Stockholm School of Economics
Department of Economics
Course 5210
Master's Thesis in Economics

Minimum Wage Effects on Industry Specialization: An Empirical Investigation of 17 European Countries

Abstract

Minimum wage laws are an intensely debated topic within politics, as within academics. Previously, neoclassical minimum wage research had reached an apparent consensus that minimum wages will increase unemployment, especially of the unskilled and youth. This insight, however, has been fiercely challenged and today no academic consensus regarding minimum wage effects exists. In theory, the minimum wage can have positive, as well as negative consequences on welfare, ultimately which are larger is an empirical question. We contribute to the body of empirical minimum wage research by testing minimum wage effects on industry specialization, suggesting that high minimum wages can increase a countries specialization in high skilled industries. We have constructed a dataset covering 17 European countries and 52 industries and investigate a 10-year time period from 1993-2002. Our results show that the direction of the minimum wage's effect on industry specialization is as expected, although this effect is only statistically significant at the 10 percent level. Therefore, we conclude that there is a statistical dependence of the patterns of industry specialization on the minimum wage. However, the unreliability of our results raises doubts on whether the minimum wage can be used as a policy tool to alter a nation's structure of industry specialization.

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Presentation:	March 29th 2007, 10:15-12:00, Room 343

Acknowledgements

Foremost, we would like to express our gratitude to Jonas Vlachos, our advisor, for all his invaluable input throughout the writing of this thesis. Further we owe words of thanks to Per Skedinger for providing us with help designing estimations similar to his, Dana Blumin from the OECD for supplying us with hard to obtain data for our calculations and various labor organizations across Europe for their collaboration during this thesis. Finally we would like to thank our families for their tremendous support in completing this work.

Table of Contents

1. Introduction

"Can anything be done to spread the benefits of a growing economy more widely? Of course. A good start would be to increase the minimum wage" (Paul Krugman, NY Times, 14.07.2006)

The debate concerning the minimum wage has been intense in the political as well as in the academic forum ever since it was first introduced in New Zealand in 1896. In neoclassical theory, the predictions at which economists arrived were highly negative and this conception became widely accepted. It was believed that an increase in the minimum wage would reduce demand especially for unskilled labor. Initially, this was also supported by most of the data. The acceptance of the negative impact of the raising or instituting of the minimum wage has led neoclassical minimum wage theory to become a basic principle in introductory economics classes and in the thinking of politicians favoring free markets.

Still, the issue of the minimum wage remains on the political agenda. Very recently in the U.S., a raise of the Federal Minimum Wage was passed after the Democratic Party took over control of the Senate as well as the House of Representatives. In Europe the political debate has heated up since the Schengen Agreements were put in place enabling free labor mobility across Europe. In Sweden, for instance, the wage differential between Swedish and Eastern European wages causes a general fear that cheap labor from the eastern members of the European Union would deteriorate the wage rate for low skilled labor. In Vaxholm the labor organization Byggnads organized a blockade to prevent Latvian workers from constructing a school and only allowed them to continue their work once they had agreed to work under the Swedish collective agreement. The case is currently under evaluation at the European Court of Justice.

In current research, the findings of neoclassical theory have become contested, as the introductory quote by Krugman illustrates. More advanced theoretical modeling and econometric testing have changed the uniform view economists formerly had with regard to the minimum wage, and contemporary predictions to its impact vary. To quote a recent review on minimum wage research by Neumark and Wascher (2006, p.2): *"Clearly, no*

consensus now exists about the overall effects on low-skilled employment of an increase in the minimum wage."

So, who is right? In this paper we try to add to the ongoing discussion on the effects of instituting or raising minimum wages and test how they could affect a country's industry structure. In doing so, we extend Skedinger's research (2005, 2006) on the "minimum wage bite", which he defines as the minimum wage divided by the median wage. In his recent paper in "Ekonomisk debatt" Skedinger writes (2006, p.76): "*Empirical evidence concerning the potential correlation between structural adjustments and minimum wages in different sectors tend to be missing."*[1] By offering empirical evidence our paper tries to contribute to the body of existing literature. In order to test the effect of the minimum wage bite on industry specialization we have constructed a dataset containing the minimum wage bite for 17 countries across 52 industries. In our sample, all countries are members of the European Union and the OECD with the exceptions of Norway which is only member of the OECD.

Thus, the main question in our thesis is: *Will a relatively high minimum wage, compared to median income, increase specialization in high skill industries (relative to low skill industries)?*

The structure of this paper is as follows: First we give a review of the relevant literature before discussing the theoretical implications of our testing. After that, we present the econometric model used in our analysis. Next we elaborate the definitions and sources of the data used before proceeding with the regression analysis. Further, we describe and analyze the results. Finally, we discuss the main findings of our thesis and thereafter conclude.

[1]The original quotation in Swedish is: *"Empirisk evidens rörande de eventuella sambanden mellan strukturanpassning och minimilöner i olika sektorer förefaller emellertid saknas."* (Skedinger, 2006, p.76)

2. Literature Review

Since the passing of the "Fair Labor Standard Act" (1938) in the US, the minimum wage debate has been heated in academic research. After more than three decades of research, introduced by Lester (1946, 1947) and Stigler (1946), an apparent consensus was reached on how minimum wages would affect employment, especially that of the unskilled and youth (Brown, Gilroy and Cohen, 1982).

Therefore, most introductory economics textbooks contain a brief description on the effects of the minimum wages on employment based on Stigler's seminal work (1946). The general implications of these models are that if the minimum wage is set above the competitive free market equilibrium, the demand for labor moves back along the demand curve. Moving along this curve, the proportional change in employment in response to the change in the minimum wage equals the elasticity of demand for unskilled labor multiplied by the proportional wage increase. If demand for labor is elastic, the increased minimum wage will increase unemployment, if demand for labor is inelastic, it will not (Brown, 1988). Thus the employment and wage effects in these very basic models (imposing very stringent *ceteris paribus* assumptions) rely heavily on the elasticity of demand and this is ultimately an empirical question.

The most influential empirical paper on this matter was published in 1981 by the "Minimum Wage Study Commission" containing a survey written by Brown, Gilroy and Kohen (republished 1982) presenting the mainstream economic consensus at that time (1982, p.524): *"time-series studies typically find that a 10 percent increase in the minimum wage reduces teenage employment by one to three percent"*. This can be considered as the overarching academic consensus of the time, thus letting research on minimum wage effects come to halt for roughly a decade (Neumark and Wascher, 2006).

At the beginning of the 1990s, however, the academic debate on the effects of minimum wages was rejuvenated, following an increased political debate on this topic. Using more elaborate econometric models and exploiting US-state level differences in minimum wage, scholars found a new playing field to research the effects. This strand of literature has come to be known as the "new minimum wage research".

The majority of empirical research within the area of minimum wages was conducted in order to evaluate effects on employment. If an increased minimum wage stimulates an increase or a decrease in employment is not theoretically consistent and varies depending on the form of employment, for instance whether the employer has market power, i.e. monopsony bargaining power (Björklund et al., 2000). Regulating this kind of market might stimulate employment growth as it breaks the monopsonist's market power. However, if the minimum wage is set above a certain level, employment will decrease no matter the structure of the market (Skedinger, 2006). Empirical evidence from Sweden suggests that an increase of the minimum wage by 10 percent decreased the level of employment by 5 percent in the group affected by the change of the minimum wage rate (Skedinger, 2006).

Even though these findings are mostly persistent, recent studies performed in the US show contradictory results. In 1994, Card and Krueger (1994) analyzed the effects of the minimum wage on employment when one state increased its minimum wage (New Jersey) and a neighboring state (Pennsylvania) held it constant. The findings from this survey suggest that the employment actually increased in New Jersey, contrary to the general beliefs of minimum wages' effect on employment, but in line with the argument of the employers having had market power. However, these findings have been under severe criticism and it remains uncertain whether the suggested effect exists or not. Researchers are trying to asses the matter by using time series data and results based on longer time series have reversed the findings of the above study (Neumark and Wascher, 2000). Thus, the general consensus is, once again, that an increase in the minimum wage should be associated with a decrease in employment (Skedinger, 2006). This conclusion still remains contested.

Furthermore, research has been carried out to determine whether the benefits from a minimum wage increase might still have welfare improving effects, even with a possible reduction in employment. Two papers by Flinn (2003, 2006) using continuous time models of search established that an increased minimum wage can be welfare improving depending on whether the contact rate (the arrival rate of contacts to job searchers) is considered exogenous or not. Hence, as often in economics, the theoretical predictions depend on the model specification and on the given parameters.

The insight that welfare can be increased by specialization and trade is as old as the field of economics itself. Smith and Riccardo already observed this matter and most economists

would agree on their basic observations. Therefore, we will not engage in the discussion of the relevant literature and throughout this paper we maintain that increased specialization should be considered beneficial to an economy via the welfare improving effects of trade. More contested are the factors that will cause this kind of welfare improving specialization. The origins and the development of the relevant literature in this field will be discussed in the following.

