The domestic production of such goods declines and more and more unskilled workers have to be absorbed by the non-traded sector. This restructuring process is accompanied by a continuous fall in the unskilled wage, which is linked to the price of the imported intermediate via the zero profit condition. Alternatively, we may say that the shrinking of the domestic I-sector reduces the demand for unskilled labor causing its wage to fall.

Eventually no worker is employed in the production of the imported intermediates. From this point on the further fall in their price need not reduce the domestic unskilled wage any more. The latter is now closely related to the demand for good Y because this is the only sector employing unskilled labor. In fact, the falling price of imported intermediate goods rises the demand for good Y via two channels. First, the cheap input from abroad boosts the X sector leading firms in this sector to demand more of the non-traded good Y which they use as an intermediate. Second, the fall in the price of imported intermediate goods represents a terms of trade improvement. The generated income effect leads to increased consumer demand for good Y. Both effects tend to raise the wage of unskilled labor.

6.3 Phase 1: close substitutes of the imported intermediates are produced also domestically

Suppose that initially the aggregate category I is produced also domestically. The equilibrium at each point of time can be described then by the following system of equations.

$$\begin{aligned}
w_L &= p_I && (6.3.1)\\
w_L &= p_Y && (6.3.2)\\
c_X(p_Y, p_I, w_H) &= 1 && (6.3.3)\\
a_{HX}(p_Y, p_I, w_H).X &= \bar{H} && (6.3.4)\\
a_{YX}(p_Y, p_I, w_H).X &= Y_X && (6.3.5)\\
a_{IX}(p_Y, p_I, w_H).X &= I_X && (6.3.6)\\
Y_C^{marsh.}(p_Y, 1, w_L L + w_H H) + Y_X &= L_Y && (6.3.7)\\
I_X + L_Y - \bar{L} &= I_M && (6.3.8)
\end{aligned}$$

Where w_H and w_L are the wages of skilled and unskilled labor respectively, p_Y, p_I are the prices of goods Y and I respectively. Note that good X has been chosen as numéraire and its price is set to one in Eqs. 6.3.3 and 6.3.7. $c_X(.)$ is the cost function and $a_{HX}(.)$, $a_{YX}(.)$, $a_{IX}(.)$ the corresponding optimal requirements of the three inputs per unit output of good X. $\bar{H}$ and $\bar{L}$ are the endowments with skilled and unskilled labor respectively. X is output of good X, Y_X and I_X are the total amounts of good Y and I respectively used in the production of good X. $Y_C^{marsh.}(.)$ is the marshallian demand function for good Y. L_Y is total unskilled labor used in the production of good Y and I_M are the imports of good I. The system consists of eight equations in the eight variables p_Y, w_L, w_H, X, Y_X, I_X, L_Y, I_M. Eqs. 6.3.1- 6.3.3 are the zero profit conditions for the three produced goods. Note that by choice of units we have normalized the per-input requirements of unskilled labor in the production of goods Y and I to one. Eqs. 6.3.4-6.3.8 represent the goods and factor market equilibrium conditions. Note that after the normalization L_Y is both total labor used in the production of good Y and output of good Y (as such it stands on the right-hand-side of 6.3.7 where the left-hand-side gives the demand for good Y). The latter consists of two terms - consumption demand and input demand from the X sector. Eq. 6.3.8 gives the imports of good I as a residual between domestic demand, I_X, and domestic production, $\bar{L} - L_I$ (this is total unskilled labor allocated to sector I; with the normalization it is also the domestically produced output of good I).

It is now obvious that as long as the system 6.3.1-Eq. 6.3.8 holds, the fall in p_I translates directly into a proportional fall in the real unskilled wage w_L. The price of the non-traded intermediates also falls in the same proportion (6.3.2). The changes in the other endogenous variables during this phase can be derived qualitatively as follows. The price of skilled labor rises (6.3.3). Since the prices of goods Y and I change proportionately we can apply the composite commodity theorem to derive the changes in the input coefficients: $a_{HX}(.)$ would unambiguously fall and the input coefficient of the composite good would rise. The fall in $a_{HX}(.)$ implies a rise in the output of good X (6.3.2). Since the total input of skilled labor is fixed by the endowment the rise in the output of good X implies that at least one of Y_X and I_X should rise. I assume that both rise. Note that this does not exclude certain complementarity between skilled labor and the non-traded intermediates in the production of good X. In particular, it is possible that the per unit input coefficient of non-traded intermediates falls even though we have established that the input coefficient of the composite good rises. Taking the whole effect however, i.e. the change in $a_{HY}(.)$ and the change in X, in 6.3.6 it appears extremely unlikely that the change in Y_X is negative. This would imply that increasing the input of good I, while keeping the other two inputs in the production of good X fixed, the marginal product of the Y-input falls.

