Rapporter
Reports
41/2013

Statistics Norway

Statistisk sentralbyrå

Marit Linnea Gjelsvik

The Demand for Labour by Education

A Sectoral Model of the Norwegian Economy

Reports 41/2013

Marit Linnea Gjelsvik

The Demand for Labour by Education

A Sectoral Model of the Norwegian Economy

Statistisk sentralbyrå • Statistics Norway
Oslo–Kongsvinger

Reports In this series, analyses and annotated statistical results are published from various surveys. Surveys include sample surveys, censuses and register-based surveys.

Published October 2013

ISBN 978-82-537-8755-8 (printed)
ISBN 978-82-537-8756-5 (electronic)
ISSN 0806-2056
Subject: Arbeid og lønn/Sysselsetting

Print: Statistics Norway

Symbols in tables	**Symbol**
Category not applicable	.
Data not available	..
Data not yet available	…
Not for publication	:
Nil	-
Less than 0.5 of unit employed	0
Less than 0.05 of unit employed	0.0
Provisional or preliminary figure	*
Break in the homogeneity of a vertical series	—
Break in the homogeneity of a horizontal series	|
Decimal punctuation mark	.

Preface

Since the early 1990s, Statistics Norway has produced model-based projections of supply and demand of labour by education. Supply and demand are modeled separately. This report studies the factors that influence firms' demand for workers with different skills, forming the basis for the projections on the demand side.

This report has been financed by Ministry of Education and Research, Ministry of Labour, Ministry of Trade and Industry and the Labour and Welfare Service. The author wishes to thank Ådne Cappelen, Thomas von Brasch and Terje Skjerpen for constructive comments and excellent research assistance during the process of bringing this analysis together.

Statistics Norway, 9 September 2013

Hans Henrik Scheel

Abstract

Since the 1970s, relative wages have remained fairly stable in Norway, and the structure of wages can be regarded as relatively compressed. This means that wages are relatively low for workers with high skills whereas wages for low skilled workers are high, by international comparison. This makes it more attractive for a person seeking employment to come to Norway if he or she is low skilled. After the enlargement of the EU/EEA in 2004, the number of migrant workers to Norway has increased sharply. It is therefore of particular interest to examine the factors that determine the enterprises' demand for labour by education, in particular the importance of relative wages.

This report studies the factors that determine the demand for workers with different skills. In particular, we investigate to what extent relative wage differences may explain the large increase in the demand for highly educated labour in the longer term. Earlier modelling of demand for labour in Norway has in large part distinguished between workers with high and low education. In this report, we divide the workforce into three different groups according to the level of education. Persons with primary and secondary general education are considered as low skilled, while those with higher education at university or college level are considered as high skilled. Persons with secondary vocational education do not formally have longer education than those with secondary general education, but they have acquired technical skills, and are possibly more skilled than persons with secondary general education in working life. This labour category is therefore considered to be medium skilled.

In this report we examine the price sensitivity of demand for labour with different education and the substitution possibilities between education groups. The analysis is based on data from 1972-2007 and includes 13 industries in the Norwegian market activities. Our results indicate by and large greater price sensitivity in demand for labour with low skills. A wage increase will thus lead to a greater decline in demand for low skilled labour than for those with medium and high skills. Furthermore, we find that the various educational groups are substitutes in most industries and that the substitution possibilities are generally greater between low and medium skilled labour. The effects are considerable in some labour intensive industries, indicating that higher relative wages for low skilled are likely to result in a shift in demand towards medium skilled labour at the expense of low skilled labour. We also find support for the theory that technological progress increases demand for high skilled labour and reduces the need for low skilled labour.

Sammendrag

Siden 1970-tallet har relative lønninger holdt seg nokså stabile i Norge, og lønnsstrukturen er ganske sammenpresset. Dette betyr at lønningene er relativt lave for arbeidstakere med høy utdanning sammenliknet med andre land, mens det motsatte er tilfellet for arbeidstakere med lav utdanning. Dette gjør det mer attraktivt for en arbeidssøker å komme til Norge hvis han eller hun er lavt utdannet. Etter utvidelsen av EU / EØS i 2004, har antall arbeidsinnvandrere til Norge økt kraftig. Det er derfor av særlig interesse å undersøke hva som bestemmer bedriftenes etterspørsel etter arbeidskraft etter utdanning, og særlig betydningen av relative lønninger.

Denne rapporten undersøker hvilke faktorer som er viktige for bedriftenes etterspørsel etter arbeidskraft med ulik kompetanse. Spesielt undersøker vi i hvor stor grad relative lønnsforskjeller kan forklare den store økningen i etterspørselen etter høyt utdannet arbeidskraft i et lengre perspektiv. Tidligere modellering av etterspørsel etter arbeidskraft i Norge har i stor grad skilt mellom arbeidskraft med høy og lav utdannelse. I denne rapporten deler vi arbeidskraften inn i tre ulike utdanningsnivåer. Personer med utdannelse på grunnskolenivå og med videregående allmennutdannelse betraktes som lavt utdannete, mens personer med høyere utdannelse fra universitet eller høyskole betraktes som høyt utdannete. Personer med videregående fagutdannelse har formelt sett ikke lengre utdannelse enn personer med videregående allmennutdannelse, men de har en yrkesrettet kompetanse, og det er rimelig å anta at de betraktes som mer kompetente fra bedriftenes side. Disse er derfor skilt ut som en egen utdanningsgruppe benevnt medium utdanning.

I denne rapporten ser vi spesielt på prisfølsomheten til etterspørselen etter arbeidskraft med ulik utdanning og substitusjonsmulighetene mellom utdanningsgruppene. Analysen er basert på data fra 1972-2007 og omfatter 13 næringer i norsk markedsrettet virksomhet. Resultatene våre indikerer jevnt over større prisfølsomhet overfor gruppen med lavest utdannelse. Den samme lønnsøkningen vil dermed føre til en større etterspørselsnedgang etter personer med lav utdannelse enn etter personer med medium og høy utdannelse. Videre finner vi at de ulike utdanningsgruppene er substitutter i de fleste næringene og at substitusjonsmulighetene jevnt over er størst mellom lavt og medium utdannet arbeidskraft. Effektene er betydelige i enkelte arbeidsintensive næringer, slik at økt relativ lønn til lavt utdannete trolig vil gi seg utslag i en betydelig vridning i etterspørselen mot medium utdannet på bekostning av lavt utdannet arbeidskraft. Vi finner også støtte for teorien om at teknologiutviklingen øker etterspørselen etter høyt utdannete og reduserer behovet for lavt utdannet arbeidskraft.

Contents

Preface ... **3**

Abstract ... **4**

Sammendrag ... **5**

1. Introduction ... **7**

2. Data ... **10**

3. The model ... **13**

4. Empirical results ... **16**
4.1. Estimation of static cost shares for high skilled and low skilled labour ... 16
4.2. Dynamic cost share equations for high skilled and low skilled labour ... 22
4.3. Decreasing the labour costs for low skilled labour ... 23

5. Conclusions ... **25**

References ... **26**

Appendix A: Education classification, variables, definitions, key to industries and employment shares ... **27**

Appendix B: Test of cointegration and plots of the error correction terms ... **29**

Appendix C: Detailed estimation results ... **37**

Appendix D: Residual misspecification tests ... **46**

Appendix E: Scenarios ... **47**

List of figures ... **51**

List of tables ... **52**

1. Introduction

Over the past decades, demand for high skilled labour has grown considerably in most OECD-countries. A large part of the increased demand has been met by increased supply of labour with higher skills and educational levels, but increased wage premiums or increased unemployment among low educated workers in many OECD-countries indicate that supply has not increased sufficiently to meet the demand. In Norway, Hægeland et al. (1999) find that educational premiums have increased clearly when controlling for self-selection in higher education. Hægeland and Kirkebøen (2007) also find an increase in educational premiums in recent years. Nevertheless, the differences in wage premiums and unemployment figures have remained relatively small in Norway compared to other OECD-countries. Kahn (1998) links this to the strong centralization of wage bargaining during the late 1980s and 1990s.

What are the sources of the increase in demand for college educated labour? Berman *et al.* (1994) investigate the shift in demand in 450 industries in U.S. manufacturing, and finds that most of the shift away from production to non-production employment occurred within industries, and is caused by skilled biased technical change (SBTC). A smaller part of the shift can be accounted for by changes in product demand away from those manufacturing industries that are exposed to international competition, i.e. between-industry changes. Machin (1996) and Mellander (2000) apply the same framework to UK and Swedish manufacturing data, reaching the same conclusion, and Machin and Van Reenan (1998) and Berman, Bound and Machin (1998) finds further support for the SBTC hypothesis using internationally comparable data for several countries.

In Norway, Bjørnstad and Skjerpen (2006) have examined the demand for skilled and unskilled employment in the Norwegian mainland sector. They employed the large-scale macro economic model, MODAG, with heterogeneous labour. Labour is divided into two groups, unskilled and skilled. They, too, find that the increased demand for skilled workers mainly has occurred within industries.

While Bjørnstad and Skjerpen distinguished between skilled and unskilled workers, we distinguish between workers with what we refer to as low, medium and high skill competence. Using a translog framework, we estimate the demand for labour in 13 Norwegian industries covering the private sector, but excluding the primary industries. Labour input is broken down into low skilled, medium skilled and high skilled labour according to the degree of formal education, and static labour cost shares for high skilled and low skilled labour are estimated. The cost shares for high skilled and low skilled labour in a given industry depend on relative hourly wages in addition to the level of technology and the capital to output ratio.

In the estimation of the cost shares in a given industry, we have required that all the implied own price elasticities are non positive. If this requirement is broken, we have replaced the full translog specification with a more restrictive one, where the parameters associated with these price effects are set to ensure that the own price elasticity is zero. In two industries, all coefficients are restricted, implying that the cost shares for high skilled and low skilled labour are independent of relative wages. In four industries, among them the two largest service industries, all own price elasticities were found to be negative, and the full translog system was estimated. In the remaining sectors, some coefficients were restricted while others were estimated.

The coefficients relating to relative wages are statistically insignificant in several industries. This suggests that in a majority of the industries, we can’t reject the hypothesis that the elasticity of substitution between different skill groups is equal to 1, as in the Cobb Douglas case. The demand for labour with different skills thus respond to changes in relative wages, but in such a way that the cost shares are unaltered. Moreover, the coefficients relating to capital intensity are significant in a little less than half of the industries in explaining the cost shares for high skilled labour, and in three of the industries in the cost share equation for low skilled labour. The capital intensity thus seems to be more important in explaining the cost shares for high skilled labour than low skilled labour. On the other side, the trend coefficients are significant in the cost share equations for both high skilled and low skilled labour. The effects are positively estimated in the cost share equations for high skilled labour and negatively estimated in the cost share equations for low skilled labour. This means that our results give support to the hypothesis of skilled biased technical change, consistent with the findings in numerous earlier studies.

Even though there is limited support in the data for the hypothesis that relative wages are important in deciding the cost shares by education group in a given industry, we believe that the price mechanism could be more than the results suggest. As we will demonstrate in Section 2, relative wages have been very stable in the estimation period, and this could be the reason why the effects of relative wages are hard to estimate precisely. The limited variation in the capital intensity could also be part of the reason why the coefficients relating to the capital intensity turned out insignificant in several industries. Since we believe that the price mechanism and the level of capital are important factors in explaining the firms' labour cost shares by education, we have chosen to include these effects in the cost share equations for high skilled and low skilled labour despite of the coefficients' relatively low level of significance. We thus postulate that the cost shares by education group within industries depend on relative wages, the capital intensity and the level of technology, captured by the trend coefficients in the translog functions.

Whether our description captures the development in the cost shares in a satisfactory way, can to a certain degree be tested statistically. If our model is correct, the error terms from the estimated cost share equations should be stationary. Unit root tests reject the hypothesis of a unit root in the error terms in ten of the 13 industries, both in the cost share equation for high skilled and low skilled labour. In only one industry, the null hypothesis of a unit root is not rejected in any of the error terms.

Using this framework, we may derive estimates of elasticities of substitution and own and cross price elasticities for each education group for a given level of overall labour use. The elasticities of the demand for labour and substitution are made over the period 1972-2007 and the Norwegian economy is disaggregated into 13 industries in the private sector, including six manufacturing industries (but excluding the primary industries). The estimation results show that relative wages can account for a limited part of the adjustment of firms on labour costs. In the two largest service industries, the elasticities of substitution between the labour categories are small. These industries employ more than half of the employment base in our data measured in man hours. The results thus suggest that the firms look at other factors than relative labour costs when they decide on optimal labour inputs in production.

Nevertheless, the effects of relative wages on demand for labour are considerable in several industries. The substitution effects between medium skilled and low skilled labour, measured by the implied elasticities of substitution, or Allen elasticities of substitution, are substantial in large industries like production of engineering products, construction and other private services, in addition to industries like production of oil platforms and ships, oil and gas exploration and electricity. The cross price elasticities are asymmetric, pointing to larger effects on the demand for medium skilled labour as a response to changes in the wages going to low skilled labour in most industries. However, it is demand for low skilled labour that is most responsive to changes in the wages to medium skilled labour in some large industries. Medium skilled and low skilled labour is regarded as substitutes in all industries but one, implying that the firms are likely to substitute one skill group for the other if the relative wages were to change.