The Heckscher-Ohlin model (Ohlin, 1933), a cornerstone of neoclassical trade theory, predicts that with free and competitive trade, countries export the good that uses its abundant factor intensively and that this will make factor prices converge across countries. This factor price equalization theorem, developed by Samuelson (1949), is arguably the most significant conclusion from the HO-model, but it is also the theorem which has found the least agreement with empirical evidence. The first author to challenge it with data was Leontief (1953) establishing the so called "Leontief paradox". Using input-output tables Leontief calculated how much labor and how much capital was required for $1 million worth of U.S. exports. He then used the same capital/labor requirements to calculate the capital/labor ratio used in imports, implying the same technology for all countries (which, after all, is a basic assumption of the HO-model). His results showed that the U.S., which was assumed to be capital abundant in comparison to the rest of the world, is indeed labor abundant – an obvious paradox, which remained unresolved until Leamer (1980) discovered that Leontief had performed the wrong test. Leamer argued that not the capital/labor ratios should be compared, but the "factor content" of trade. Instead his research, based on the multi industry, multi factor extension of the HO-model developed by Vanek (1968), known as the HOV-model, stated that if capital is abundant relative to labor in country *i*, then the capital/labor ratio in production for country *i* exceeds the capital/labor ratio embodied in consumption. By reformulating Leontief's test, Leamer shows that the U.S. is in fact specialized in production of goods intensively utilizing capital (Leamer, 1980).

Nonetheless, the basic assumption in the empirical literature testing the HOV model is that technology is identical across countries. Bowen, Leamer, Sveikauskas (1987) and Trefler (1995) performed various diagnostic tests on the data to determine which assumption of the HOV model was most likely going to cause it to fail. Their conclusion was that the assumption of equal technology was particularly invalid, and in more recent times, a new strand of literature has developed allowing for technology differences caused by various

factors: Sachs (2001) argues that climate and geography will account for varying technology, Jones and Hall (1999) investigate the effects of social capital, Clark and Feenstra (2003) analyze the efficiency with which labor is utilized, while Acemoglu, Johnson and Robinson (2001) believe that institutions are the main determinant for differences in technology. The final research aspect on the role of institutions coincides with our approach.

Research on the effect of institutions on trade is rather scarce, yet currently growing in number. Levchenko (2004) illustrates that various proxies for institutional quality can partially explain international trade flows as well as the distribution of the gains from trade. Svaleryd and Vlachos (2002) investigate how the institutional development of financial systems affects the openness to trade. Later the same authors test the patterns of international specialization for countries' well endowed with financial institutions (2005). Further, Costinot (2005) and Nunn (2005) theoretically model international trade under imperfect contract enforcement.

Closer to this paper, Saint-Paul (1997) relates labor market protection to international specialization. His research illustrates how countries with high firing costs specialize in the production of secure good in the later stage of their product life cycle. Further, Galdon (2002) links labor market protection to the development of the *New Economy* in certain countries. He delivers evidence that countries with low employment protection seem to have specialized more in high-tech industries. Finally Cuñat and Melitz (2005) show that countries with a more flexible labor market specialize in high dispersion industries, meaning that these countries will specialize in industries that are more affected by frequent productivity shocks.

Having reviewed the literature, we believe ours to be the first research paper to explicitly test the minimum wage on industry specialization.

3. Theoretical Implications of the Minimum Wage Bite

This paper can be considered an extension to research carried out using the HOV model. In our approach, we consider variations of the minimum wage bite as variations in countries' institutional settings, and hence as a cause of differences in country specific technologies. Conversely, we consider technology at the industry level the same in all countries. As both technologies affect an industry's production, the exact same industry in a different country may produce differently. This way of modeling parsimonious technology was first introduced by Davis and Weinstein (2001). In practical terms, this means that the capital and skill intensities in each industry are the same across all countries and for our sample these values are drawn from US industrial data. The institutional setting, i.e. the minimum wage bite, is the source of variation to country specific technologies and will alter the production function faced by every industry in each country.

Yet the question remains in what way the minimum wage bite (as institutional cause of technology variation) will affect the production function: Will it increase or decrease the efficiency of an input factor? Textbook economics normally emphasizes the issue of increased unemployment caused by high minimum wage rates. Nevertheless this is not the entire range of the effects caused by them. In Stigler's seminal article on minimum wage legislation, he notes that *"If a minimum wage is effective, it must therefore have one of two effects: First, workers whose services are worth less than the minimum wage are discharged, (…); or, second, the productivity of the low-efficient worker is increased"* as *"the laborers may work harder; or the entrepreneurs may use different production techniques."* (1946, pp.1-2). In academic research, the focus has been mostly on the former effect, and so far empirical investigations on the productivity effects of minimum wages are very sparse. In a study by Forth and O'Mahony (2003), they find indications that the minimum wage has increased productivity in at least some sectors. Further, a survey commissioned by the Low Pay Commission in the UK (Bullock and Hughes, 2001) found some evidence of increased efficiency for small and medium sized enterprises caused by the National Minimum Wage. However, as the literature in this area is limited, the magnitude of these effects is hard to assess. Nonetheless, there is evidence of their existence and we believe it is valid to say that the introduction or the increase of the minimum wage can increase the productivity of the input factor labor.

For our analysis this means the following: Under perfect competition, every worker is rewarded the value of his marginal product (Stigler, 1946). If the minimum wage is set above the competitive market equilibrium, this is no longer possible. With this rigidity forced upon the labor market, we assume that the minimum wage will increase the productivity of a country's labor force. Thus, all else being held equal, industries that have a demand for higher skilled labor will expand, as they can pay workers at the value of their marginal product, which will lie on or above the minimum wage rate. Contrary to this, industries will contract in which the value of each worker's marginal product lies below the mandatory wage rate. If this hypothesis holds, is ultimately an empirical question which we will examine in the remainder of this thesis.

4. Regression Model

To test the effect of the minimum wage on specialization, we have constructed the following model:

$$SPEC_{ij} = \alpha + \beta_1 WAGEB_j \cdot SKILL1_{iUS} + \beta_2 HC_j \cdot SKILL1_{iUS} + \beta_3 CAPEND_j \cdot CAPINT_{iUS} + \theta_1 DINDUSTRY_i + \ldots + \theta_{i-1} DINDUSTRY_i + \delta_1 DCOUNTRY_j + \ldots + \delta_{j-1} DCOUNTRY_j + \varepsilon_{ij}$$

Where $SPEC_{ij}$ is the specialization in industry *i* in country *j*, $WAGEB_j$ is the minimum wage bite in country *j*, $SKILL1_{iUS}$ is the skill intensity for industry *i* in the United States and HC_j is the relative endowment of human capital in country *j*. $CAPEND_j$ is the capital endowment in country *j* and $CAPINT_{iUS}$ is the capital intensity for industry *i* in the United States. $DINDUSTRY_i$ are *i*-1 industry dummies capturing industry specific effects and $DCOUNTRY_j$ are *j*-1 country dummies capturing country specific effects.[2] A summary of the variables and notations used in this paper can be found in *Table A.1*, in *Appendix A.* A complete definition of how the variables have been estimated and where the data was gathered from will be presented in the next chapter.

The HOV-model would predict that "*countries are internationally competitive in industries that are intensive in the use of factor inputs that countries have abundant supplies of*" (Svaleryd and Vlachos 2005, p.117) and they will specialize in these industries. As we want to isolate how minimum wages affect specialization, we need to construct a model which controls for the variation caused by country specific factor endowments. This means we have to include interaction terms for industry level skill intensities and country level human capital endowments, as well as industry level capital intensities and country level capital endowments. To control for country fixed effects and industry fixed effects, we have included a dummy variable for every country and industry. By using these dummies, we can account for average country specialization effects across all industries and the average industry specialization effects across all countries.

[2] The number of dummies has been set to i-1 and j-1 respectively to prevent perfect multicollinearity.

The focus of our analysis is the coefficient and the significance of the interaction term $WAGEB_j \cdot SKILL1_{iUS}$. This term will capture the relative specialization effect on industries in comparison to one another within a country which cannot be explained by endowments and fixed effects. As illustrated in the previous chapter, we expect β_1 to be positive. The detailed analysis of our regression will follow after the discussion of the data.

The methodology used is in line with recent research related to the HOV-framework. Belloc (2004), for instance, investigates the labor market institutions' effect on comparative advantage. Cuñat and Melitz (2005) interact a labor market rigidity index with an industry volatility index against net exports, and finally, Svaleryd and Vlachos (2005) regress the interaction effect of financial intensity and financial endowment proxies against international specialization. Thus, we strongly feel that this is the correct model to test our hypothesis.

5. Data

We will be using data covering 52 industries in 17 European countries and benchmarking these with capital and skill intensities from the Unites States, leaving us with 884 observations in total. In this chapter we will present the reader with a description of the data source used for each variable, as well as the definition according to which the variable has been specified. Foremost, we include an in depth discussion of our construction of the minimum wage bite, as we consider this to be one of the essential contributions of our thesis.