With Y_X and I_X rising it is easy to establish the remaining results. Obviously the imports of intermediate goods rise (actually this follows from the fall in their price, but it can be seen now also in 6.3.8). The consumption demand for good Y rises because its price falls and income rises (income rises due to the terms of trade improvements; the assumption of identical and homothetic preferences excludes the possibility that demand falls in light of rising income and falling relative price). Finally, from Eq. (8) we obtain the main result - L_y rises because both Y_X and $Y_C^{marsh.}(.)$ rise. I assume that the continuous fall in L_Y will eventually lead to specialization - the economy would produce only goods Y and X with the total endowment of unskilled labor allocated to the non-traded sector ($L_Y = L$). This brings us to the second phase in which the further fall in p_I increases the unskilled wage.

6.4 Phase 2: close substitutes of the imported intermediates are not produced domestically

When good I is not produced domestically the equilibrium values of all endogenous variables satisfy the following system.

$$
\begin{aligned}
w_L &\geq p_I & (6.4.1)\\
w_L &= p_Y & (6.4.2)\\
c_X(p_Y, p_I, w_H) &= 1 & (6.4.3)\\
a_{HX}(p_Y, p_I, w_H).X &= \bar{H} & (6.4.4)\\
a_{YX}(p_Y, p_I, w_H).X &= Y_X & (6.4.5)\\
a_{IX}(p_Y, p_I, w_H).X &= I_X & (6.4.6)\\
Y_C^{marsh.}(p_Y, 1, w_L L + w_H H) + Y_X &= \bar{L} & (6.4.7)\\
I_X &= I_M & (6.4.8)
\end{aligned}
$$

This is obtained from 6.3.1-6.3.8 by transforming 6.3.1 to an inequality (costs exceed marginal revenue) and setting $L_y = L$. We have one equation and one variable (L_Y) less. Suppose now that w_L continues to fall or remains constant. A similar reasoning as in the previous Section leads us to a contradiction. If w_L falls or remains constant then w_H must rise (6.4.3). The composite theorem cannot be applied now because the fall in p_I and p_Y is not proportional. However, both intermediate inputs, Y and I, become cheaper relative to skilled labor in any case. As in the previous section this will lead to an increase in both Y_X and I_X unless there are extreme substitutability/complementarity patterns in the production of good X, which I rule out by assumption. Consumption demand for good Y must rise as before due to the income effect (we have still a terms of trade improvement and we assumed that the relative price of good Y does not rise). But if both consumption demand, $Y_C^{marsh.}(.)$, and input demand, Y_X, for good Y rise then its output must also rise. However, this is not possible because the output of good Y is fixed by the endowment with unskilled labor, s. Eq. 6.4.7. It follows that w_L must rise during that phase.

6.5 Conclusion to Chapter 6

In this Section I addressed the most recent trends in wage inequality in the US. Rather than seeking a complete explanation for these trends, my purpose was to check wether they can be reconciled with the Trade-Hypothesis, which attributes the sharp inequality increases during the 1980's to globalization pressures. Consistent with the analysis in the rest of the thesis I focussed on outsourcing - the phenomenon of substituting the domestically produced unskilled-intensive intermediate goods for imported - as the mean channel though which the "globalization pressures" lead to reduced domestic demand for unskilled labor. I presented evidence suggesting that this phenomenon was more intense during the 1980's as it was before and after. This evidence appears fully consistent with the trade-based explanation for the inequality increase during the 1980's. I presented also a theoretical model in which globalization (or more precisely the catch-up process of newly industrialized countries) was modelled as a continuous fall in the price of imported intermediate goods. The model implied a fall in the real wage of unskilled labor during the initial phase. Interestingly, the model suggests that the resulting fall in the real wage of unskilled may be a temporary phenomenon and that eventually globalization may lead to rising real wages of the unskilled workers.

7 Summary in German

Zusammenfassung auf Deutsch

Die vorliegende Dissertation untersucht die Rolle von Arbeitsmarktinstitutionen, Internationaler Handel und technischer Fortschritt als Bestimmungsfaktoren der Lohnungleichheit. Sie besteht aus zwei allgemeinen Kapiteln (2 und 4) und drei spezifischen (3, 5 and 6), die den Grossteil des Beitrags in sich konzentrieren. Der Aufbau und der Inhalt der einzelnen Kapitel ist wie folgt.

Ziel vom 2. Kapitel ist es, einen Überblick über das Thema zu verschaffen. Auf informelle Art und Weise wird zuerst auf den Besonderheiten des Arbeitsmarktes eingegangen. Dann werden die wichtigsten Begriffe zur Messung der Lohnungleichheit eingeführt. Anhand dieser wird die Entwicklung von Löhne und Beschäftigung im internationalen Vergleich dargestellt, und die Fragen für den Rest der Arbeit formuliert.