On average, the substitution effects measured by Allen elasticities of substitution are less strong between high skilled and low skilled labour than between medium skilled and high skilled labour. The effects are nevertheless large in production of oil platforms and ships and in electricity. In two manufacturing industries, these labour inputs are complements, and the substitution effects measured by the Allen elasticities of substitution are relatively large.

The implied substitution effects between high skilled and medium skilled labour are generally smaller than between medium skilled and low skilled and between high skilled and low skilled. The results point towards high skilled and medium skilled being complements in seven industries and substitutes in the remaining six. While the degree of substitution is strong in some manufacturing industries and in oil and gas exploration, the degree of complementarity is particularly strong in production of oil platforms and ships and in electricity. Since some industries show complementarity as opposed to substitutability between these two factors, an increase in the price of high skilled or medium skilled labour is likely to lead to changes in the structure of employment, with rising employment of other skill group in the industries where these are substitutes and reducing employment in the industries where these are complements.

Having established the long run cost shares for high skilled and low skilled labour, we next estimate dynamic equations where we include deviations from the long run static cost share relations as regressors. The long-term development in the cost share of high and low skilled labour is driven by the deviation between the estimated static relationship and the actual cost share in the previous period, i.e. we estimate ecm- equations. In all the dynamic equations the estimated effect of the error correction term is significantly negative. We consider this as a support to the static equation which we impose on the cost shares. We also use the empirical results to examine the effects of a different wage structure in the largest manufacturing industry and in the largest service sector industry. The Norwegian wage setting is centralized and co-ordinated, placing much emphasis on the competitiveness of the exposed sector. Compared to other OECD countries, the wage premium in Norway is relatively low. In a counterfactual analysis we study the effects of a different wage structure where relative wages for low skilled labour is 10 per cent lower than the historical experience. This leads to increased demand for low skilled labour and reduced demand for high skilled and medium skilled labour in both industries. The effects on the demand for low skilled and high skilled labour are larger in the manufacturing industry, whereas the effect on demand for medium skilled is stronger in the service industry.

Section 2 presents an overview of the development in employment and wage cost shares for the various skill groups in Norway in recent decades. Section 3 presents the econometric framework while Section 4 presents the empirical results. Detailed estimation results are reported in Appendix C, while Appendices B and D contain tests of cointegration of the ecm-terms used in the dynamic estimations and residual misspecification tests of the dynamic cost share relations, respectively. Section 4 also presents the results of a counterfactual simulation based on an alternative assumption of the wage development along with Appendix E. Section 5 contains a summary and concluding remarks.

2. Data

The work in this paper is based on final national account (NA) figures up until 2006 and preliminary figures for 2007[1]. However, NA data with an educational distribution of the labour market extends only from 2000. These numbers are chained with data used in Bjørnstad and Skjerpen (2006); see Bjørnstad *et al.* (2010) for further details. In total, the annual panel data set covers 13 sectors over the period 1972 - 2007. The data contain time series for the capital stock and labour as well as gross output in constant 2006-prices. Capital is measured at the end of the period in the Norwegian national accounts, and is treated as a quasi fixed factor. The included observations used to estimate the model therefore spans the period 1973 - 2007. Details of the data and constructed variables are given in Appendix A, along with an overview of the industries and their codes.

Formal educational attainment is used as indicator of workers' qualifications since it is relatively easy to measure. Relatively accurate information about a person's education is available from administrative registers. We separate skill groups by qualification and length in accordance with the typical design of the Norwegian educational system which corresponds closely with international standards for education (ISCED97). Using formal education as indicator of qualification among workers is of course not without problems. Formal education has to some extent replaced job experience without this being accompanied by an increase in qualifications. Alternative indicators are however not easy to come by. The distinction between different occupations is not as clear cut, and moreover, a person's occupation may change if he or she moves from one industry to another. The degree of education is divided into five categories:

- Primary and lower secondary education (ISCED 0-2)
- Upper secondary education general programs (ISCED 3 and 4)
- Upper secondary education vocational programs (ISCED 3 and 4)
- Tertiary education, lower degree (ISCED 5, lower degree)
- Tertiary education, higher degree (ISCED 5, higher degree and ISCED 6)

Low skilled labour is defined as workers with primary and lower secondary education, i.e. below 11 years of schooling, and labour with upper secondary education in general programs, i.e., between 11 and 13 years of schooling. Workers with upper secondary education in vocational programs are classified as medium skilled labour. High skilled labour comprise workers with tertiary education at higher and lower levels, i.e., more than 13 years of schooling. The argument underlying this classification is that we wish to distinguish by length of education on one hand and by qualification on the other. Persons with vocational education possess procedural knowledge at some technical level (e.g., an electrician or a hairdresser) and are most likely regarded as skilled in working life. In contrast, persons with primary and lower secondary education and persons with upper secondary education are not likely to have acquired such procedural skills.

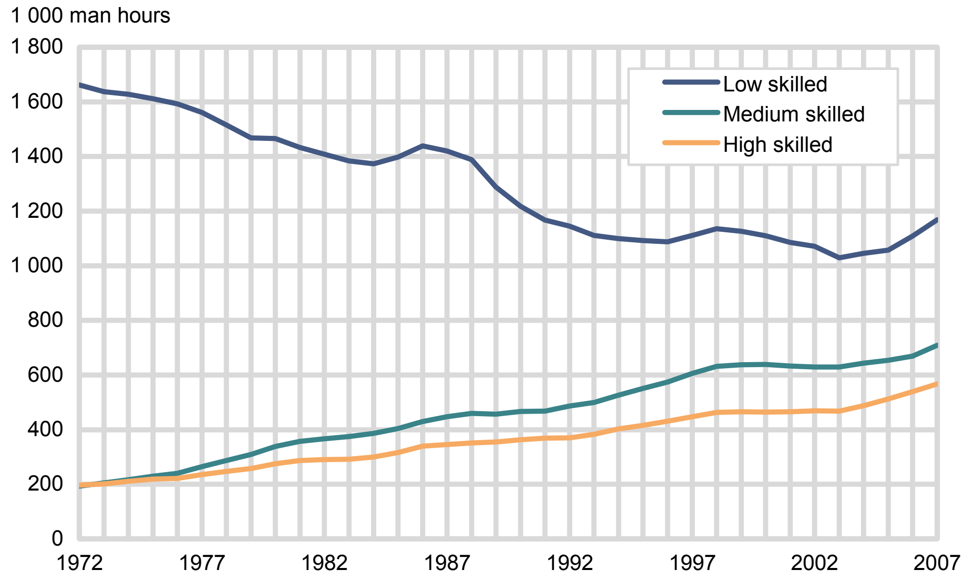
After the EU/EEA enlargement in 2004, the flow of foreign workers and immigrants seeking work in Norway has increased much. A considerable share of these has not been registered with an education, which has resulted in a strong increase in the number of workers with unknown education it the Register of the Population's highest Level of Education (PHE), particularly in 2006 and 2007. As in Bjørnstad *et al.* (2010), we have treated these workers as low skilled.

Figure 2.1 show the aggregated number of man hours performed by both wage earners and self employed persons in the 13 industries jointly for each of the three defined skill groups. Over the sample period, the number of man hours carried out by low skilled workers has dropped by 29 per cent from 1,661 million man hours in

[1] The figures can still be revised as a result of main revisions.

1972 to 1,168 million man hours in 2007. In contrast, the number of man hours performed by workers with tertiary education increased from 197 million man hours to 567 million man hours. This represents nearly a triplication over the time horizon we are investigating. The number of man hours performed by workers with secondary vocational schooling has increased even stronger, from 193 million man hours to 709 million man hours.

Figure 2.1. Employment in 1000 man hours by skill category in the private business sector (less primary industries)



The total cost of employing a certain labour category also depends on the wage level. Figure 2.2 shows the development in the wage per hour for high skilled, medium skilled and low skilled labour from 1972 to 2007. The wage level has increased for all education groups in the data period and in 2007, wages were more than 10 times higher than in 1972 for all groups. In 2007, the average wage level amounted to 266 kroner per hour for low skilled workers, 287 kroner per hour for medium skilled workers and 394 kroner per hour for high skilled workers. In relative terms, however, wages by skill category have been very stable over the estimation period. Figure 2.3 shows hourly wage rates for high skilled and low skilled workers relative to medium skilled workers in the period 1972-2007. Relative wages for those with higher education fluctuated somewhat early in the data period, but has been relatively stable since 1987. As a matter of fact, the relative wages for high skilled workers were lower in 1972 than in 2007. Relative wages for low skilled workers have increased somewhat since 1977. This means that low skilled workers have increased the wages compared to high skilled workers in the estimation period. All in all, this development yields cost shares by education according to Figure 2.4, reflecting increased use of labour inputs with higher skills in the production process.

Figure 2.2. Wage per hour in kroner for the various skill groups. 1972-2007

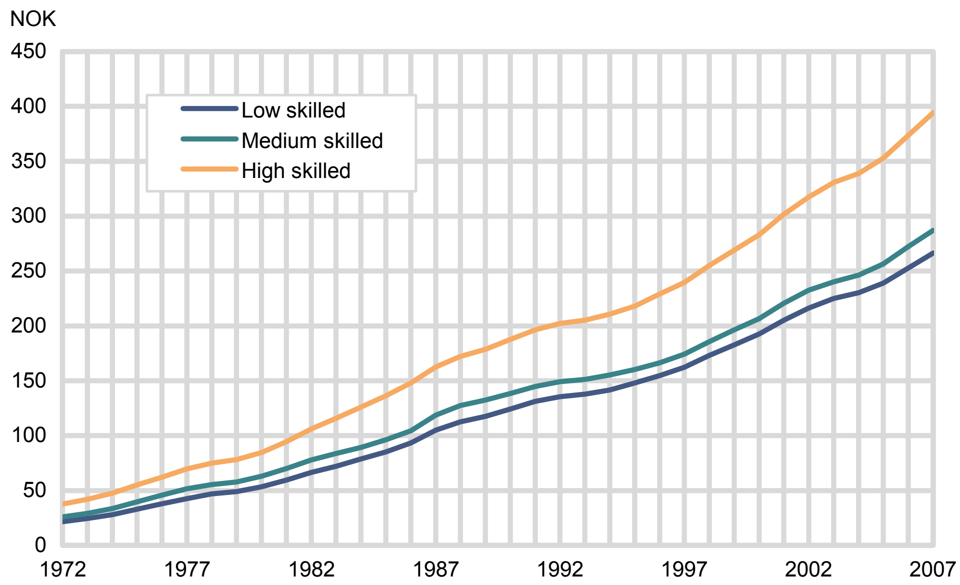


Figure 2.3. Hourly wage for low skilled and high skilled workers relative to medium skilled workers. 1972-2007

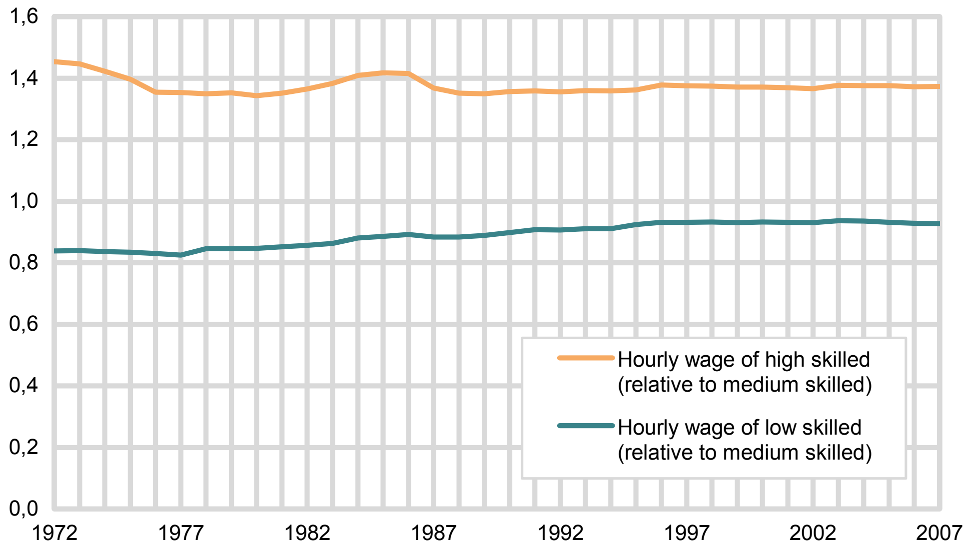
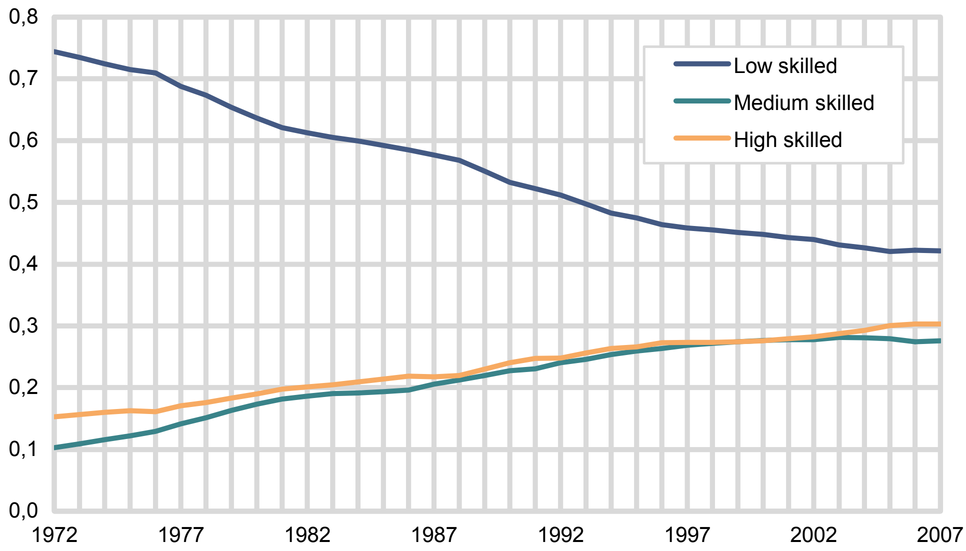


Figure 2.4. The total cost by skill group relative to the total labour costs, 1972-2007



3. The model

The translog cost function is widely used in economic model building, and is a generalization of the Cobb Douglas function allowing for estimation of second order effects such as elasticities of substitution. These are functions of second derivatives of the production function. An implication is that the translog function allows for cost shares to vary over time, in contrast to the Cobb Douglas framework, where cost shares are constant. This is a desired characteristic when we model the cost of, and hence the demand for various skill groups.