5.1 Specialization

In the literature we find various measures of industry specialization. Balassa (1979), for instance, recommends using the difference between exports and imports scaled by total trade, while Gustavsson et al. (1999) suggest a quotient of production and consumption of a good. These ratios, however, are affected by a country's consumption pattern and as a consequence do not completely illustrate the industrial structure of a country. A further shortcoming of Balassa's specialization measure is that it only includes tradable goods. This results from the fact that this measure was devised primarily to analyze comparative advantages in international trade. We, however, are concerned with the structure of the industry as a whole. We prefer not only a direct measure of industry specialization that is not altered by a country's differing consumption preferences, but also includes industries producing non tradable goods. Thus, we have chosen to use a relative measure of industry value added calculated according to following formula:

$$SPEC_{ij} = \frac{VA_{ij}}{\sum_{j=1}^{n} VA_{ij}}$$

VA_{ij} stands for "Value Added", where subscript *i* denotes industry i and subscript *j* denotes country j. Data for this calculation has been taken from the 60-industry database (60 Ind) of the Groningen Growth & Development Center (GGDC)[3], a description of the industry classifications can be found in *Appendix E*. This database is based on the OECD STAN database, which has been expanded by adding additional yearly observations. We have chosen the timeframe 1993-2002, as this period gives us roughly two business cycles, allowing us to avoid a cyclical bias in our dependant variable and we have pooled the data. 2002 is the final

[3] Available [online]: http://www.ggdc.net/dseries/60-industry.html [2006-10-30]

year in which the GGDC has complete observations for all countries we are inspecting, hence we have chosen this to be the end year of our sample period.

5.2. Minimum Wage Bite

The minimum wage bite, also known as *"Kaitz Index"* (Kaitz, 1970), is an established estimate within the field of labor economics (Skedinger, 2006). *"The Kaitz Index"* is determined by the ratio between the minimum wage and the mean wage, and it is expressed in percent. As Skedinger (2006) argues, the median wage is a better indicator of the income of the average worker and will better capture effects of the wage dispersion within a given country or sector. In our subsequent analysis, we will us his slightly altered version of the *"Kaitz Index"*, as we relate the minimum wage to median instead of mean income.

We consider the modified minimum wage bite to be the best measure for the level of the minimum wage for mainly three reasons. First, as the minimum wage bite is a relative measure it provides us with a value that is comparable across countries. Second, using nominal wage rates would generate an unreasonably large spread, as they would not account for differences in purchasing power across countries. In January 2006 the minimum wage ranged in the European Union alone between 82 and 1 503 Euros per month (Regnard 2006). Finally, the nominal minimum wages give no indication on their relative height compared to other wages within the economy. Contrary to this, the minimum wage bite we use relates minimum to median wage and corrects for this problem.

In general, minimum wages are either statutory or collectively agreed on. Statutory minimum wages are set by the government of each country and are regulated by national law, while collectively agreed minimum wages are negotiated through collective bargaining agreements with labor organizations. The OECD publishes the minimum relative to median wage for OECD countries that have statutory minimum wages on a yearly basis. In the sample studied 14 countries have statutory minimum wages, which are Belgium, the Czech Republic, France, Greece, Hungary, Ireland, Luxembourg, the Netherlands, Poland, Portugal, the Slovak Republic, Spain, and the United Kingdom. See *Table B.1* in *Appendix B.* for the values of the minimum wage bite for the year 2002.

Estimating the minimum wage in countries with collectively agreed minimum wages is a difficult task. First, the collective agreements are not as easily accessible as the statutory wage

laws. Second, in most countries there are many labor organizations, which try to reach agreements within their specific industry or region. This implies different regulations for every industry and even every region with regard to a workers age, skill, employment form, tenure, and position. For the Swedish labor market, approximately 580 collective agreements exist, and according to the National Mediation Office as many as 500 will be renegotiated in 2007. It is thus a very difficult task to reach an overview of these agreements.

As there is no general minimum wage with collective agreements, we had to find an alternate measure as a proxy for the minimum wage. After reviewing the literature, we decided to define a proxy in a similar way to Skedinger (2005, 2006). Skedinger determines the minimum wage for a well defined worker, to whom he refers as a *"typical person"*[4]. In the more recent article, this is a 20 year old male worker with no higher education or professional experience (2006).[5] With this type of definition, it becomes possible to compare the minimum wage guaranteed by different collective agreements in different sectors, and a proxy for the potentially lowest wage can been constructed.

In order to make our proxy for the minimum wage more comparable with the statutory minimum wage we defined our own *"typical worker"* to be at the very bottom of these wage agreements. To ensure international comparability, we chose this person to be employed in a sector that has comparable skill and capital requirements across countries and that is ideally regulated only by one collective agreement per country[6]. Considering the above aspects, we defined the typical worker as an 18 year old male, employed in the construction sector with no higher education or professional experience.

We then proceeded by sending out a questionnaire to the relevant labor organizations in Austria, Finland, Germany, Italy, Norway, and Sweden asking for the minimum wage of our typical person in the year 2002[7], the end year of our sample period.[8] The minimum wage for

[4] Skedinger (2005, 2006) uses the Swedish word *"typperson"*, and we have chosen to use a direct English translation of the term as our methodology is based on his work.
[5] In his earlier work (2005), Skedinger further characterized this *"typical person"* as working in Västerås, the 5th largest city in Sweden.
[6] One exception to this is the German estimation of the minimum wage bite. In Germany there are different collective agreements for different regions. Therefore the German estimate is based on the collective agreements in the region "West".
[7] For consistency reasons, we chose to only use values from this year. In our regression the minimum wage bite is interacted with skill intensity and for this measure we only have values for the year 2002.
[8] A complete list of the labor organizations that we have contacted is presented in the reference list.

this proxy worker can be found in *Table B.3.* In order to estimate a minimum wage bite for these countries comparable with the one constructed by the OECD for countries with statutory minimum wages, we had to obtain median wage statistics. Upon request, we received data from the OECD regarding the median wage for all OECD countries in the year 2002. Unfortunately, no data was available for Italy and we therefore had to exclude Italy from our sample. The statistics from the OECD contain data on annual or monthly median earnings. As the information we received from the labor organizations on minimum wages were generally quoted in earnings per hour, we used data on effective hours worked from the OECD Employment Outlook (2003) to calculate the minimum wage bite. We believe that this proxy is of good quality, as the minimum wage bite calculated by the OECD uses the exact same median wage data.

Still, we would like to point to certain inconsistencies that surface in the related literature after scrutinizing the results of our minimum wage bite calculations. According to our estimates, the minimum wage bite for Sweden is one of the lowest in the sample. Initially, this seemed to be a rather odd finding. Previous research had suggested that in comparison with other European Union members and the United States, Sweden should be a country that has one of the highest minimum wages, as well as one of the highest minimum wage bites (Skedinger, 2006). We do not consider this to reduce the validity of our calculations and believe that this opposing result can be explained. As it was our aim to construct a measure for the theoretically lowest wage within each country in an internationally comparable industry and relate this to a country's median wage, we do not see this obvious contradiction as a threat to our findings. And indeed, in the Swedish construction industry, the lowest possible wage is very low compared to the general median wage. After taking a closer look at the collective agreements for the construction industry, it becomes clear that the differences in our assessment arise from how we defined the *typical person*. The age of the *typical person* in our sample is 18, whereas he is 20 years old in the study by Skedinger (2006). In 2002, the hourly minimum wage for an 18 year old construction worker in Sweden was 51.50 SEK, resulting in a minimum wage bite of 31.94 percent. For a 20 year worker within the same sector the hourly minimum wage was 103.00 SEK, resulting in a minimum wage bite of 63.87 percent, a figure more in line with the one predicted by Skedinger.