Der 3. Kapitel wendet sich der Hypothese, dass die Erhöhung der Unterbeschäftigung in vielen kontinentaleuropäischen Ländern das Spiegelbild von der Erhöhung der Lohnungleichheit in Angelsächsischen Ländern ist (Krugmann 1994, 1995, Freeman, 1995). Dabei steht die Lohnungleichheit zwischen ähnlich qualifizierten Arbeitskräften im Mittelpunkt. Ein wichtiger Beitrag gegenüber der früheren Literatur ist, dass die institutionellen Unterschiede zwischen den Länder endogen erklärt werden. Das erlaubt den Wettbewerb zwischen den Arbeitsmarktinstitutionen, der dadurch entsteht, dass die Länder durch zunehmenden Handel und Kapitalmobilität näher aneinander gebracht werden, zu analysieren. Das entwickelte politisch-ökonomische Model liefert Aussagen über die Auswirkungen der Globalisierung auf die Arbeitsmarktinstitutionen und damit auch auf die und Lohnungleichheit.

Die restlichen Kapitel der Dissertation wenden sich besonders der Lohnungleichheit zwischen Arbeitskräften mit unterschiedlicher Qualifikation und Fähigkeiten. Im 4. Kapitel werden die wichtigsten Hypothesen zur Erklärung der steigenden Lohnungleichheit sowie die Methoden, die zu derer Überprüfung entwickelt worden sind, dargestellt. Diese Darstellung bildet die Basis für die Analyse in den letzten zwei Kapiteln.

Im 5. Kapitel wird die Rolle vom technischen Fortschritt einerseits und internationalen Handel andererseits, als Bestimmungsfaktoren für die relative Nachfrage nach qualifizierter Arbeit empirisch untersucht. Die Hauptmethode, die dazu verwendet wird ist die "Kostenanteilsregression" (Berman, Bound und Griliches, 1994, Feenstra und Hanson, 1996, Autor, Katz und Krueger, 1998). Eine entscheidende Neuerung gegenüber früheren Beiträgen betrifft die Modellierung des Effekts von Änderungen in den Importen von Zwischenprodukten auf die abhängige Variable. Die vorgeschlagene neue funktionale Form berücksichtigt die relative Arbeitsintensität der einheimischen Produktion sowie die der importierten Produkte. Ein wichtiges Erkenntnis aus der Verwendung der neuen Formel ist, dass technischer Fortschritt und das Phänomen Outsourcing (Verlagerung der Produktion ins Ausland) oft gleichzeitig hervortreten (d.h. sie finden in den gleichen Industrien statt). Aus diesem Erkenntnis und aus den Ergebnissen der Regressionsanalyse kommt es zu dem Schluss, dass beide Faktoren für die Erhöhung der relativen Nachfrage nach qualifizierter Arbeit von gleicher Bedeutung waren und dass ihre Wirkung möglicherweise von starken Komplementarität geprägt war. Die Tatsache, dass die meisten früheren Beiträge dazu neigen, die Rolle des technischen Fortschrittes hervorzuheben wird auf die inadäquate Messung des Effektes von Handel zurückgeführt.

Im 6. Kapitel wird auf den neuesten Entwicklungen der Lohnungleichheit in den USA eingegangen. Es wird geprüft, ob die Hypothese, dass internationaler Handel und insbesondere Outsourcing eine der Hauptursachen für die Erhöhung der Lohnungleichheit während den 1980er Jahren waren, mit der Stabilisierung der Lohnungleichheit seit den 1990er Jahren konsistent ist. Die Analyse deutet darauf hin, dass diese Frage positiv beantwortet werden kann. Zum einen wird empirische Evidenz dargestellt, dass die Importe von Zwischenprodukten ähnlich wie Lohnungleichheit eine Trendwende seit den 1990s aufweisen. Zum anderen wird ein theoretisches Modell dargestellt, in welchem die kontinuierlich fallenden Importpreise zuerst den Reallohn von unqualifizierter Arbeit mindern (während der Phase in der die importierten Zwischenprodukte auch im Innland produziert werden), danach aber diesen Lohn erhöhen (dies ist die Phase der Spezialisierung wobei unqualifizierte Arbeit nur in der Produktion von nicht-handelbaren Gütern eingesetzt wird).

Zum Schluss muss noch explizit betont werden, dass die Analyse in der ganzen Arbeit positiv-ökonomisch ausgerichtet ist. Die Ergebnisse, die im Grossen und Ganzen der Globalisierung eine wichtige Rolle als Bestimmungsfaktor der Ungleichheit zuordnen lassen, dürften nicht als Anregung zum Einsatz bestimmter wirtschaftspolitischen Instrumenten interpretiert werden.

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