The decision of firms to employ different inputs to achieve a given level of output is treated in the framework of duality in the translog model. For a well behaved production function there exists a dual cost function which has embedded in it all the technology of the original production function. The cost function in a specific industry is represented as:

$$\begin{aligned} \ln C_t &= \beta_0 + \sum_i \beta_{i0} \ln(W_{i,t}) + \frac{1}{2}\sum_i\sum_j \beta_{ij} \ln(W_{i,t}) \cdot \ln(W_{j,t}) \\ &+ \sum_i \beta_{iK} \ln(\frac{K_{t-1}}{Y_t}) \cdot \ln W_{i,t} + \frac{1}{2}\beta_{KK} \ln^2(\frac{K_{t-1}}{Y_t}) \\ &+ \sum_i \beta_{iT} \ln W_{i,t} \cdot \frac{t}{(40+t)} + \beta_{KT} \ln(\frac{K_{t-1}}{Y_t}) \cdot \frac{t}{(30+t)} + \beta_{TT} \frac{t}{(30+t)} \end{aligned} \quad (3.1)$$

This is a cost function of the form in Berman et al. (1994) where we assume constant return to scale and where capital is a quasi-fixed variable. The subscripts i and j run across the variable factors of production: high skilled (H), medium skilled (M) and low skilled (L) labour. C represents variable costs, W denote input prices on labour and K and Y represent the volume of capital and value added respectively. The general level of technology is represented by the term $\frac{t}{(30+t)}$ which serves to affect the cost for all types of labour, and therefore the total cost of production. Skill biased technology is further represented by the term $\ln(W_{it}) \cdot \frac{t}{(30+t)}$.

The motivation for choosing this time trend representation is purely pragmatic. We wish to ensure that the future demand for labour by education is not dominated by the time trend development, as could be the case if the trend is linear. In the data period, the demand for skilled labour has been particularly strong. As the share of skilled labour in the labour force now is at a higher level, we believe that the future scope for growth in high skilled labour is less. For this reason, a diminishing time trend is a better representation of the factor shares.

The cost-minimizing factor demands are obtained by applying Shephard's lemma, which states that if *C(Y, W)* gives the minimum total cost of production, then the cost-minimizing set of factor demands is given by

$$x_i^* = \frac{\partial \ln C(Y,W)_t}{\partial \ln(W_{it})} = \frac{\partial \ln(C_t)}{\partial \ln(W_{it})} \cdot \frac{W_{it}}{C_t} = x_i \cdot \frac{W_i}{C_t} \equiv s_{it}$$

when the cost function is expressed in logs. The following restrictions are then imposed for symmetry additivity and linear homogeneity in factor input prices

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

$$\Sigma_i \beta_{i0} = 1$$

$$\Sigma_i \beta_{ij} = 0$$

$$\Sigma_j \beta_{ij} = 0$$

This yields the linear economic system of cost shares within industries:

(3.2)

$$s_H = \beta_{H0,k} + \beta_{HH,k} \ln(\frac{W_{Hk}}{W_{Mk}})_t + \beta_{HL,k} \ln(\frac{W_{Lk}}{W_{Mk}})_t + \beta_{HK,k} \ln(\frac{K_{k,t-1}}{Y_{k,t}}) + \beta_{HT,k} \frac{t}{(30+t)}$$

(3.3)

$$s_L = \beta_{L0,k} + \beta_{HL,k} \ln(\frac{W_{H,k}}{W_{M,k}})_t + \beta_{LL,k} \ln(\frac{W_{Lk}}{W_{Mk}})_t + \beta_{HK,k} \ln(\frac{K_{k,t-1}}{Y_{k,t}}) + \beta_{HT,k} \frac{t}{(30+t)}$$

Here we have introduced the subscript k for industries. Since the cost shares sum to unity, one cost share equation is redundant. We have chosen to exclude the cost share equation for medium skilled persons from the system.

We do not estimate the cost function in (3.1), which would provide us with an estimate of β_0 but is otherwise inessential. The cost share system we estimate is going to distribute the demand for labour further in the large scale macro economic model, MODAG. In MODAG, demands for various input factors are decided by the level of production in addition to relative prices of the input factors. The input factors are labour, various types of energy and real capital stocks and materials in each industry. Thus, the optimal use of labour is already decided in the factor demand system.

For the translog cost function, the Allen elasticities of substitution (A_{ij} and A_{ii}), the own price elasticities (η_{ii}) and the cross price elasticities (η_{ii}) are computed as

(3.4) $$A_{ij} = \frac{(\beta_{ij} + \hat{S}_i \hat{S}_j)}{\hat{S}_i \hat{S}_j}, i \neq j$$

(3.5) $$A_{ii} = \frac{(\beta_{ii} + \hat{S}_i^2 - \hat{S}_i)}{\hat{S}_i^2}$$

(3.6) $\eta_{ij} = A_{ij} \cdot \hat{S}_i, i \neq j$

(3.7) $\eta_{ii} = A_{ii} \cdot \hat{S}_i$,

where $\hat{S}_i$ is the fitted cost share of education category i.

Sufficient conditions for monotonicity and concavity of the underlying technology require that the fitted cost shares are positive and that the Hessian matrix formed by the elasticity coefficients of labour is negative semi-definite. Following Harris et al. (1993) we apply a less severe test, where concavity is assumed if own price elasticities are non-negative. This yields necessary, if not sufficient conditions for concavity.

The static relationship which we impose on the cost shares for high skilled and low skilled labour in (3.2) and (3.3) cannot be expected to hold in the short run. The ideal way to impose dynamics in this system is to add variables that are part of the long run solution on difference form. However, with annual observations from 1973 to 2007, we are not able to estimate the entire system simultaneously and obtain poor estimates. Instead, we estimate the factor shares of high skilled, medium skilled and low skilled workers in 13 industries using a two-step procedure. Labour costs for high skilled and low skilled workers are estimated directly as

(3.8)
$$\begin{aligned} S_{Hk,t} &= \beta_{H0,k} + \beta_{HH,k} \cdot \ln(\frac{w_{Hk}}{w_{Mk}})_t + \beta_{HL,k} \cdot \ln(\frac{w_{Lk}}{w_{Mk}})_t \\ &+ \beta_{HK,k} \cdot \ln(\frac{K_k}{Y_k})_t + \beta_{HT,k} \cdot \frac{t}{(30+t)} + \omega_{H,t} \end{aligned}$$

(3.9)
$$\begin{aligned} S_{Lk,t} &= \beta_{L0,k} + \beta_{HL,k} \cdot \ln(\frac{w_{Hk}}{w_{Mk}})_t + \beta_{LL,k} \cdot \ln(\frac{w_{Lk}}{w_{Mk}})_t \\ &+ \beta_{LK,k} \cdot \ln(\frac{K_k}{Y_k})_t + \beta_{LT,k} \cdot \frac{t}{(30+t)} + \omega_{L,t} \end{aligned} .$$

We have added error terms in (3.2) and (3.3) with standard assumptions. Based on the estimation results, error correction terms are derived from the long run cointegrating relationship as:

(3.10)
$$ecm_{Hk,t} = s_{Hk,t} - \begin{Bmatrix} \hat{\beta}_{H0,k} + \hat{\beta}_{HH,k} \cdot \ln(\frac{w_{Hk}}{w_{Mk}})_t + \hat{\beta}_{HL,k} \cdot \ln(\frac{w_{Lk}}{w_{Mk}})_t \\ + \hat{\beta}_{HK,k} \cdot \ln(\frac{K}{Y})_t + \hat{\beta}_{HT,k} \cdot \frac{t}{(30+t)} \end{Bmatrix}$$

(3.11)
$$ecm_{Lk,t} = s_{Lk,t} - \begin{Bmatrix} \hat{\beta}_{L0,k} + \hat{\beta}_{HL,k} \cdot \ln(\frac{w_{Hk}}{w_{Mk}})_t + \hat{\beta}_{LL,k} \cdot \ln(\frac{w_{Hk}}{w_{Mk}})_t \\ + \hat{\beta}_{LK,k} \cdot \ln(\frac{K}{Y})_t + \hat{\beta}_{LT,k} \cdot \frac{t}{(30+t)} \end{Bmatrix} .$$

Thus, we construct error correction terms containing the deviation between the actual cost shares in period t and the long run cost shares of high skilled and low skilled labour given by estimation of (3.2) and (3.3). The error correction terms from the estimated static relationship in Step 1 are used in Step 2, when dynamic cost share equations for low skilled and high skilled labour are estimated. The point of departure is the general equation explaining the change in the cost shares for high skilled and low skilled labour as:

$$
\begin{aligned}
\Delta s_{Hk,t} &= \alpha_{H0,k} + \alpha_{HH,k} \cdot ecm_{Hk,t-1} + \alpha_{HL,k} \cdot ecm_{Lk,t-1} \\
&+ \gamma_{HH,k} \cdot \Delta \ln(\frac{w_{Hk}}{w_{Mk}})_t + \gamma_{HL,k} \cdot \Delta \ln(\frac{w_{Lk}}{w_{Mk}})_t + \gamma_{HK,k} \cdot \Delta \ln(\frac{K_{k,t-1}}{Y_{k,t}}) \\
&+ \gamma_{HH1,k} \cdot \Delta \ln(\frac{w_{Hk}}{w_{Mk}})_{t-1} + \gamma_{HL1,k} \cdot \Delta \ln(\frac{w_{Lk}}{w_{Mk}})_{t-1} + \gamma_{HK1,k} \cdot \Delta \ln(\frac{K_{k,t-1}}{Y_{k,t}})_{t-1} \\
&+ \theta_{HH,k} \cdot \Delta s_{Hk,t-1} + \xi_{Hk,t}
\end{aligned}
\tag{3.12}
$$

$$
\begin{aligned}
\Delta s_{Lk,t} &= \alpha_{L0,k} + \alpha_{HL,k} \cdot ecm_{Hk,t-1} + \alpha_{LL,k} \cdot ecm_{Lk,t-1} \\
&+ \gamma_{LH,k} \cdot \Delta \ln(\frac{w_{Hk}}{w_{Mk}})_t + \gamma_{LL,k} \cdot \Delta \ln(\frac{w_{Lk}}{w_{Mk}})_t + \gamma_{LK,k} \cdot \Delta \ln(\frac{K_{k,t-1}}{Y_{k,t}}) \\
&+ \gamma_{LH1,k} \cdot \Delta \ln(\frac{w_{Hk}}{w_{Mk}})_{t-1} + \gamma_{LL1,k} \cdot \Delta \ln(\frac{w_{Lk}}{w_{Mk}})_{t-1} + \gamma_{LK1,k} \cdot \Delta \ln(\frac{K_{k,t-1}}{Y_{k,t}})_{t-1} \\
&+ \theta_{LL,k} \cdot \Delta s_{Lk,t-1} + \xi_{Lk,t},
\end{aligned}
\tag{3.13}
$$

where Δ denotes the first difference operator. The estimated long run error correction terms for high skilled and low skilled labour are included in the general equations for both labour types. The coefficients $\alpha_{HH,}$ $\alpha_{HL,}$ α_{LH} and α_{LL} measure the share of the deviation that is corrected in the present period. The short run variation is thus explained by the same variables that explain the long run adjustment on difference form, represented by γ-coefficients.

4. Empirical results

In Step 1, the system of cost shares consisting of equations (3.8) and (3.9) assumes that the cross price effect is the same in the two cost share equations, i.e. that effect on the cost share of high skilled labour of an increase in the price of low skilled labour is identical to the effect on the cost share of low skilled labour of an equal increase in the price of high skilled labour. The full-information maximum likelihood (FIML) estimator is based on the entire system of equations and enables us to handle this cross price symmetry. In addition, computation of FIML estimates of the parameters ensures invariance with respect to the choice of which share equation we drop. Therefore, we estimate (3.4) and (3.5) by FIML.