5.3. Skill Intensity

Regarding the skill intensity, the literature generally assumes two approaches. First, compensation of labor is seen as a proxy for skill, hence an industry's labor compensation over value added is used as a measure of an industry's skill intensity (Svaleryd and Vlachos, 2005). Further, Levchenko (2004) approximates the skill intensity by calculating the ratio of production workers over total workers in each industry, as formerly the US Bureau of Labor Statistics (BLS) provided such classifications of labor in its statistics[9]. However, in newer releases these have been replaced by a more detailed occupational classification system called the *"Standard Occupation Classification"* system (SOC) for every industry. Since the introduction of the SOC, Levchenko's calculations are no longer possible when newer data is used. Therefore, we have chosen to define our own measure of skill intensity using SOC data. A characteristic of this data is that the lower the digit in the SOC, the more skill intense occupations should be considered. *"Management Occupations"*, for instance, are classified in the lowest class (11), followed by *"Business and Financial Operations Occupations"* (13) and *"Computer and Mathematical Occupations"* (15). Lower skill industries, such as *"Food Preparation Occupations"* (35) and *"Farming, Fishing, and Forrest Occupations"* (45), are assigned much higher digits. We have defined all employees in SOC occupations as *"high skilled workers"* up to a certain threshold and have calculated our measure of skill intensity in the following manner:

$$SKILL_{iUS} = \frac{HISKILLWORK_{iUS}}{TOTALWORK_{iUS}}$$

As $HISKILLWORK_{iUS}$ we have classified workers employed according to the SOC system in classes 11-29 in industry *i*. For the denominator, we used the number of all people employed in all SOC classes in industry *i*. Since the end year of our observation period for this thesis was chosen to be 2002, we used data from this year for our calculations. Pooling the data over our sample period would not have been possible, as the SOC was first defined in 2000, and with the 2002 release the BLS switched to a different industry classification system. Furthermore, we find it reasonable to assume that industry skill intensities should not fluctuate as much during a business cycle as, for instance, capital expenditures would. We believe the cyclical component of this variable to be less important, yet are still aware that we have ignored this issue. To concord the US employment data to our dependant variable, we

[9]U.S. Department of Labor's Bureau of Labor Statistics, available [online]: http://www.bls.gov/oes/oes_dl.htm [2006-10-23]

have used conversion tables provided by the GGDC (2006), this table, as well as the SOC classification system at the 2-digit aggregate level, can be found in *Table G.1.* and *Table F.1.* respectively.

5.4. Human Capital

To control for endowments, we include a variable measuring a country's relative endowment for high-skilled workers. Noted research in the field of measuring human capital endowments has been performed by Barro and Lee (2000). The authors calculated educational attainment as a proxy for capital stock using a perpetual inventory method for 142 countries, for which they supply data up to the year 1995. Up to the year 2000 they provide estimates. As we would like to keep the year of our human capital stock data consistent with the year of our skill intensity data, we prefer using statistics from the year 2002. For our purpose, we find data provided by EUROSTAT to be congenial, as our thesis' focus is on countries within the European Union. We gathered data on total graduates according to the International Standard Classification of Education (ISCED), for the levels 5 and 6 per 1 000 of population in 2002[10]. ISCED level 5 is equivalent to the first stage of tertiary education and ISCED level 6 is equivalent to the second stage of tertiary education.[11] We believe this to be a viable approximation for country level human capital endowments in our analysis. Further, this kind of proxy is also found in related literature (Svaleryd and Vlachos, 2005) and Barro and Lee (2000) use a very similar method as a robustness check for their estimations.

5.5. Capital Endowment

To our knowledge, no satisfactory current data exists on internationally comparable and reliable capital endowments. The Penn World Tables, for example, contain a dataset for *"capital stock per worker"*. However, this time series has not been updated since 1992. In a recent paper (2006), the OECD recognizes this problem, but offers for our analysis little advice on how to solve it. The problem we encountered was that either the data was not internationally comparable, or not recent enough. Hence we have used a not completely satisfactory workaround to this problem and have compiled our own values for capital endowments according to following formula:

[10] Eurostat, available [online]: http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996,45323734&_dad=portal&_schema=PORTAL&screen=welcomeref&open=/edtr/educ&language=en&product=EU_MASTER_education_training&root=EU_MASTER_education_training&scrollto=0 [2006-10-23]

[11] These classifications have been defined by UNESCO. Available [online]: http://www.unesco.org/education/information/nfsunesco/doc/isced_1997.htm [2007-02-10]

$$CAPEND_j = \left(\frac{I_j}{RGDP_j} \right) \cdot RGDPWORK_j$$

Where $\left(\frac{I_j}{RGDP_j} \right)$ stands for "*investment share of GDP in country j*" and $RGDPWORK_j$ stands for "*real GDP per worker in country j*". Data for both have been taken from the Penn World Table 6.2[12] and have been pooled over our sample period from 1993-2002 in order to control for cyclical fluctuations. We are aware of the obvious drawbacks of this way of calculating capital endowments. This type of measurement implies (among other shortcomings) a constant depreciation rate across countries and that investments in each country have the same marginal effect on the existing capital stock. It is obvious that this is not a perfect measure. Nonetheless, we prefer using current values to outdated ones. A better measure for capital endowment would, nevertheless, improve the validity of our analysis.

5.6. Capital Intensity

As with capital endowment, measuring capital intensity is not as straightforward as it seems. Levchenko (2004, p.29) for instance, measures capital intensity as "*one minus total compensation in value added*". We have chosen a method similar to Svaleryd and Vlachos (2005) and have used the annual industry data from the US on capital expenditures and total employees. We have calculated our capital intensity according to following formula:

$$CAPINT_{iUS} = \frac{CAPEXP_{iUS}}{EMPLOYEES_{iUS}}$$

Data was taken from the OECD STAN database[13], using pooled values for the period 1998-2002. "*Gross fixed capital formation at current prices*" was used for $CAPEXP_{iUS}$ and "*Total employment, full-time equivalents*" for $EMPLOYEES_{iUS}$. We chose not to use our full sample period for this calculation, as values for "*Total Employment, full time employment equivalents*" prior to 1998 have been merely estimated and not effectively measured. Again, we used the conversion tables of the GGDC to recode the data to match our dependant variable. We are well aware of the shortcomings of our way of measuring capital expenditure (after all, this assumes depreciation rates, for example, to be constant across all expenditures and industries), however, we have not found a more satisfactory and current measure in the literature.

[12] University of Pennsylvania website. Available [online]: http://pwt.econ.upenn.edu [2006-10-12]
[13] Available [online]: http://www.sourceoecd.org [2006-11-23]

5.7. Deletion of Observations

Originally, the database supplied by the GGDC included 57 industries. The industries *"Fishing"* and *"Public Administration and compulsory social security"* had to be removed, as the BLS did not supply occupational classifications for these and we could not calculate skill intensities. The industries *"Research and Development"*, *"Private households with employed persons"* and *"Extra-territorial organizations and bodies"* had to be deleted, as values for annual capital expenditures are not provided by the OECD and capital intensities could not be computed. Italy and Luxembourg, two countries originally part of our sample, had to be dropped as the OECD has no data on median income for Italy and no human capital data was available for Luxembourg from Eurostat. For a complete list of countries and industries, please see *Appendix B.* and *Appendix E.*

6. Analysis and Discussion

This chapter of our thesis will describe the procedures used to analyze our data and we will discuss the findings. Further, we evaluate variations in the regression analysis to check for the robustness of our results and address the problem of simultaneous causality.

6.1 Main Model

To analyze our data we performed a multiple regression analysis using Ordinary Least Squares (OLS). As discussed in *Chapter 3.*, we expect the coefficient of the $WAGEB_j \cdot SKILL1_{iUS}$ interaction variable to be positive.

Our initial analysis shows the expected results: The coefficient of interest had a value of 0.0641 and is significant at the 5 percent level (*p*-value 0.048). The explanatory power of our model is roughly 50 percent (R^2 of 0.480). However, the graphical analysis of our results shows that we have a severe case of heteroscedasticity in our model. Subsequently, we performed the Goldfeldt-Quandt's test to statistically verify that the error term was indeed heteroscedastic: The null hypothesis of a homoscedastic error term was rejected at the 5 percent level (For detailed results of this test, please see *Appendix D.*). To correct this problem, we performed the same regression with heteroscedasticity robust variances and standard errors, leaving the estimated coefficients and the explanatory power of the model unchanged. In this second estimation, the *p*-value increased to 0.082, making the coefficient of interest insignificant at the 5 percent level, yet remaining significant at the 10 percent level. Therefore, we believe to have found robust statistical evidence that the minimum wage bite affects industry specialization at the 10 percent level of significance. See *Table C.1.* in *Appendix C.* for a complete summary of the results.

6.2. Robustness Checks

To evaluate the reliability of our findings we performed several robustness checks, each of which will be presented here briefly.

6.2.1. Alternate Measure for Skill Intensity

In order to control whether the definition used for skill intensity affects the outcome of our analysis, we ran the same heteroscedasticity robust regression as in the main model, but used

a second skill intensity measure. The alternate approximation is based on labor compensations per industry and was calculated according to following formula:

$$SKILL2_{iUS} = \frac{AVGCOMP_{iUS}}{\sum_{i=1}^{n} AVGCOMP_{iUS}}$$

Where $AVGCOMP_{iUS}$ is the average labor compensation per employee (in USD) in industry *i* divided by the average labor compensation per employee for all industries in the United States.

Data for this measure was again taken from GGDC's 60-Industry database for the year 2002. The results from this regression are summarized in *Table C.1.* in *Appendix C*. The variable of interest remains positive (0.00788), however the *p*-value increases substantially to 0.530. To a lesser extent, the R^2 dropped as well (0.447). From this regression, we find verification that the expected sign of our interaction term seems correct. Nevertheless, this result casts doubts on the validity of our first skill intensity measure and if the minimum wage really has an effect on industry specialization. It strikes us as odd that the correlation between these two skill intensity measures is not very high (0.411). Still, we believe that the skill intensity proxy based on SOC data is valid, as it actually captures the nature of an industry's occupational structure rather than simply comparing the level of compensation across industries. We find it reasonable that the SOC based measure fits the data much better and seems to be able to explain far more industry specialization.

6.2.2. Observations from Countries with Statutory Minimum Wages

In order to control whether our definition of the minimum wage bite for countries with collectively agreed minimum wages is acceptable, we ran heteroscedasticity robust regressions with observations only from countries with statutory minimum wages. If our estimates for the collectively agreed minimum wages are biased, we would expect a difference in the outcome of the regression. From our working hypothesis, it is clear that we expect minimum wages to affect industry specialization, however, we do not expect the size nor significance of this effect to change whether the minimum wages are collectively agreed upon or statutory. The $WAGEB_j \cdot SKILL1_{iUS}$ coefficient variable takes a value of 0.100, which is somewhat larger than with our complete sample. Further the level of significance has increased by 0.8 percentage points (*p*-value of 0.074). This might be an indication that our estimated minimum wages are not a valid proxy of the statutory minimum wage. We would

like to point out though that we only estimated four countries' minimum wage according to our methodology and we believe that the sample size would be too small to conclude that our approximations are invalid. From these results one could also infer that statutory wages affect industry specialization more than collectively agreed ones. We do not want to make this stark conclusion from our analysis and believe this would be an interesting topic for future research. Nonetheless, we find verification with this model specification that the minimum wage will have an effect on industry specialization at the 10 percent significance level, as in our original model.

6.2.3. Observations from Manufacturing Industries

Using the original measure for skill intensity, manufacturing industries[14] have an average skill intensity of 0.166, compared to 0.242 in the non manufacturing industries. Further, the variance of skill intensities in manufacturing is much lower as well (0.0200 vs. 0.0364). In light of these numbers, we find it reasonable to classify manufacturing industries as relatively low skill industries as compared to the other industries in our sample. As we reasoned in previous paragraphs, we believe that a high minimum wage bite will increase specialization in high skill industries, while it will reduce it in low skill industries. Therefore, we expect a high minimum wage to reduce specialization in manufacturing industries. As a robustness-check to our original model we reran the heteroscedasticity robust regression of our main model, this time for manufacturing industries only. As expected, the coefficient of the interaction term was negative (-0.00834), however insignificant with a *p*-value of 0.543. Again, the coefficient has the expected sign and we consider this a further validation for our theoretical predictions and for our empirical model. However, as the coefficient is only slightly negative (with a standard error of 0.0137 and the high *p*-value), it also could be assumed that the effect is zero. We would like the reader to keep this in mind when interpreting these results. Again, they can be found in *Appendix C*.

6.3. Simultaneous Causality

In this section, we will discuss possible events and factors that may imply simultaneous and/or reversed causality between the dependant and the explanatory variables.

Regarding the minimum wage bite, there are several factors which may lead to an outcome in which the structure of industry specialization in a certain country affects the minimum wage

[14] 60 Ind No. 5 - 31.

bite. In a country with an increasing share of high-skilled and well paid labor, the effect of a small minimum wage raise would be less severe, as it would affect a smaller proportion of the workforce. In this scenario, the unemployment increase caused by the minimum wage raise might be very little, making it politically easier to pass such laws.

Furthermore, it could be argued that a high degree of specialization in high skilled industries might cause an increase in the skill intensities and human capital endowments of these industries, as opposed to the reverse causality suggested in our analysis. For certain regions, as for instance, the IT cluster in Silicon Valley (US) or the pharmaceutical cluster in Basel (Switzerland), this might hold. Both of these regions have positioned themselves as leaders within a certain sector and it is evident that a certain type of human capital will be attracted to them from across the world. Further, they profit from vast educational funding from large corporations, thus, not only increasing the human capital stock, but also possibly increasing the skill intensity within their industry.

Additionally, as capital is mobile across nations and industries, one could argue that investments are being made in countries with a highly specialized industry structure. Popular business literature would suggest that countries with highly specialized clusters in certain industries will be more profitable than countries with less successful clusters (Porter, 1998). As a consequence, this would attract more Foreign Direct Investment which is in turn a determinant for capital endowment as we have chosen to define it in our sample. Hence, increased industry specialization will potentially affect capital inflows and thus capital endowments and intensities.

Although there might be issues of simultaneous or reversed causality in our model, we have not chosen to further investigate this here and leave it open to future research.

6.4. A Note on the Limitations of Our Analysis

We would like to point out limitations of our regression analysis due to the construction of the data set and the regression analysis. As we primarily used pooled data, we cannot account for structural changes that took place *within* industries during our sample period. In our model, all industry specialization is accounted by concentrating value added over GDP of the industry *as a whole* given *constant skill and capital intensities.* Of course in reality, changes to these intensities can be the cause for increased specialization in one specific industry. Italian shoe

manufacturers are a prime example for an industry that formerly was classified as a low skill industry, which has however emerged as a highly specialized high skill industry. This example illustrates two limitations to our analysis: First, we cannot account for changes in the skill intensities in certain industries in certain countries. For this kind of analysis we would need detailed panel data, which we do not have. Secondly, even if we had such data, it is not apparent if improved skills in this industry would have made the skill level of the entire industry greater than before, as the shoe manufacturing industry is only one subgroup of the industry class “leather and footwear.” Further, some countries might increases specialization in high skill industries by increasing skill and capital endowments. But again, for this kind of analysis we would need detailed panel data containing skill and capital intensities from every country in our sample, not just from the US. We would therefore like the reader to keep in mind that in this thesis we only account for industry specialization across highly aggregated industries, whereby we hold intensities and endowments constant across countries.

7. Main Findings & Conclusion

As stated in the introduction, the main question of our thesis is: *Will a relatively high minimum wage, compared to median wage, increase industry specialization in high skill industries (relative to low skill industries)?* We found this topic to be particularly intriguing, as the minimum wage is a constant in the political debate and prior research on the minimum wage effects on industry specialization does not seem to exist. To test this hypothesis, we have constructed a dataset containing 52 industries across 17 European countries giving us a total of 884 observations. Further, we developed a methodology to assess the impact of minimum wage in countries without a statutory wage and calculated these for four countries in our sample.

In theory, we expected a high minimum wage bite to increase industrial specialization in high skill industries and the reverse effect in low skill industries. If the minimum wage is set above the competitive labor market equilibrium, labor can no longer be paid the value of its marginal product. However, there is reason to believe that a minimum wage will increase the productivity of a country's labor force (Bullock and Hughes, 2001); (Forth and O'Mahony, 2003). Industries in which there is demand for high skilled labor and in which the value of the marginal product of labor is equal to or above the minimum wage rate will profit from this development and expand. Industries in which more productive, and therefore more expensive, labor is not needed, will find it inefficient to employ labor and contract.

When reviewing the results of our main model, we believe it is reasonable to assume that our hypothesis holds at the 10 percent significance level: There is a statistically determinable relationship between the minimum wage bite and industry specialization. Furthermore, the explanatory power of our model seems satisfactory as the R^2 of 0.4803 suggests that almost 50 percent of the variation in specialization is captured by the model. The sub-sample containing only observations for statutory minimum wages confirms these results. As a validation of our theoretical argumentation, the regression including only observations for manufacturing industries shows that low skill industries reduce specialization when a high minimum wage is in place, albeit with low statistical significance.

We would, nonetheless, like to point out the certain areas where our model did not perform well: In no valid specification of our model did the interaction term of interest reach the

statistically critical 5 percent significance level. Further, we have serious doubts about the quality of some explanatory variables: The model using only observations from countries with statutory minimum wages performs slightly better than our full model in which we have added calculated minimum wage bites. When using an alternate measure for skill intensity, our model performed remarkably worse. As pointed out in the data chapter, we are not satisfied with the quality of our variables for the capital endowments and intensities. We are aware of the deficiencies, but have not come up with a better solution to this problem. We feel it is important to mention that all of the data of our explanatory variables have been compiled manually from different sources using different classification systems, such as the North American Industry Classifications System (NAICS) opposed to International Standard Industry Classification (ISIC). Even though a very large amount of research and effort has been put into these calculations, we believe better data would significantly increase the validity of our results. Finally we would like the reader to keep in mind possible problems in our analysis with reverse, as well as with simultaneous causality.

Ending the validity discussion of our model, we would like to summarize the main points regarding the internal validity and then address the question if the model is externally valid. Our model can provide some statistical evidence of the interdependence between industry specialization and the minimum wage bite. However, too low statistical significance, unreliable explanatory variables and causality issues clearly prevent us from declaring this model fully internally valid. As this is the case, the model cannot be considered externally valid. We doubt this model is strong enough to be used to make reliable predictions about the effect of a minimum wage raise on industry specialization and do not recommend this to be done.