In Step 2, where we estimate final dynamic equations according to (3.12) and (3.13), we do not have any symmetry restrictions, and the dynamic equations can be estimated independently by OLS. All computation is made using Eviews 7. For an overview of the industries and industry codes, see Table A.1 in the Appendix.

4.1. Estimation of static cost shares for high skilled and low skilled labour

Table 4.1 shows the implied own price elasticities from estimating (3.8) and (3.9), i.e. the unrestricted translog system. In four industries, all elasticities were negative. In two industries, all elasticities were positive and thus incompatible with cost minimization. In the remaining seven industries, at least one own price elasticity was positive. Hence, it was necessary to estimate a new and restricted translog system in all but four industries.

Table 4.1. Own price elasticities for low skilled, medium skilled and high skilled labour in the unrestricted translog system (1972-2007)

		η_{LL}	η_{MM}	η_{HH}
15	Consumption goods	0.090	-0.588	0.329
25	Misc. manufacturing	-0.103	-0.831	0.029
30	Energy intensive manufacturing	1.452	0.645	-0.406
40	Petroleum refineries	-1.106	0.035	-0.055
45	Engineering products	-0.657	-0.393	-0.072
50	Oil platforms and ships	-3.699	-0.074	0.098
55	Construction	-2.666	-1.908	0.356
63	Financial intermediates	0.871	0.049	0.866
64	Oil and gas exploration	-2.158	-3.050	-1.989
71	Electricity	-1.808	1.849	0.600
74	Domestic transportation	1.101	0.995	1.287
81	Wholesale and retail trade	-0.337	-0.506	-0.689
85	Other private services	-0.470	-0.673	-0.042

In the cases where the concavity assumption is violated in the labour dimension, we have set the parameter coefficient of this labour type in such a way that $\eta_{ii} = 0$ in the translog system and estimated new and restricted static cost shares. For example, if the own price elasticity of high skilled labour is positively estimated in a given industry, this implies that the isolated effect of an increase in wages for high skilled labour is an increase in the demand for high skilled labour in this industry. For this to be the case, the firms could not have been in optimum in the first place. We thus estimate a new static relation where this coefficient is restricted so that $\eta_{HH} = 0$. According to (3.5) and (3.7) this implies that $\beta_{HH} = \hat{S}_H - \hat{S}_H^2$, where $\hat{S}_H$ is the fitted cost share in the unrestricted translog. Since we require β_{HH} to equal zero when $\hat{S}_H$ refers to the unrestricted cost share, the implied own price elasticity will deviate from this, depending on the differences between the fitted cost shares in the unrestricted translog and in the restricted translog system. This is the reason why the own price elasticities are somewhat different from zero in Table 4.1. The effect on the demand for a specific skill group from an increase in its own wage is nevertheless minimal.[2] In industry 63 and 74, the concavity assumption was not fulfilled for all three skill groups, and β_{HH}, $\beta_{HL,}$ and β_{LL} are all restricted.

There are no a priori restrictions on the trend coefficients and the coefficients relating to the capital intensity, which can result in both increased and decreased demand for the various education groups. The coefficients of the capital intensity and the trend are thus estimated without any sign restriction. Table 4.2 shows the estimation results from Step 1, with new static cost shares from the restricted translog model.

Our results indicate that the price effects are of less importance in the determination of cost shares by education. As can be seen in the table, β_{HH} is restricted in six industries, implying no effect on the demand for high skilled labour as a result of changes in the wages going to high skilled relative to medium skilled labour. Of the remaining seven industries, $\hat{\beta}_{HH}$ is significant in two industries. β_{HL} is restricted in four industries and significant in two industries. β_{LL} is restricted in five industries and significant only in one. The sign of $\hat{\beta}_{HH}$ is positively estimated in most cases, while $\hat{\beta}_{LL}$ is ambiguous. For the own price elasticities to be non positive, the sign of these coefficients must be lower than 0.25. The cross price coefficient, $\beta_{HL,}$ is estimated to be negative in most industries.

The estimated sign of the coefficients relating to capital intensity are positive in some industries and negative in others, implying that an increase in the capital intensity can result in a decrease or an increase in the associated cost share equation. In the cost share equation for high skilled, these effects are significant in a little

[2] In industry 25, β_{HH} and β_{HL} had to be restricted for all own price elasticities to be non positive, while in industry 30, it was sufficient to restrict β_{LL} to arrive at non positive own price elasticities for medium skilled and high skilled labour. The other industries were restricted if own price elasticities were positive in the unrestricted translog.

less than half of the industries, but in only three of the industries in the cost share equation for low skilled. The capital intensity thus seems to be more important in explaining the demand for high skilled labour than low skilled labour.

The estimate of the constant term is significant in about half of the industries in the cost share equations for high skilled labour. The constant term is highly significant in all the cost share equations for low skilled labour.

Except for industry 85, the estimated trend coefficients are highly significant in the cost share equations for high skilled labour. In industry 85, the effect is significant only at the 10 % significance level. The trend coefficients are highly significant in all the cost share equations for low skilled labour. The effects are positively estimated in the cost share equations for high skilled labour and negatively estimated in the cost share equations for low skilled labour. This means that our results give support to the hypothesis of skilled biased technical change, consistent with the findings in numerous earlier studies.

Table 4.2. Parameter estimates in the translog system of cost shares by industry. Standard errors in parentheses

industry	β_{HO}	β_{HH}	β_{HL}	β_{HK}	β_{HT}	β_{LO}	β_{LL}	β_{LK}	β_{LT}
15	-0,030	0.111*	-0,152	-0,048	0,247	1,023	0.247*	0,178	-0,905
	(0,017)		(0,057)	(0,027)	(0,023)	(0,021)		(0,063)	(0,070)
25	-0,038	0.180*	-0,223	-0,056	0,415	1,031	0.246*	0,048	-1,000
	(0,007)		(0,062)	(0,026)	(0,038)	(0,028)		(0,055)	(0,066)
30	0,064	0,058	-0,078	0,014	0,267	0,844	0.221*	0,083	-1,052
	(0,082)	(0,129)	(0,163)	(0,030)	(0,035)	(0,139)		(0,068)	(0,084)
40	0,153	0,202	0.006*	-	0,162	0,545	0,032	-	-0,710
	(0,015)	(0,077)		-	(0,028)	(0,051)	(0,232)	-	(0,023)
45	0,112	0,179	-0,053	0,051	0,212	0,785	0,008	-0,032	-0,874
	(0,129)	(0,245)	(0,333)	(0,020)	(0,062)	(0,186)	(0,614)	(0,038)	(0,101)
50	0,102	0.185*	0,403	0,037	0,208	0,492	-0,799	-0,070	-0,924
	(0,045)		(0,326)	(0,017)	(0,054)	(0,231)	(0,711)	(0,023)	(0,104)
55	0,018	0.090*	-0,014	-0,010	0,075	0,726	-0,837	0,033	-0,816
	(0,026)		(0,121)	(0,013)	(0,025)	(0,143)	(0,355)	(0,045)	(0,133)
63	0,051	0.250*	-0.226*	-0,042	0,664	0,903	0.249*	0,033	-0,687
	(0,061)			(0,059)	(0,140)	(0,059)		(0,057)	(0,138)
64	0,301	-0,602	0,029	0,102	0,418	0,258	-0,305	0,079	-0,160
	(0,066)	(0,140)	(0,164)	(0,023)	(0,068)	(0,067)	(0,160)	(0,013)	(0,048)
71	0,443	0.238*	0.156*	-0,158	0,263	0,562	-0,306	-0,020	-0,789
	(0,095)			(0,041)	(0,038)	(0,080)	(0,241)	(0,016)	(0,060)
74	0,021	0.154*	-0.100*	-0,055	0,296	0,846	0.249*	0,045	-0,613
	(0,078)			(0,055)	(0,062)	(0,050)		(0,034)	(0,041)
81	0,030	0,023	-0,010	-0,008	0,277	0,868	0,057	0,007	-0,574
	(0,047)	(0,095)	(0,057)	(0,007)	(0,049)	(0,066)	(0,109)	(0,012)	(0,091)
85	0,262	0,228	-0,129	0,061	0,167	0,618	0,056	-0,057	-0,333
	(0,088)	(0,138)	(0,175)	(0,027)	(0,100)	(0,125)	(0,256)	(0,040)	(0,142)

In Step 2, we construct ecm-terms from estimation of (3.8) and (3.9), and estimate dynamic error correction equations explaining the change in the cost shares for high skilled and low skilled labour in each industry. Hence, we regard the results from Step 1 as given, regardless of the significance of the findings. If there is any substance in our theory, and the static relationship in (3.8) and (3.9) holds in the long run, and the error terms from estimation of (3.8) and (3.9), referred to as $ecm_{H,t}$ and $ecm_{L,t}$, should be stationary.

Eviews provides various unit root tests. Most frequently these tests have null hypothesis that the time series in question are non stationary, implying that the evidence must point against this to conclude with stationarity. In general, the ADF test, which is most frequently used in unit root testing, have very low power against I(0) alternatives that are close to being I(1). That is, unit root tests cannot distinguish highly persistent stationary processes from non stationary processes very well. Also, the power of unit root tests diminish as deterministic terms are added to the test regressions. That is, tests that include a constant and trend in the test regression have less power than tests that only include a constant in the test regression. The tests proposed by Elliot, Rothenberg and Stock (1996), the ERS point-optimal test, have higher power, and we have chosen to use this test.

The ERS point-optimal unit root test tests the null hypothesis that ecm-term has a unit root against the alternative, that the ecm-term is stationary. Table B.1 in Appendix B provides these tests in all 13 industries along with critical values at 1%, 5% and 10% significance level, respectively. At 10% significance level, the null hypothesis is rejected in ten industries concerning both $ecm_{H,t}$ and $ecm_{L,t}$. Only in industry 63, there is no formal support of co-integration as the null hypothesis cannot be rejected in any of the ecm-terms. In all other industries there is support for co-integration in at least one of the two equations.

In order to decide whether or not the time series are stationary and thus support the existence of co-integration in the static cost share equations, it is also important to examine the time series graphically. Figures B.1 – B.13 show the error terms from the estimation of the cost shares for high skilled and low skilled in the various industries. The overall impression is that non rejection of a unit root in the error terms seems to be a result of the fact that the time series do not cross their mean frequently enough rather than that the series drift away from their mean.

Next, we look at the implied elasticities, taking the results from the static estimation as given. We thus disregard the weak level of significance in the rest of the discussion. The elasticities have been calculated using fitted factor shares from 2005[3]. The implied Allen elasticities of substitution are given in Table 4.3 together with fitted cost shares in 2005, while own price and cross price elasticities are given in Table 4.4. Considering own price elasticities first, all are close to zero or negative, depending on whether the associated coefficient is restricted or estimated. This implies that our results are compatible with concavity and cost minimization in the labour skill dimensions. Of the three own price elasticities, the largest in general in absolute size is η_{LL}, followed by η_{MM} and η_{HH}. This means that the demand for low skilled labour is most responsive to changes in its own price. The average value of η_{LL} is -1.684 when we disregard the industries where the own price elasticities are set to zero. The effects are largest in the production of oil platforms and ships, in construction, in oil and gas exploration and in electricity. Both high skilled and medium skilled labour are relatively irresponsive to changes in their own price with average numeric values of -0.634 and -0.554 for medium skilled and high skilled labour, respectively. The demand is most sensitive for medium skilled labour in construction and for both high and medium skilled labour in oil and gas exploration.

If the cross price coefficient between two skill groups is zero, the associated Allen elasticity of substitution is unity, implying that a price raise of 1 per cent for a skill group increases the demand for the alternative skill group by 1 per cent. This is the Cobb Douglas case. As Table 4.3 shows, our estimation results point to larger cross price elasticities than in the Cobb Douglas case in 6 of the industries between all skill groups.

The implied Allen elasticity of substitution between high skilled and low skilled labour, associated with the value of A_{HL}, suggests that these labour inputs are substitutes in nine industries and complements in three. The average value of $\hat{A}_{HL}$ is 1.698 in the industries where these skill groups are substitutes and -0.788 when

[3] The cost shares from 2005 are used as base for computation because we consider it to be the last normal data point. In 2006 and 2007 the unemployment rates in Norway were particularly low. The trend variable is 0.523 in 2005.

they are complements. In production of engineering products, construction, domestic transportation and in other private services, the Allen elasticity of substitution is smaller than unity. The possibilities of substitution thus seem to be limited in large industries. On the other hand, the degree of substitutability is strong in the industries producing oil platforms and ships and electricity. While high skilled and low skilled are most likely to be substitutes in most industries, the effect is non-symmetric with η_{HL} larger than η_{LH} on average. Thus, higher wages to low skilled is likely to result in a larger increase in the employment of high skilled than the opposite. However, in the industries producing consumption goods and misc. manufacturing, employment of high skilled is likely to fall, all other variables held constant. Since some industries show complementarity as opposed to substitutability, any change in the payment of high skilled or low skilled labour will lead to changes in the structure of employment between industries. The effects are mostly smaller than unity and our results thus point towards firms generally being less responsive to changes in remuneration to high and low skilled labour than what follows from a Cobb Douglas specification.