Related to our thesis, we see various possible fields for future research: First, the issue of simultaneous and reverse causality should be addressed. A possible way of solving this problem would be by developing a complete model taking both directions of causality into account. Second, a great deal of industry specialization takes place *within* an industry. We do not account for this kind of specialization, as this would infer changes to an industry's skill intensities, which we hold constant. Finally, as the results for the sample containing only observations from countries with statutory minimum wages were stronger than the results for the complete sample, it would be interesting to investigate this further. The question arises if there is indeed a difference between the structural effects caused by statutory minimum wages

and collectively agreed ones. Is it possible to say that a statutory minimum wage has a larger effect on productivity and industry specialization than a collectively agreed one?

To conclude we would like to raise the point that in general the minimum wage might take up too much space in the political forum. Our research does not point to the conclusion that the industry specialization structure of an economy can be effectively altered or improved by using the minimum wage as an industrial policy tool. Further, the negative view of minimum wages causing unemployment, are heavily contested as well. As neither positive nor negative effects are clearly identifiable, it could be argued that importance of the minimum wage has been exaggerated, in politics as well as in academics. Charles Brown, a leading empirical economist in this field and coauthor of the study published by the "Minimum Wage Study Commission" (1982) raised doubts about the severity of this issue approximately 20 years ago. To him, the political and academic weight of the discussion had become out of proportion with the actual impact of the issue:

"It is hard for me to see evidence that minimum wage increases have benefits which would overcome an economist's aversion against to interfering with reasonably competitive markets. But the case against the minimum wage seems to me to rest more upon that aversion than on the demonstrated severity of any harm done to those directly affected" (Brown 1988, p.13)

In light of our findings, we find it hard to argue against his point.

8. References

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Labor Organizations

In order to define the minimum wage for our *"typical worker"*, the following labor organizations were contacted (detailed references are available upon request):

Austria	*Arbeiterkammer*	www.aknoe.at
Finland	*Palvelualojen Ammattiliitto*	www.pam.fi
Germany	*Boeckler*	www.boeckler.de
Norway	*Fellesforbundet*	www.fellesforbundet.no
Sweden	*Byggnads*	www.byggnads.se

9. Appendices

A. Variables and Notations

Table A.1. Variables and notations used.

Variable	Notation
Specialization	$SPEC_{ij}$
Minimum wage bite	$WAGEB_{j}$
Human capital	HC_{j}
Skill intensity, SOC based measure	$SKILL1_{iUS}$
Skill intensity, alternate measure	$SKILL2_{iUS}$
Capital endowment	$CAPEND_{j}$
Capital intensity	$CAPINT_{iUS}$
Industry dummy variable	$DINDUSTRY_{i}$
Country dummy variable	$DCOUNTRY_{j}$
Value added	VA_{ij}
High-skilled workers	$HISKILLWORK_{iUS}$
Total amount of workers	$TOTALWORK_{iUS}$
Total investments	I_{j}
Real Gross Domestic Product	$RGDP_{j}$
Real Gross Domestic Product per worker	$RGDPWORK_{j}$
Total number of employees	$EMPLOYEES_{iUS}$
Minimum wage	$MINWAGE_{j}$
Median wage	$MEDWAGE_{j}$
Capital expenditure	$CAPEXP_{iUS}$
Manufacturing dummy	$DMAN_{i}$
Average compensation per employee	$AVGCOMP_{iUS}$
Denotations	
United States denotation	US
Country denotation	j
Industry denotation	i

B. Estimates of the Explanatory Variables

Table B.1. Estimates of the explanatory variables for the countries used in the sample.

Country	Included in the Regression Model	Minimum Wage Bite (per cent in 2002)	Statutory Minimum Wage	Capital Endowment (pooled 1993-2002)	Human Capital Endowment (per cent in 2002)
Austria	Yes	66.7	No	12 945.14	26.6
Belgium	Yes	47.4	Yes	12 815.83	55.9
Czech Republic	Yes	36.7	Yes	4726.03	24.2
Finland	Yes	42.4	No	8 926.40	59.8
France	Yes	60.7	Yes	11 559.97	71.4
Germany	Yes	64.5	No	10 904.43	30.9
Greece	Yes	49.0	Yes	6 507.351	26.1
Hungary	Yes	48.8	Yes	4 418.52	38.9
Ireland	Yes	38.8	Yes	10 400.77	70.9
Luxembourg[a]	No	53.4	Yes	24 284.29	-
Netherlands	Yes	51.6	Yes	11 217.00	42
Norway	Yes	59.5	No	13 402.03	50.4
Poland	Yes	39.5	Yes	2 794.53	76.4
Portugal	Yes	44.2	Yes	7 434.93	40.3
Slovak Republic	Yes	44.4	Yes	3 336.69	30.7
Sweden	Yes	32.0	No	9 863.86	41.5
Spain	Yes	29.7	Yes	8 314.20	43.8
United Kingdom	Yes	43.7	Yes	8 414.42	73.5
United States	No	33.4	Yes	13 425.22	57.6

Notes: [a] Deleted from the sample due to the lack of data on human capital endowment.
Sources: OECD, Penn World Tabls, Eurostat, and our calculations.

Table B.2. Minimum wage bite in 2002 for countries not used in our sample.

Country	Minimum Wage Bite (per cent)	Statutory Minimum Wage
Australia	56.7	Yes
Canada	41.8	Yes
Japan	31.4	Yes
Korea	25.1	Yes
Mexico	19.3	Yes
New Zeeland	44.6	Yes

Source: OECD

Table B.3. Data for estimating the minimum wage bite for countries with collectively agreed minimum wages.

Country	Sector	Hourly Minimum Wage[b] (national currency)	Hourly Median Wage[c] (national currency)	Minimum Wage Bite (per cent)
Austria	Construction	1 218.71	1826.57	66.72
Finland	Construction	6.57	15.48	42.43
Germany	Construction	1709.00	2,651.00	64.47
Norway	Construction	108.50	182.24	59.53
Sweden	Construction	51.50	161.26	31.94

Notes: [b] Based on questionnaires sent out to labor organizations in the respective countries.
[c] Based on data from the OECD, see the data chapter for a complete description.
Sources: AKNOE, Boeckler, Byggnads, Fellesforbundet, Rakennusliitto, OECD.

C. Regression Results for the Estimated Models

Table C.1. Results from OLS and White's regressions.

Variable		Main Model, (OLS)	Main Model (White's)	Main Model with Alternative Skill Measure (White's)	Manufacturing Only (White's)	Only Statutory Minimum Wages, Skill 1 (White's)	Only Statutory Minimum Wages, Skill 2 (White's)
$WAGEB_j \cdot SKILL1_{iUS}$	Coefficient	0.0640517	0.0640517	-	-0.0083448	0.1002982	-
	Std. Error	0.032398	0.0367297		0.013722	0.0560249	
	Significance	0.048**	0.082*		0.543	0.074*	
$WAGEB_j \cdot SKILL2_{iUS}$	Coefficient	-	-	0.0095838	-	-	0.0071151
	Std. Error			0.0135367			0.0215181
	Significance			0.479			0.741-
$HC_j \cdot SKILL1_{iUS}$	Coefficient	0.000695	0.000695	-	0.0001517	0.0007685	-
	Std. Error	0.0002153	0.0002961		0.0001327	0.0003086	
	Significance	0.001***	0.019**		0.253	0.013**	
$HC_j \cdot SKILL2_{iUS}$	Coefficient	-	-	0.0001268	-	-	0.000141
	Std. Error			0.0001124			0.0001189
	Significance			0.260			0.236
$CAPEND_j \cdot CAPINT_{iUS}$	Coefficient	1.26e-09	1.26e-09	9.31e-10	4.44e-10	-1.28e-09	-1.66e-09
	Std. Error	3.73e-09	2.18e-09	1.87e-09	8.14e-10	1.95e-09	1.58e-09
	Significance	0.737	0.565	0.618	0.586	0.512	0.292
Industries		52	52	52	27	52	52
Countries		17	17	17	17	12	12
Number of observations		884	884	884	459	624	624
R^2		0.4803	0.4803	0.4747	0.5381	0.4560	0.4468
$\overline{R}^2$		0.4355	-	-	-	-	-

Notes: *** The coefficient is significant at the one per cent level (2-tailed).
** The coefficient is significant at the five per cent level (2-tailed).
* The coefficient is significant at the ten per cent level (2-tailed).

D. Heteroscedasticity Test

Graphical Analysis

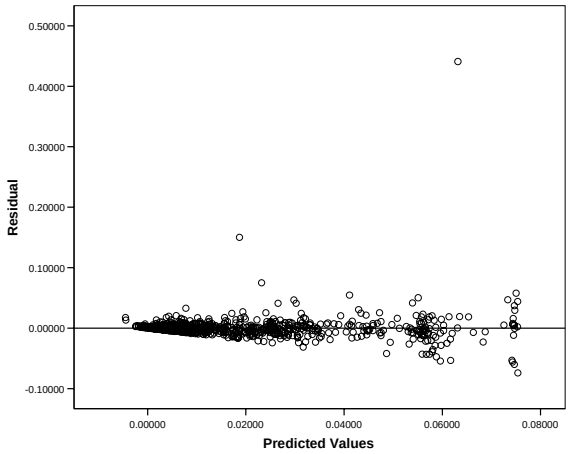

Figure D.1 Scatterplot of the predicted values versus the residuals.