On average, the estimated substitution effects between high skilled and medium skilled, associated with the value of A_{HM}, are quite similar to the substitution effects between high skilled and low skilled labour across industries where these pairs of labour inputs are substitutes. Looking more closely at particular industries, however, the substitution effects are quite different. More industries seem to explore complementarity between high skilled and medium skilled. For example, while high skilled and low skilled labour were found to be strong substitutes in production of ships and oil platforms, high skilled and medium skilled labour seem to be strong compliments. Across industries where these pairs of labour inputs are complements, $\hat{A}_{HM}$ is -0.910 on average, while $\hat{A}_{HM}$ is 1.717 on average across industries where they are complements. Thus, the degree of substitution is stronger than the degree of complementarity on average. The substitution possibilities are relatively strong in several large manufacturing industries, but in the large service industries, the effects of changed wages are limited. According to Table 4.4, the effects are quite symmetric with η_{MH} and η_{HM} being relatively similar on average for industries with substitution possibilities. Across industries where there is complementarity, the average value of η_{MH} is -0.255 while it is calculated to -0.499 for η_{HM}. Thus, the results point to medium skilled labour being more sensitive to changes in the payment of high skilled labour than high skilled labour is to changes in the payment of medium skilled. However, in other private services, the demand for high skilled is more sensitive to a changes in the price of medium skilled labour.

The implied Allen elasticity of substitution between medium skilled and low skilled labour, associated with the value of A_{ML}, is generally higher than A_{HL} and $A_{HM,}$ and thus suggests larger substitution effects between medium skilled and low skilled. Except for a slight degree of complementarity in industry 30, medium and low skilled labour are found to be substitutes. This means that firms will substitute between this pair of labour inputs if the wages to one of them changes, all other factors held constant. If we disregard industry 30, which is a small industry employing around 2 per cent of total employment measured in man hours, the implied Allen elasticity of substitution is 1.909 on average. This suggests that the substitution effects between medium skilled and low skilled labour is stronger than in the Cobb Douglas case. The effects are considerable in labour intensive industries like manufacturing of engineering products, construction and other private services, so changes in wages to low skilled are likely to have substantial impact on the demand for medium skilled workers and vice versa. On average, η_{ML} is somewhat higher than η_{LM}, suggesting that medium skilled labour is slightly more sensitive to changes in the wages to low skilled than the opposite. However, the overall effects of changed wages on employment depend on the relative size of the industries. In the two largest service industries, low skilled labour is more sensitive to changes in the wages going to medium skilled. It is thus not certain what the total employment effect would be of a wage change between the two skill groups.

Lindquist and Skjerpen (2003) use a translog framework to study substitution between skilled and unskilled labour (and other variable inputs) in Norwegian manufacturing with data from 1972 to 1997 and find that the estimated elasticity of low skilled labour with respect to high skilled wage, $\hat{\eta}_{LH}$, is 1.381 while the elasticity of high skilled labour with respect to low skilled wage, $\hat{\eta}_{HL}$, is estimated to 0.639 for overall manufacturing employment. Our estimates, consisting of industries 15, 25, 30, 40, 45 and 50, vary between -0.646 and 1.896 for $\hat{\eta}_{LH}$, and the unweighted average is 0.176. For $\hat{\eta}_{HL}$, the implied elasticities vary between -0.278 and 1.856, resulting in an unweighted average of 0.312 for the manufacturing industries. Both studies thus find that the demand for high skilled is less sensitive to price changes for low skilled than the demand for low skilled is to changes in wages going to high skilled. Still, the effects are stronger in Lindquist and Skjerpen (2003). There are many explanations to why we would expect the results to deviate, however. The translog specification and the level of aggregation, both with respect to labour and industry, as well as the estimation period, are different. Also, they impose concavity prior to estimation. Differences in the fitted share equations and in the data point for cost shares are also a source of deviation between these results. Given the variations in methodology, our implied elasticities of $\hat{\eta}_{LH}$ and $\hat{\eta}_{HL}$ seem quite robust.

Mellander (2000) covers 24 industries in Swedish manufacturing with data from 1985-1995 and uses a similar framework as Lindquist and Skjerpen (2003). Labour is divided into 4 levels, where labour category N1 refers to persons with less than 9 years of schooling, labour category N2 refers to persons with 9 year compulsory school, labour category N3 consists of persons with upper secondary school and labour category N4 consists of persons with higher education. In our data, low skilled labour covers labour categories N1 and N2, in addition to those in labour category N3 with upper secondary education in general programs. Medium skilled labour corresponds to those in category N3 having an upper secondary vocational education. High skilled labour corresponds to category N4. Thus, we would expect the cross price elasticity η_{LM} to be somewhat similar to Mellander's finding of $\hat{\eta}_{N1N3}$ of 3.57 and $\hat{\eta}_{N2N3}$ of -0.38. Our findings of $\hat{\eta}_{LM}$ varying between -0.11 and 1.03 in the manufacturing industries seem to be in good accordance with this. Also, a value of $\hat{\eta}_{ML}$ between -0.01 and 2.09 seems acceptable in connection with 0.97 for $\hat{\eta}_{N3N1}$ and -0.11 for $\hat{\eta}_{N3N2}$. According to this study, the group which we categorize as low skilled is quite heterogeneous, and while labour with less than 9 years of schooling are substitutes to labour with upper secondary school, labour with 9 years compulsory school seems to be complements. We do not address this heterogeneity in our data. Moving to the cross price elasticities between medium skilled and high skilled labour, $\hat{\eta}_{MH}$ vary between -1.90 and 0.64, while $\hat{\eta}_{HM}$ vary between -0.90 and 0.37. Correspondingly, Mellander (2000) finds an implied elasticity of 0.26 for $\hat{\eta}_{N3N4}$ and 0.58 for $\hat{\eta}_{N4N3}$. Mellander (2000) thus find a stronger sensitivity of the demand for high skilled labour in the case of a wage increase for medium skilled than our results indicate. Moreover, our results point towards demand for medium skilled labour being more sensitive to changes in the price of high skilled labour, while Mellander (2000) finds the opposite. For the cross price elasticities between low skilled and high skilled labour, $\hat{\eta}_{LH}$ vary between -0.65 and 1.90. Mellander (2000) finds estimates of -1.95 and 0.26 for $\hat{\eta}_{N1N4}$ and $\hat{\eta}_{N2N4}$, which is in good accordance with our results. Finally, $\hat{\eta}_{HL}$ vary between -0.28 and 1.86 which can be compared to -0.49 and 0.13 for $\hat{\eta}_{N4N1}$ and $\hat{\eta}_{N4N2}$, respectively.

Table 4.3. Fitted cost shares and implied Allen elasticities of substitution calculated for the year 2005

	Fitted cost shares, 2005			Allen partial elasticities					
industry	s_L	s_M	s_H	A_{HH}	A_{HM}	A_{HL}	A_{MM}	A_{ML}	A_{LL}
15	0,556	0,317	0,127	0,012	2,031	-1,162	-1,626	0,464	0,000
25	0,435	0,330	0,235	0,000	1,560	-1,183	-2,218	0,841	0,000
30	0,324	0,427	0,249	-2,082	1,190	0,027	-0,667	-0,033	0,023
40	0,169	0,543	0,288	-0,044	-0,328	1,130	-0,008	0,586	-3,816
45	0,317	0,409	0,274	-0,261	-0,124	0,386	-0,960	1,347	-2,075
50	0,250	0,505	0,245	0,000	-3,754	7,584	-0,229	4,138	-15,783
55	0,376	0,525	0,100	-0,001	-0,442	0,617	-3,725	5,322	-7,599
63	0,476	0,050	0,474	0,001	-0,007	0,000	-0,058	0,013	-0,001
64	0,221	0,353	0,426	-4,673	4,810	1,309	-8,635	4,534	-9,758
71	0,192	0,416	0,392	-0,004	-1,412	3,075	0,003	2,881	-12,551
74	0,523	0,290	0,187	0,046	0,005	-0,019	-0,027	0,013	-0,001
81	0,562	0,255	0,183	-3,759	0,706	0,906	-1,985	0,670	-0,599
85	0,385	0,173	0,443	-0,095	-0,301	0,245	-3,901	2,097	-1,223

Table 4.4. Implied own and cross price elasticities calculated for the year 2005:

industry	η_{HH}	η_{HM}	η_{HL}	η_{MH}	η_{MM}	η_{ML}	η_{LH}	η_{LM}	η_{LL}
15	0,002	0,258	-0,147	0,644	-0,516	0,147	-0,646	0,258	0,000
25	0,000	0,366	-0,278	0,515	-0,732	0,278	-0,515	0,366	0,000
30	-0,517	0,296	0,007	0,509	-0,285	-0,014	0,009	-0,011	0,007
40	-0,013	-0,095	0,326	-0,178	-0,004	0,318	0,191	0,099	-0,644
45	-0,072	-0,034	0,106	-0,051	-0,393	0,551	0,122	0,427	-0,657
50	0,000	-0,919	1,856	-1,897	-0,116	2,090	1,896	1,035	-3,947
55	0,000	-0,044	0,062	-0,232	-1,954	2,792	0,232	1,998	-2,854
63	0,000	-0,003	0,000	0,000	-0,003	0,001	0,000	0,006	0,000
64	-1,989	2,047	0,557	1,699	-3,050	1,601	0,290	1,003	-2,158
71	-0,001	-0,554	1,206	-0,588	0,001	1,200	0,589	0,552	-2,405
74	0,009	0,001	-0,004	0,001	-0,008	0,004	-0,010	0,007	0,000
81	-0,689	0,129	0,166	0,180	-0,506	0,171	0,509	0,376	-0,337
85	-0,042	-0,133	0,108	-0,052	-0,673	0,362	0,094	0,807	-0,470

4.2. Dynamic cost share equations for high skilled and low skilled labour

Variables which have significant effect on the change in the cost shares are kept in the final cost share equations. In arriving at these equations, emphasis have been put on residuals being well behaved and obeying the standard assumptions of OLS regressions. In some equations, we have chosen to include parameter estimates that are not strictly significant to arrive at residuals without autocorrelation, which turned out to be the largest problem in the estimation. The dummies are also basically included to ensure that the residuals pass the normality tests. Parameter stability has also been an important criterion.

We have started out with equations (3.12) and (3.13), and in many industries, the estimated coefficients $\hat{\theta}_{HH}$ and $\hat{\theta}_{LL}$ associated with the lagged endogenous variables, were significant with higher numeric values than $\hat{\alpha}_{HH}$ and $\hat{\alpha}_{LL}$, i.e. the coefficients associated with the error correction terms. While this usually has led to well specified equations with respect to parameter stability, significance level and misspecification tests, this is unfortunate for the short term dynamics. The short term coefficients should ideally not dominate the long run effects by being large and with opposite signs. In both cases, an increase in the wages for one skill group, which in the long run leads to increases in the demand for the other two groups, can cause the demand to decrease in the short run.

This seems implausible. We have therefore tried to find equations that satisfy our requirements without large estimated values on short term coefficients and on the lagged endogenous variable. In some cases, it has been necessary to include impulse dummies or step dummies to arrive at equations with the desired characteristics. In other industries, the best result of this overall evaluation has been to keep some variables that are not strictly significant at 5 per cent significance level, while in other industries we have accepted some unfortunate short term effects in order to arrive what we consider to be the best dynamic specification. The overall focus is that the long term properties are reasonable.

Final dynamic equations of (3.12) and (3.13) are summarised in Appendix C. Residuals misspecification tests from the chosen specifications are reported in Tables D.1 and D.2 in Appendix D, respectively. The tests shows that the residuals are well behaved, satisfying the critical assumption of residual normality in OLS estimation.

4.3. Decreasing the labour costs for low skilled labour

As we pointed out in Section 2, the wage structure in Norway is relatively compressed compared to what is the case in most other OECD-countries. Despite of the low return on education, Norway has a relatively high share of workers with a tertiary education. Several explanations for this have been pointed out, for example that there are no tuition fees for attending public higher education in Norway and that the Norwegian State Educational Loan Fund offers grants and loans to students that are free of interest during education. Also, the educational capacity has increased much during the last decades.

What would be the consequences of a different wage structure for the demand for labour by education? In this section we consider a counterfactual simulation in order to quantify the effects of increasing the wages for high skilled and medium skilled labour relative to low skilled labour in two large industries. The historical experience – where relative wages are fairly stable – is referred to as the baseline path. The simulation with lower wages for low skilled workers is the counterfactual simulation.

First, we look at the isolated effects of decreasing the wages going to low skilled workers by 10 per cent in the engineering industry (industry 45), which is one of the largest manufacturing industries in Norway. The shift is carried out in 1990 and the wage decrease is permanent. Total labour costs are determined elsewhere in MODAG, so this variable is exogenous in this experiment. In 1990, the wage share going to low skilled constituted 43 per cent of total labour costs in this industry. As a result of the wage decrease, total labour costs are decreased by roughly 5 per cent in 1990.

In Appendix E, Figure E.1.1 and E.1.2 illustrates the effect of decreasing the wages to low skilled labour (relative to medium skilled labour) and total labour costs in the engineering industry. All deviations are expressed relative to the level in the baseline, Figure E.1.1 in per cent and Figure E.1.2 in percentage points. As the first graph in Figure E.1.1 illustrates, relative wages between low skilled and medium skilled labour in the alternative scenario is 10 per cent lower than the relative wage in the baseline scenario from 1990. Relative wages between high skilled and low skilled are the same in the two calculations, so wages to high skilled are 10 per cent higher relative to low skilled from 1990 labour as well.

When low skilled labour becomes cheaper than other labour inputs, firms will want to reduce the use of highly skilled and medium skilled labour in addition to increasing the use of low skilled labour. The extent to which these factors can be substituted is determined by the value of $\hat{\eta}_{HL}$ of 0.106, which is relatively small, and the value $\hat{\eta}_{ML}$ of 0.551, which is somewhat higher. We can therefore expect that firms will want to use more low skilled labour and less high and medium skilled labour. The use of medium skilled labour is expected to decrease more than the use of highly skilled labour compared to the baseline scenario. Figure E.1.1 confirms that this is the case.

It is the development of the dynamic cost shares that determine the estimated use of high and low skilled labour, both in the baseline scenario and in the alternative scenario with a different wage regime. These are given in Table C.9 for low skilled labour and Table C.10 for high skilled labour in Appendix C, and in Figure E.2.2, they are denoted cost shares, low skilled and cost shares, high skilled. The cost share and thus employment of medium skilled labour is determined by the adding up restriction of the cost shares. When the relative wages for low skilled is reduced, the dynamic cost share for high skilled labour is higher than what firms consider to be optimal. The opposite is the case for low skilled labour. This is reflected in the size of the error correction terms, ecm_H, and ecm_L from (3.10) and (3.11), which is positive for the high skilled and negative for low skilled labour. However, firms will gradually use more of the cheaper input factor and substitute away from high and medium skilled labour. The positive deviation in ecm_H reduces the cost share for low skilled and the negative deviation in ecm_L serves to increase the cost share of high skilled. How much of the deviation that is corrected in one period depends on the coefficients $\hat{\alpha}_{HH}$ and $\hat{\alpha}_{LL}$, which are estimated to -0.309 and -0.216, respectively. Thus, it takes some time before the dynamic cost shares have adjusted fully to the new wage regime. Eventually, the dynamic cost shares approaches the long run cost shares and ecm-terms will approach zero. Figure E.1.1 shows that in 2007, 17 years after wage reduction, the wage shares for the three labour inputs are roughly unchanged. Employment, measured in man hours, have on the other hand been reduced by 5 percent for medium skilled and about 2 ½ percent of high skilled Man hours worked by low skilled has on the other hand increased by nearly 6 percent.

As we have mentioned before, emphasis has been on the long term properties of the dynamic cost share equations. This has in some cases resulted in problematic short-term effects. Figure E.1.2 shows that immediately after the shift there is a perhaps unreasonable negative effect on ecm_H. This is caused by a strong short-term effect of reduced relative wages in the dynamic cost share equation in Table C.9 which causes the dynamic wage share to be lower than in the baseline in 1990. The negative value of ecm_H in turn serves to push up the dynamic cost share and from 1991 the error correction term is positive.

Next, we carry out the same calculation in other private services (industry 85), i.e. we look at the isolated effects of decreasing the wages going to low skilled workers by 10 per cent in the largest service sector industry from 1990. The share of total wages going to low skilled amounted to 44 per cent, so total labour costs are decreased by roughly 5 per cent in 1990 in this calculation, too.

As in the previous simulation, all other variables are held constant, i.e. relative wage of high skilled to medium skilled is unaltered in the calculations.

In Appendix E, Figure E.2.1 and E.2.2 illustrates the effect of decreasing the wages to low skilled labour (relative to medium skilled labour) and total labour costs in other private services on the variables of interest. Figure E.2.1 expresses the deviation of the wage costs and man hours relative to the baseline scenario in per cent, while Figure E.2.2 expresses deviations in percentage points. As Figure E.2.2 shows, the dynamic cost shares, marked as wage share, low skilled and wage share, high skilled, are both reduced compared to the baseline scenario. The error correction terms, i.e. the deviation between the dynamic wage shares and the long term wage shares, are both positive. Thus, both cost shares are higher than the long term cost shares, which are compatible with lower relative wages to low skilled. In the next round, the deviations from long term cost shares pushes both cost shares down. As time goes, the dynamic cost shares approaches the long term cost shares, and the ecm-terms become smaller. In 2007, the cost shares for medium and high skilled labour are smaller than in the baseline, and the high skilled cost share is higher than in the baseline. As the estimated value of $\hat{\eta}_{HL}$ of 0.108 is smaller than the value $\hat{\eta}_{ML}$ of 0.551, the substitution towards low skilled labour has suppressed the employment of medium skilled to a larger extent than the employment of skilled. In 2007, man hours worked by medium skilled is reduced by almost 9 per cent, while man hours worked by high skilled is well 1 ½ per cent lower than in the baseline.

5. Conclusions

We have specified and estimated a model of labour cost shares in 13 industries in the Norwegian business sector. Using time series data from 1972 to 2007 we have modelled the share of labour costs going to low skilled, medium skilled and high skilled labour. Our main focus has been to assess the effects of relative wages on the demand for workers with different skills. By estimating the share of labour costs going to low skilled and high skilled labour directly as tranlog cost functions, we are able to compute the implied own price elasticities and the elasticities of substitution between low skilled, medium skilled and high skilled labour.

The results establish that technical change has been important to explain the development in the labour cost shares across industries. The capital intensity can explain some of the development in the cost shares, especially for high skilled labour. However, relative wages seem to be of less importance. The restricted translog cost function we estimated, provide us with relative price coefficients that were insignificant in many industries. Nevertheless, we believe that the price mechanism is important when firms decide on optimal labour input bundles and choose to include relative wages as regressors. Taking the estimation results as given, the implied own-price elasticities are relatively inelastic for medium skilled and high skilled labour. This suggests that a change in the wages going to medium and high skilled labour will have little impact on the firm's demand for these skill groups. For low skilled labour, on the other hand, the own price elasticities are more elastic. This suggests that the demand for low skilled labour will be reduced if the remuneration of low skilled are increased, all other factors held constant.

In addition, the results show that the implied elasticity of substitution between medium skilled and low skilled labour is generally higher than between high skilled and low skilled and between high skilled and medium skilled labour. Moreover, medium skilled and low skilled labour is in general regarded as substitutes in the various industries. This means that firms will substitute between these labour inputs if relative prices change, all other factors held constant. The effects are substantial in labour intensive industries like manufacturing of engineering products, construction and other private services, and the cross price elasticities indicate that in general, the demand for medium skilled labour is more sensitive to changes in the wages to low skilled labour than the opposite. In some large service industries, however, low skilled labour is more sensitive to changes in the wages to medium skilled labour. Thus, it is not evident that changes in relative wages have a stronger effect on the employment of medium skilled labour than on low skilled labour.

Through a counterfactual calculation, we quantify the effects of a different wage regime, where wages for low skilled persons are reduced by 10 per cent compared to medium skilled and low skilled persons from 1990. The resulting demand for labour with different skills is compared to actual historical demand referred to as the baseline. The calculations are carried out for the largest private service industry, other private services, and for the largest manufacturing industry, manufacturing of engineering products. In both industries, reduced relative wages to low skilled labour lead to higher employment of low skilled workers and lower employment of medium and high skilled labour compared to the baseline. Since the cross price elasticity is stronger between medium skilled and low skilled labour than between high skilled and low skilled labour, the wage reduction leads to a stronger reduction in the employment of medium skilled labour than in the employment of high skilled labour.

References

Berman, E., Bound, J. and Griliches, Z. (1994): Changes in the demand for skilled labor within US manufacturing: evidence from the annual survey of manufacturers, *Quarterly Journal of Economics* 109(2), 367–397.

Berman, E, J. Bound and S. Machin (1998): Implications of Skill-Biased Technical Change: International Evidence, *Quarterly Journal of Economics*, 113, 1245-1280.

Bjørnstad, R. and T. Skjerpen (2003): Technology, Trade and Inequality. Discussion Papers 364, Statistics Norway.

Bjørnstad, R., M.L. Gjelsvik, A. Godøy, I. Holm and N.M. Stølen (2010): Demand and Supply of Labor by education towards 2030, Reports 39/2010, Statistics Norway.

Elliot, G., T.J. Rothenberg, and J.H. Stock (1996): Efficient Tests for an Autoregressive Unit Root, *Econometrica*, 64, 813-836.

Harris, A., I. D. McAvinchey and A. Yannopoulos (1993): The Demand for Labour, Capital, Fuels and Electricity: A sectoral Model of the United Kingdom Economy, *Journal of Economic Studies, 20(3),* 24-35.

Hægeland, T. and L. J. Kirkebøen (2007): Lønnsforskjeller mellom utdanningsgrupper (Wage differences between educational groups). Notater 2007/36, Statistics Norway.

Hægeland, T., T. J. Klette and K. G. Salvanes (1999): Declining Returns to Education in Norway? Comparing Estimates Across Cohorts, Sectors and over Time, *Scandinavian Journal of Economics*, **101**(4), 555-76.

Kahn, M. (1998): Against the Wind: Bargaining Recentralisation and Wage Inequality in Norway 1987-91, *The Economic Journal*, **108**, 603-45.

Lindquist, K-G. and T. Skjerpen (2003): *Exploring the Change in Skill Structure of Labour Demand in Norwegian Manufacturing*, Documents 2003/9, Statistics Norway.

Machin, S. (1996): Changes in the relative demand for skills, in A.L. Booth and D.J. Snower (eds.) *Acquiring skills: Market Failures, Their Symptoms and Policy Responses*, Cambridge University Press, Cambridge.

Manchin, S. and J. Van Reenen (1998): Technology and Changes in Skill Structure: Evidence from Seven OECD Countries, *Quarterly Journal of Economics*, CXIII, 1215-1244.

Mellander, E. (2000): The Multi-Dimensional Nature of Labor Demand and Skill-Biased Technical Change, Discussion Paper 440, Centre for Economic Performance, London School of Economics and Political Science.

Appendix A: Education classification, variables, definitions, key to industries and employment shares

A.1 Education classification

GRK	Primary and lower secondary education (including unknown)
VA	Upper secondary education general programs
VF	Upper secondary education vocational programs
HO	Tertiary education, lower degree
UN	Tertiary education, higher degree

GRK and VA is classified as low skilled labour
VF is classified as medium skilled labour
HO and UN is classified as high skilled labour

A.2 Variables (from NR 2007)

k_k	= real capital stock in industry k, constant 2006 prices
$l_{i,k}$	= total employment, wage earners and self employmed, in industry k in 1000 man hours, i = high, med, low
s_i	= cost share of labour i relative to total labour costs (including payroll taxes), i = high, med, low
q_k	= gross products in industry k, constant 2006 prices
yw_k	= wage costs in industry k
$ywgrk_k$	= wage costs paid to labour with primary and lower secondary education
$ywho_k$	= wage costs paid to labour with tertiary education, lower degree
$ywun_k$	= wage costs paid to labour with tertiary education, higher degree
$ywva_k$	= wage costs paid to labour with upper secondary general education
$ywvf_k$	= wage costs paid to labour with secondary vocational education
$w_{i,k}$	= wage costs, kroner per hour, i= high, med, low and k=industry

A.3 Definitions

totalcostsk	$= (ytwhigh_k+ytwlow_k+ytwmed_k)$
KINTk	$= \log(k_k(-1)/ q_k)$ for all industries but n40
KINT40	$= (k_{40}(-1)/ q_{40})$ [4]
llowk	$=lgrk+lva$
lmedk	$=lvf$
lhighk	$=lgrk_k+lva_k$
LOGWHk	$= \log (whigh_k/wmed_k)$
LOGWLk	$= \log (wlow_k/wmed_k)$
SHIGHk	$= (ytwhigh_{k+}\ ytshigh_k / totalcosts_k$
SMEDk	$= (ytwmed_{k+}\ ytsmed_k / totalcosts_k$
SLOWk	$= (ytwlow_{k+}\ ytslow_k / totalcosts_k$
whighk	$=1000^*\ ytw_i/llow_i$
wlowk	$=1000^*\ ytw_i/llow_i$
wmedk	$=1000^*\ ytw_i/llow_i$
ytwlowk	$= ywgrk_k+ywva_k$
ytwmedk	$= ywvf_k$
ytwhighk	$=ywho_k+ywun$

[4] Due to negative values in some years, the capital intensity in this industry is not expressed in logs.

A.4 Error correction terms (constructed)[5]

ECMHk = error correction term in the cost share equation for high skilled labour, k=industry
ECMLk = error correction term in the cost share equation for low skilled labour, k=industry

A.5 Industry codes and employment shares by industry

Table A.1: Key to industries and employment shares (2005):

Key to industry code	Industry	Employment share
15	Production of consumption goods	0,037
25	Production of miscellaneous manufacturing	0,056
30	Energy intensive manufacturing	0,021
40	Production of petroleum refineries etc.	0,001
45	Engineering products	0,053
50	Production of oil platforms and ships	0,023
55	Construction	0,112
63	Financial intermediates	0,033
64	Oil and gas exploration	0,027
71	Electricity	0,008
74	Domestic transportation	0,106
81	Wholesale and retail trade	0,196
85	Other private services	0,327

[5] See Table 2 for an overview of how it is constructed in the various industries.