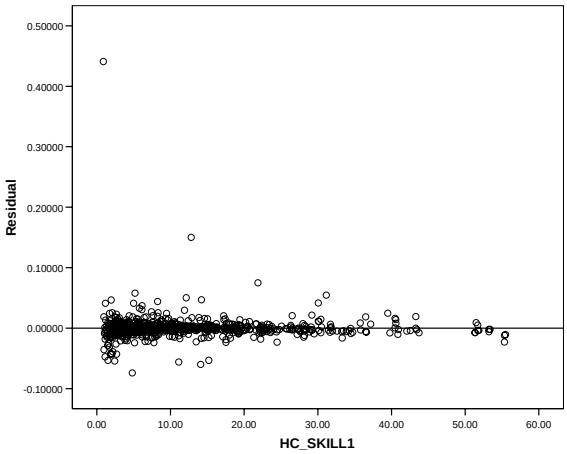

Figure D.2. Scatterplot of the interaction term of human capital and skill intensity versus the residuals.

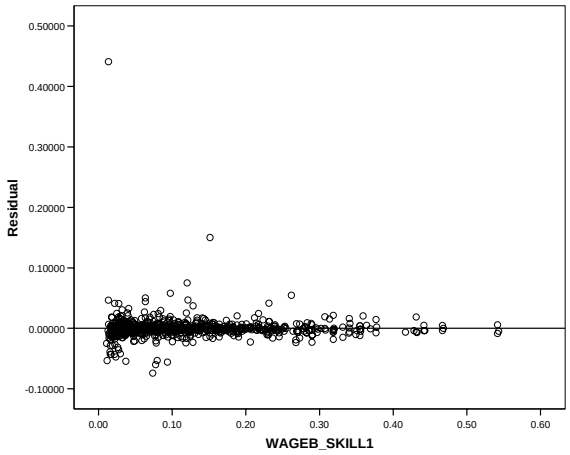

Figure D.3. Scatterplot of the interaction term of the minimum wage bite and skill intensity versus the residuals.

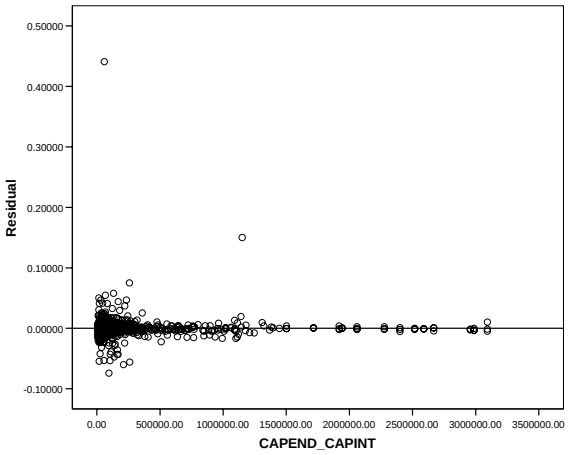

Figure D.4. Scatterplot of the interaction term of capital endowment and capital intensity versus the residuals.

Goldfeldt-Quandt's Test

The Goldfeldt-Quandt's test uses the following null hypothesis: $H_0 : \sigma_1^2 = \sigma_2^2$ i.e. the variance in the sample is constant, versus $H_1 : \sigma_1^2 < \sigma_2^2$ i.e. the error term is heteroscedastic. The test equation is as follows:

$\lambda = \frac{RSS_2 / (n_2 - k_2)}{RSS_1 / (n_1 - k_1)}$ which is *F* distributed with $(n2 - k_2)$ and $(n_1 - k_1)$ degrees of freedom.

As a first step the main model is estimated by using OLS-regression, upon which the predicted values from the regression are saved, and the sample is sorted ascending according to these. Then two groups are created by deleting $c = \frac{n}{6}$, which in our sample is equal to 147, in the middle, so that we have one group with the lowest residuals and one with the highest. By running OLS-regressions for the two groups, we obtain the residual sum of squares needed to perform the test, as shown in the following equation:

$\lambda = \frac{0.119117 / (370 - 71)}{0.009799 / (368 - 70)} = 12.1153$ which is *F* distributed with 299, 298 degrees of freedom, the critical value on the five per cent level is 1.2101. Since $\lambda_{obs} = 12.1153 > F_{crit} = 1.2101$, the null hypothesis of having a homoscedastic error term is rejected.

E. Industry Classification Table

Table E.1. Industry classification table.

60 Ind	Industry Name	ISIC rev 3	Capital Intensity	Skill Intensity 1[f]	Skill Intensity 2
1	Agriculture	01	12.56469844[g]	0.036373	0.573807
2	Forestry	02	12.56469844[g]	0.042897	0.467272
3	Fishing[d]	05	12.56469844[g]	-	0.139846
4	Mining and quarrying	10-14	85.88423014	0.254032	1.692133
5	Food, drink & tobacco	15-16	7.929761449	0.070413	1.094861
6	Textiles	17	4.8282432	0.071264	0.843982
7	Clothing	18	1.641944046	0.073732	0.702877
8	Leather and footwear	19	3.053877702	0.071810	1.007413
9	Wood & products of wood and cork	20	4.610870786	0.071477	0.855265
10	Pulp, paper & paper products	21	13.7266355	0.096495	1.397201
11	Printing & publishing	22	6.913976954	0.245632	1.052672
12	Mineral oil refining, coke & nuclear fuel	23	52.09970733	0.247136	2.202864
13	Chemicals	24	24.82365922	0.308383	1.901829
14	Rubber & plastics	25	9.377082161	0.100950	1.057681
15	Non-metallic mineral products	26	9.823091798	0.089506	1.128926
16	Basic metals	27	10.35567603	0.104333	1.336516
17	Fabricated metal products	28	5.991668216	0.128083	1.113609
18	Mechanical engineering	29	14.39279491	0.207495	1.320528
19	Office machinery	30	19.41055476	0.572376	1.917438
20	Insulated wire	313	9.345112873[g]	0.181940[h]	1.314654
21	Other electrical machinery and apparatus	31-313	9.345112873[g]	0.181940[h]	1.267747
22	Electronic valves and tubes	321	27.46301335[g]	0.394561	1.66448
23	Telecommunication equipment	322	27.46301335[g]	0.443303	1.910479
24	Radio and television receivers	323	27.46301335[g]	0.267040	1.436673
25	Scientific instruments	331	10.75464061[g]	0.371384[h]	1.724263
26	Other instruments	33-331	10.75464061[g]	0.371384	2.571029

60 Ind	Industry Name	ISIC rev 3	Capital Intensity	Skill Intensity 1[f]	Skill Intensity 2
27	Motor vehicles	34	12.41027365	0.098599	1.744007
28	Building and repairing of ships and boats	351	230.743221[g]	0.149785	1.176112
29	Aircraft and spacecraft	353	230.743221[g]	0.468691	1.944868
30	Railroad equipment and transport equipment	352+359	230.743221[g]	0.176471	1.281681
31	Furniture, miscellaneous manufacturing; recycling	36-37	4.613920823	0.101601	0.955262
32	Electricity, gas and water supply	40-41	107.8199005	0.271090	1.950576
33	Construction	45	3.871284017	0.100087	1.079842
34	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50	5.44313811[g]	0.061634	0.734646
35	Wholesale trade and commission trade, except of motor vehicles and motorcycles	51	5.44313811[g]	0.158822	1.321925
36	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	52	5.44313811[g]	0.080150	0.653376
37	Hotels & catering	55	3.101344039	0.044594	0.390847
38	Inland transport	60	12.12588065	0.056186	1.055655
39	Water transport	61	85.17840598	0.163399	1.603939
40	Air transport	62	56.42524527	0.074284	1.5572
41	Supporting and auxiliary transport activities; activities of travel agencies	63	6.611567774	0.088359	0.940944
42	Communications	64	46.56798925	0.211655	1.357804
43	Financial intermediation, except insurance and pension funding	65	20.34432033[g]	0.320240	1.368804
44	Insurance and pension funding, except compulsory social security	66	20.34432033[g]	0.385931	1.474777
45	Activities auxiliary to financial intermediation	67	20.34432033[g]	0.361520	3.638493
46	Real estate activities	70	20.28383669	0.198837	0.944077
47	Renting of machinery and equipment	71	102.1236133	0.100122	0.80197
48	Computer and related activities	72	13.08658295	0.726094	2.048675
49	Research and development	73	-	0.744853	1.870425
50	Legal, technical and advertising	741-3	5.274387533[g]	0.557019	1.455847
51	Other business activities	749	5.274387533[g]	0.132659	0.64583
52	Public administration and defense; compulsory social security[d]	75	22.93136074	-	1.979029
53	Education	80	1.959554767	0.724103	0.575781

60 Ind	Industry Name	ISIC rev 3	Capital Intensity	Skill Intensity 1[f]	Skill Intensity 2
54	Health and social work	85	5.518445511	0.724103	0.908333
55	Other community, social and personal services	90-93	4.984437466	0.486492	0.739326
56	Private households with employed persons[e]	95	-	-	0.322885
57	Extra-territorial organizations and bodies[e]	99	-	-	0

Notes:
[d] Industry deleted due to the lack of skill intensity data.
[e] Industry deleted due to the lack of capital intensity data.
[f] Full conversion of NAICS to ISIC only possible at 6-digit level, SOC data however only provided at the 5-digit level. Therefore some minor discrepancies exist. The full list of conversion discrepancies will be provided by the authors upon request
[g] Industry level data for Capital Expenditure not available at the lower aggregation class, higher aggregation class was assigned.
[h] SOC data for this industry not available, as it is contained in the next industry, hence the following industry's Skill Intensity was assigned.