Appendix B: Test of cointegration and plots of the error correction terms

To test whether the ecm-terms are stationary, we have carried out the Elliot- Rothenberg-Stock point optimal test (see Elliot, Rothenberg and Stock, 1996). The ERS-test tests the null hypothesis that $ecm_{i,k}$ has a unit root against the alternative that $ecm_{i,k}$, is stationary (i=H, L and k=industry).[6] For the null hypothesis to be rejected, the Elliott-Rothenberg-Stock test statistic must be smaller than the critical value, supporting that there is cointegration in the cost share equations (3.8) and (3.9). Test results are provided in Table B.1.

Test critical values are
1.87 at 1 % significance level
2.97 at 5 % significance level
3.91 at 10 % significance level

Table B.1: The Elliot-Rothenberg-Stock test statistic for ecm_H and ecm_L in the 13 industries

Key to industry	Industry	Test observator	
		ecm_H	ecm_L
15	Consumption goods	3,61	3.19*
25	Misc. manufacturing	0,89	3,08
30	Energy intensive manufacturing	2,72	2.94*
40	Petroleum refineries	3,30	13.50*
45	Engineering products	3,00	3,81
50	Oil platforms and ships	1,92	3.56*
55	Construction	11,61	2,86
63	Financial intermediates	34,96	11,59
64	Oil and gas exploration	1.13*	2,30
71	Electricity	3.34*	3,49
74	Domestic transportation	4,45	2,92
81	Wholesale and retail trade	3.10*	11,02
85	Other private services	2,00	3,14

* The two first observations are excluded from the test

[6] For a review of how the test is carried out, see Eviews 7 User guide II, page 387, http://schwert.ssb.rochester.edu/a425/EV72.pdf