Sources : *The Groningen Growth & Development Center, 60-Industry Database, http://www.ggdc.net/dseries/60-industry.html*

F. Occupational Classification Table

Table F.1. Standard Occupational Classification System (SOC), major groups.

SOC code[i]	Occupation
11-0000	Management Occupations
13-0000	Business and Financial Operations Occupations
15-0000	Computer and Mathematical Occupations
17-0000	Architecture and Engineering Occupations
19-0000	Life, Physical, and Social Science Occupations
21-0000	Community and Social Services Occupations
23-0000	Legal Occupations
25-0000	Education, Training, and Library Occupations
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations
29-0000	Healthcare Practitioners and Technical Occupations
31-0000	Healthcare Support Occupations
33-0000	Protective Service Occupations
35-0000	Food Preparation and Serving Related Occupations
37-0000	Building and Grounds Cleaning and Maintenance Occupations
39-0000	Personal Care and Service Occupations
41-0000	Sales and Related Occupations
43-0000	Office and Administrative Support Occupations
45-0000	Farming, Fishing, and Forestry Occupations
47-0000	Construction and Extraction Occupations
49-0000	Installation, Maintenance, and Repair Occupations
51-0000	Production Occupations
53-0000	Transportation and Material Moving Occupations
55-0000	Military Specific Occupations

Notes: [i] Each occupation in the SOC is placed within one of these 23 major groups. For more information on the Standard Occupational Classification System please visit the U.S. Department of Labor's Bureau of Labor Statistics www.bls.gov/soc.

Source: U.S. Department of Labor's Bureau of Labor Statistics www.bls.gov/soc

G. Industry Conversion Table

Table G.1. Conversion tables from Groningen Growth & Development Center.

Auxiliary Industry Number	Industry description	NAICS 97	60 Ind
1	Farms	111, 112	1
2	Support Activities for agriculture and forestry	115	1
3	Forestry and logging	113	2
4	Fishing, hunting and trapping	114	3
5	Mining	21	4
6	Utilities	22	32
7	Construction	23	33
8	Wood products	321	9
9	Nonmetallic mineral products	327	15
10	Primary metals	331	16
11	Fabricated metal products	332	17
12	Machinery, excl. Office Machinery and Photographic, Optical Instrument and Lens and Photocopying Equipment Manufacturing	333ex333313-15	18
13	Office Machinery and Photocopying Equipment Manufacturing	333313+333315	19
14	Optical Instrument and Lens Manufacturing	333314	26
15	Computer and Peripheral Equipment Manufacturing	3341	19
16	Semiconductor and Other Electronic Component Manufacturing	3344	22
17	Communications Equipment Manufacturing	3342	23
18	Audio and Video Equipment Manufacturing	3343	24
19	Navigational, Measuring, Electromedical, and Control Instruments excl. Watch, Clock, and Part Manufacturing	3345ex334518	25
20	Watch, Clock, and Part Manufacturing	334518	26
21	Manufacturing and Reproducing Magnetic and Optical Media	3346	11
22	Household Appliance Manufacturing	3352	18
23	Communication and Energy Wire and Cable Manufacturing	33592	20
24	Electric Lighting Equipment, Electrical Equipment and Other Electrical Equipment and Component Manufacturing, excl. Communication and Energy Wire and Cable Manufacturing	3351 3353 3359ex33592	21

Auxiliary Industry Number	Industry description	NAICS 97	60 Ind
25	Motor Vehicle, Motor Vehicle Body and Trailer and Motor Vehicle Parts Manufacturing	3361, 3362, 3363	27
26	Ship and Boat Building	3366	28
27	Aerospace Product and Parts Manufacturing	3364	29
28	Railroad Rolling Stock and Other Transportation Equipment Manufacturing	3365, 3369	30
29	Furniture and related products	33	731
30	Medical Equipment and Supplies, excl. Laboratory Apparatus and Furniture and Ophthalmic Goods Manufacturing	3391ex339111+339115	25
31	Ophthalmic Goods Manufacturing	339115	26
32	Laboratory Apparatus and Furniture and Other Miscellaneous Manufacturing	33911, 3399	31
33	Food and beverage and tobacco products	311, 312	5
34	Textile mills and textile product mills	313, 314	6
35	Apparel Manufacturing	315	7
36	Leather and Allied Product Manufacturing	316	8
37	Paper products	322	10
38	Printing and related support activities	323	11
39	Petroleum and coal products	324	12
40	Chemical products	325	13
41	Plastics and rubber products	326	14
42	Motor Vehicle and Motor Vehicle Parts and Supplies Wholesalers	4211	34
43	Wholesale trade, excl. Motor Vehicle and Motor Vehicle Parts and Supplies	42ex4211	35
44	Motor Vehicle and Parts Dealers and Gasoline Stations	441+447	34
45	Retail trade excl. Motor Vehicle and Parts Dealers and Gasoline Stations	44ex441+447+45	36
46	Air transportation	481	40
47	Rail transportation	482	38
48	Water transportation	483	39
49	Truck transportation	484	38
50	Transit and ground passenger transportation	485	38
51	Pipeline transportation	486	38
52	Scenic and Sightseeing Transportation and Support Activities for Transportation	487+488	41
53	Couriers and Messengers	492	42

Auxiliary Industry Number	Industry description	NAICS 97	60 Ind
54	Warehousing and Storage	493	41
55	Newspaper, Periodical, Book, and Database Publishers	5111	11
56	Software Publishers	5112	48
57	Motion picture and sound recording industries	512	55
58	Telecommunications	5133	42
59	Radio and Television Broadcasting and Cable Networks and Program Distribution	5131+5132	55
60	Data Processing Services	5142	48
61	Information Services	5141	55
62	Monetary Authorities - Central Bank and Credit Intermediation and Related Activities	521+522	43
63	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	523	45
64	Insurance Carriers and Related Activities	524	44
65	Funds, Trusts, and Other Financial Vehicles	525	44
66	Real estate	531	46
67	Rental and leasing services and lessors of intangible assets	533	43
68	Rental and leasing services and lessors of intangible assets	532	47
69	Legal services	5411	50
70	Computer systems design and related services	5415	48
71	Scientific Research and Development Services	5417	49
72	Accounting, Tax Preparation, Bookkeeping, and Payroll, Architectural, Engineering, and Related, Management, Scientific, and Technical Consulting, Advertising and Related and Marketing Research and Public Opinion Polling	5412+5413+5416+5418+54191	50
73	Specialized Design and Other Professional, Scientific, and Technical Services excl. Marketing Research and Public Opinion Polling	5414+5419ex54191	51
74	Management of companies and enterprises	55	50
75	Travel Arrangement and Reservation Services	5615	41
76	Office Administrative Services	5611	50
77	Facilities Support, Employment, Business Support, Investigation and Security Services, Services to Buildings and Dwellings and Other Support Services	5612-5614+5616-5619	51
78	Waste management and remediation services	562	55
79	Educational services	61	53

Auxiliary Industry Number	Industry description	NAICS 97	60 Ind
80	Health care and social assistance	62	54
81	Arts, entertainment, and recreation	71	55
82	Accommodation and food services	72	37
83	Automotive Repair and Maintenance	8111	34
84	Repair and Maintenance, excl. Automotive Repair and Maintenance	8112-8114	36
85	Personal and Laundry Services and Religious, Grantmaking, Civic, Professional, and Similar Organizations	812+813	55
86	Private Households	814	56
87	Federal general government	GenGov	52
88	Federal government enterprises	491	42
89	State and local general government	GenGov	52
90	State and local schools	Edu	53
91	State and local hospitals	Health	54
92	State and local government enterprises	GovEn	52

Notes: For a complete description of the methodology used, please visit: www.ggdc.net/dseries/data/60-industry/2006/60-I(s)_US_06II.pdf
Source: Groningen Growth and Development Center, www.ggdc.net