Figure B.1: Ecm-terms in industry 15

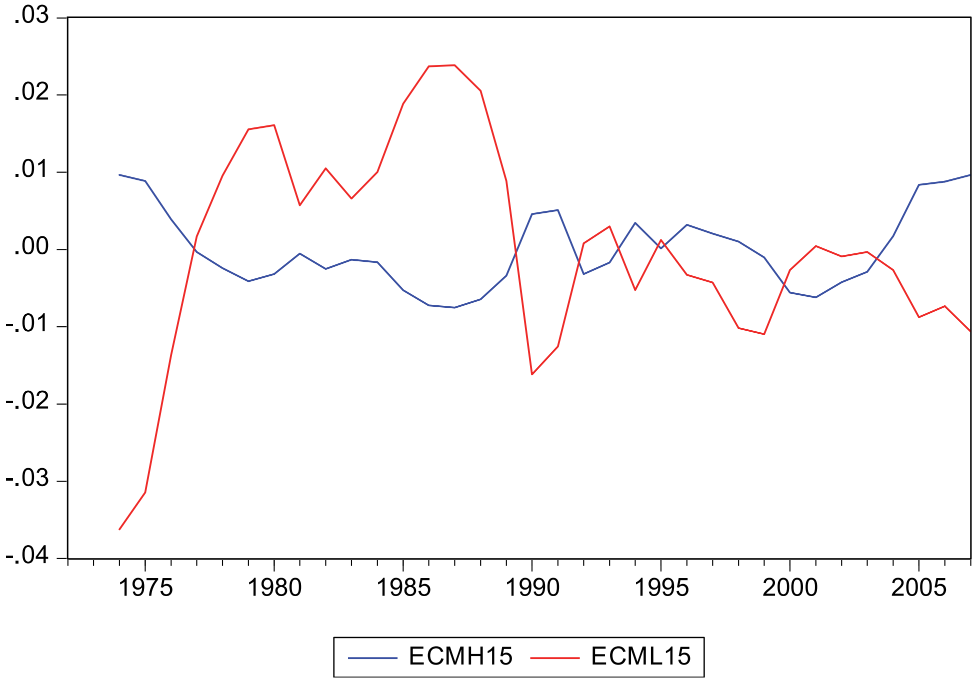


Figure B.2: Ecm-terms in industry 25

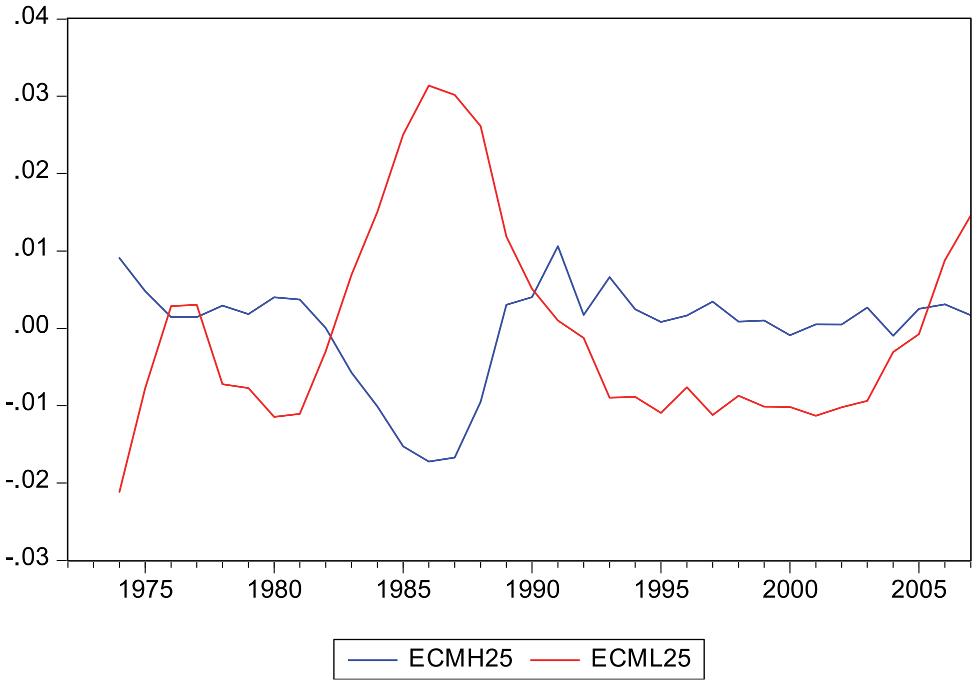


Figure B.3: Ecm-terms in industry 30

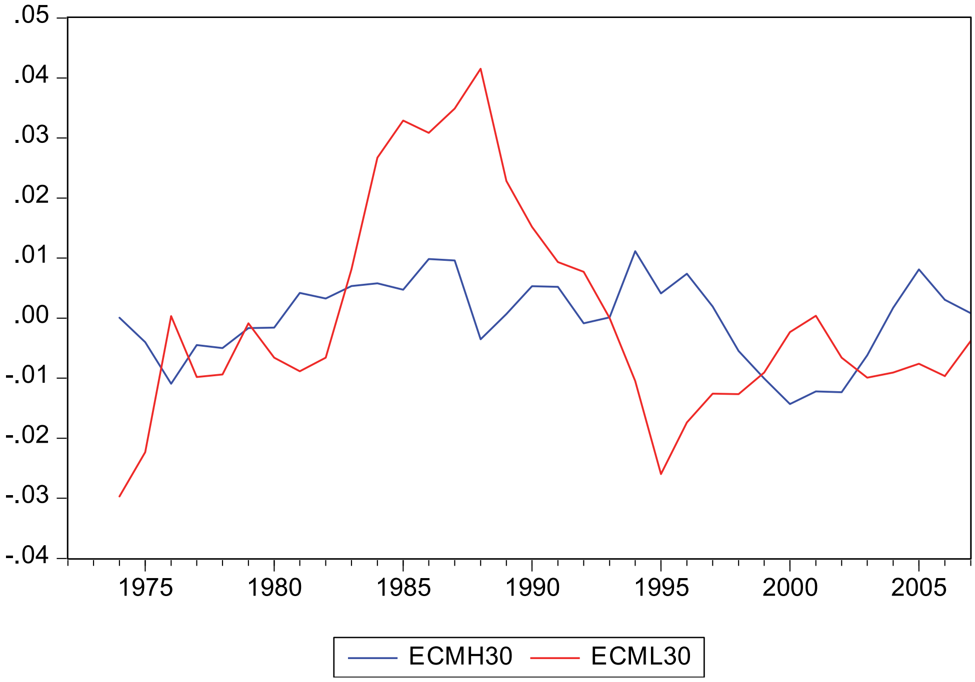


Figure B.4: Ecm-terms in industry 40

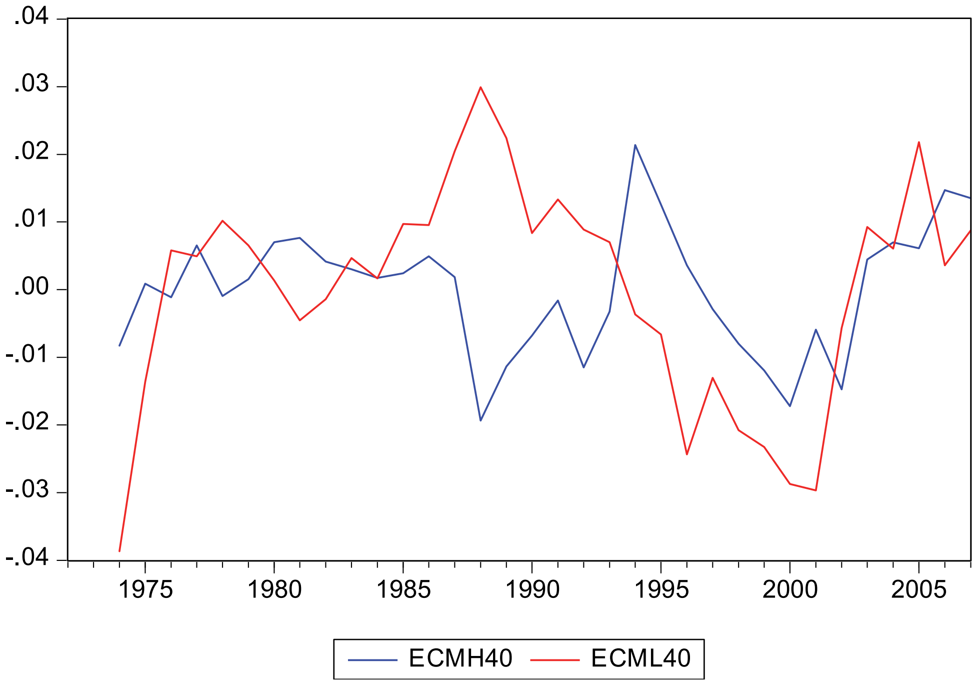


Figure B.5: Ecm-terms in industry 45

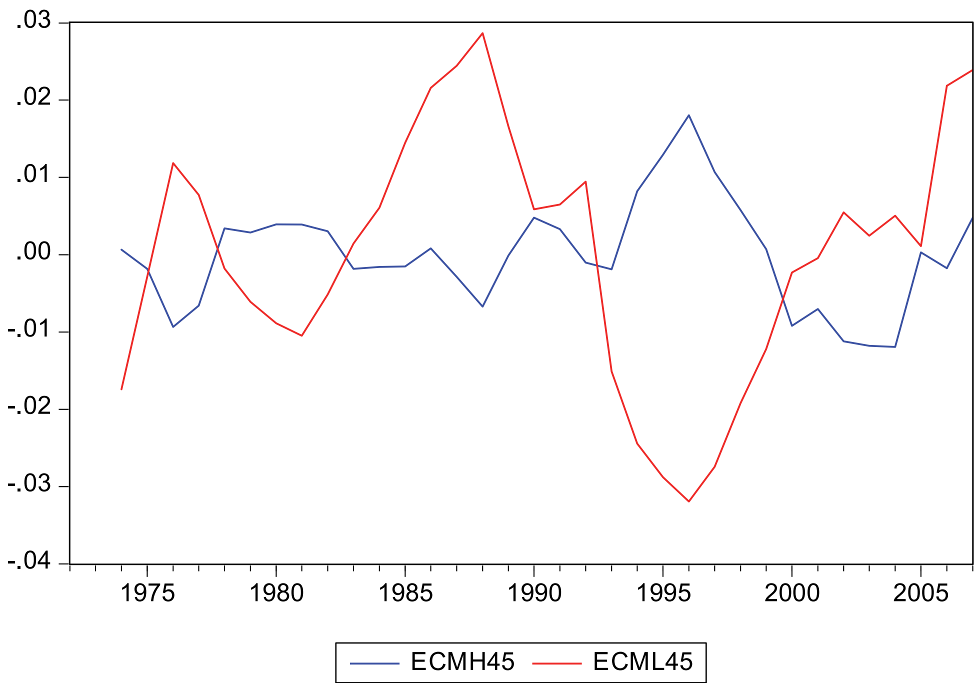


Figure B.6: Ecm-terms in industry 50

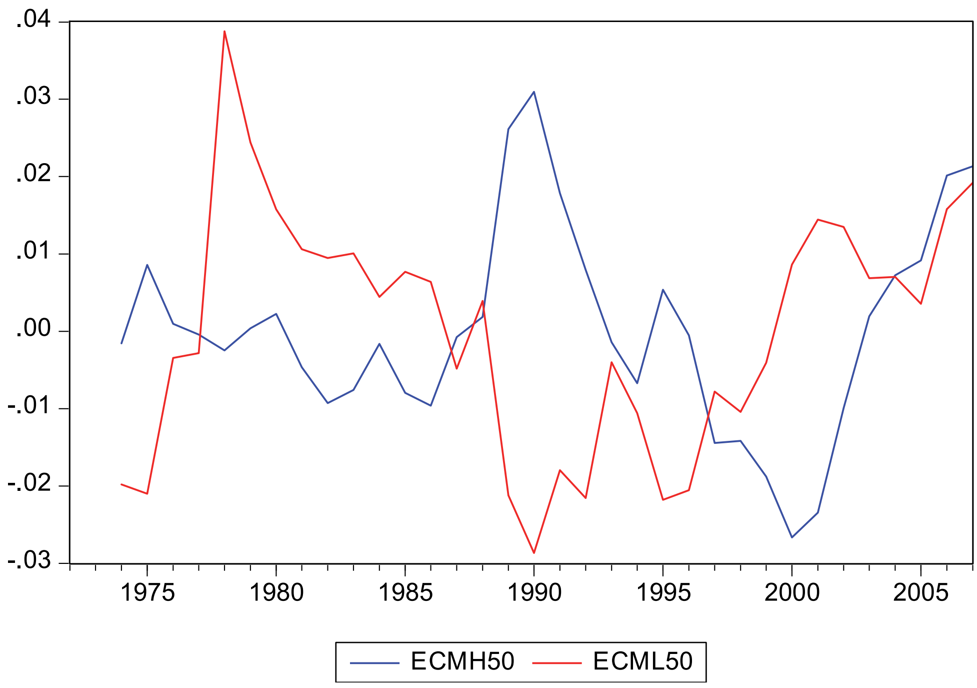


Figure B.7: Ecm-terms in industry 55

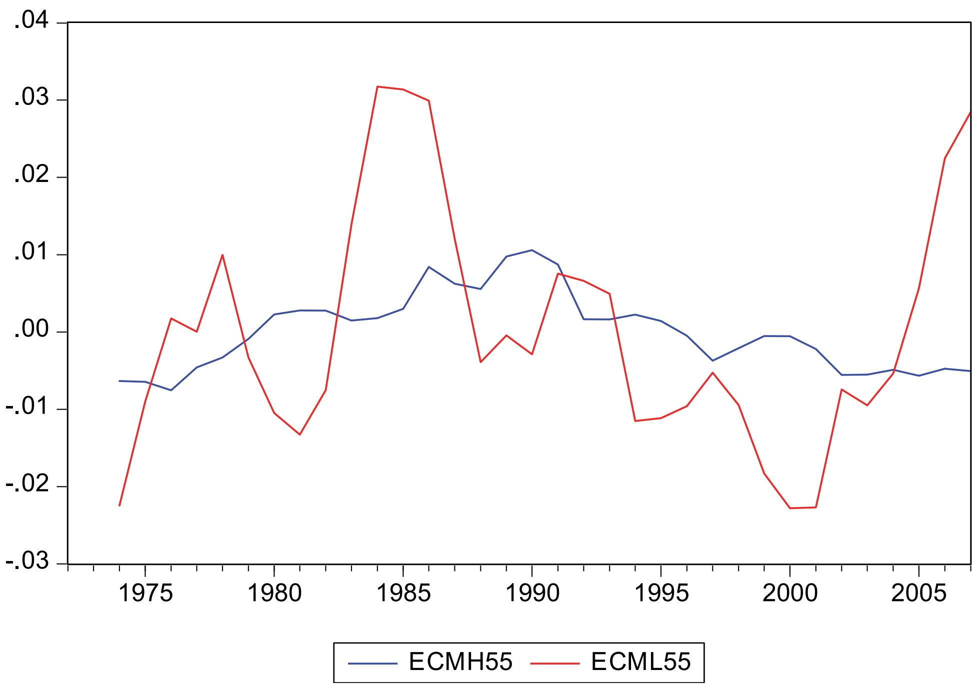


Figure B.8: Ecm-terms in industry 63

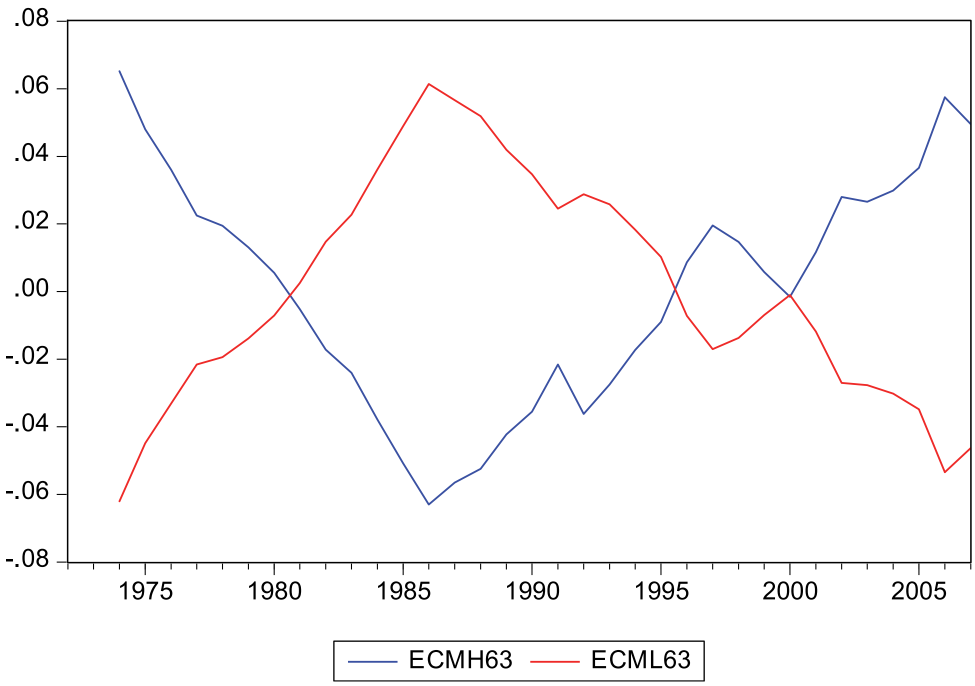


Figure B.9: Ecm-terms in industry 64

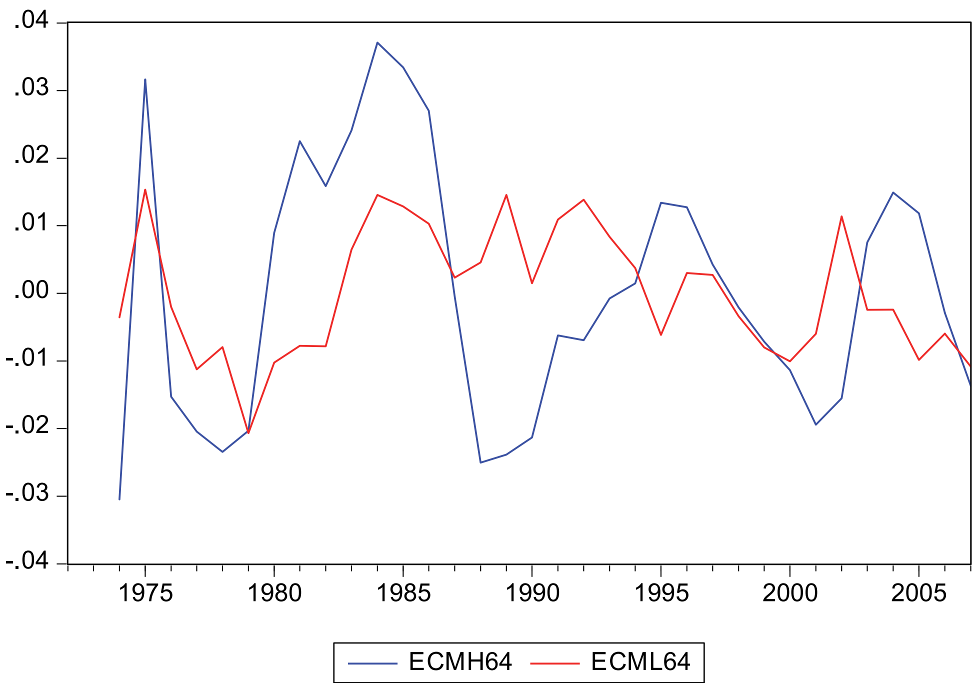


Figure B.10: Ecm-terms in industry 71

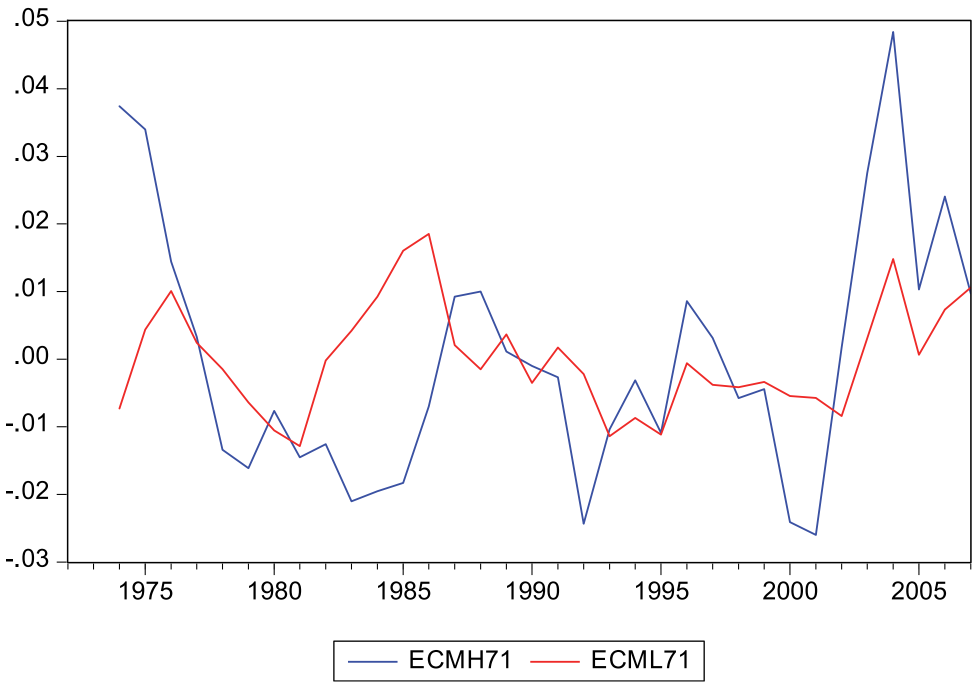


Figure B.11: Ecm-terms in industry 74

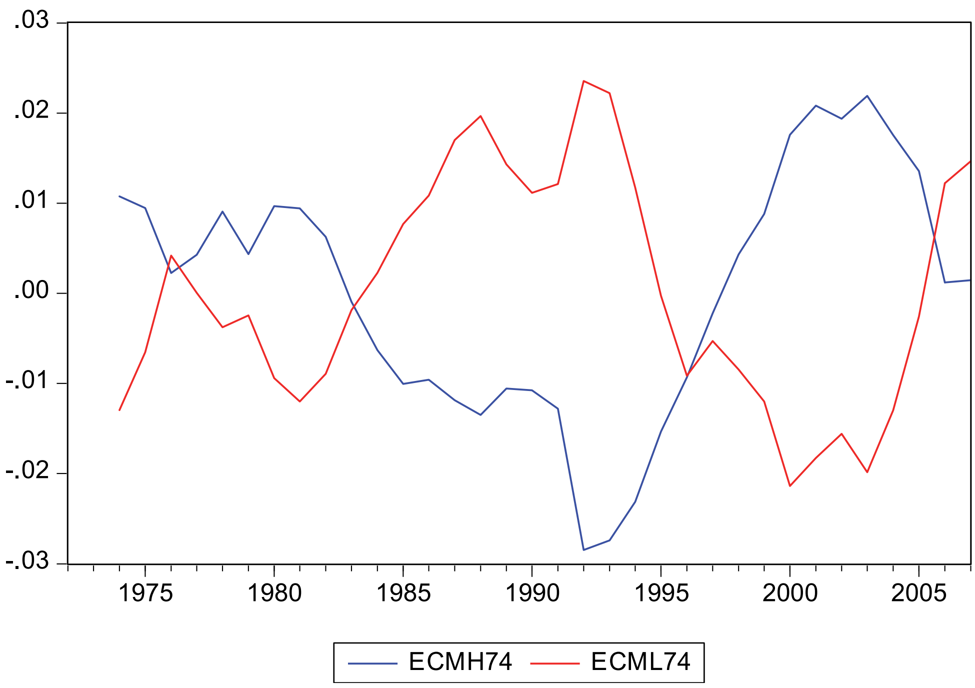


Figure B.12: Ecm-terms in industry 81

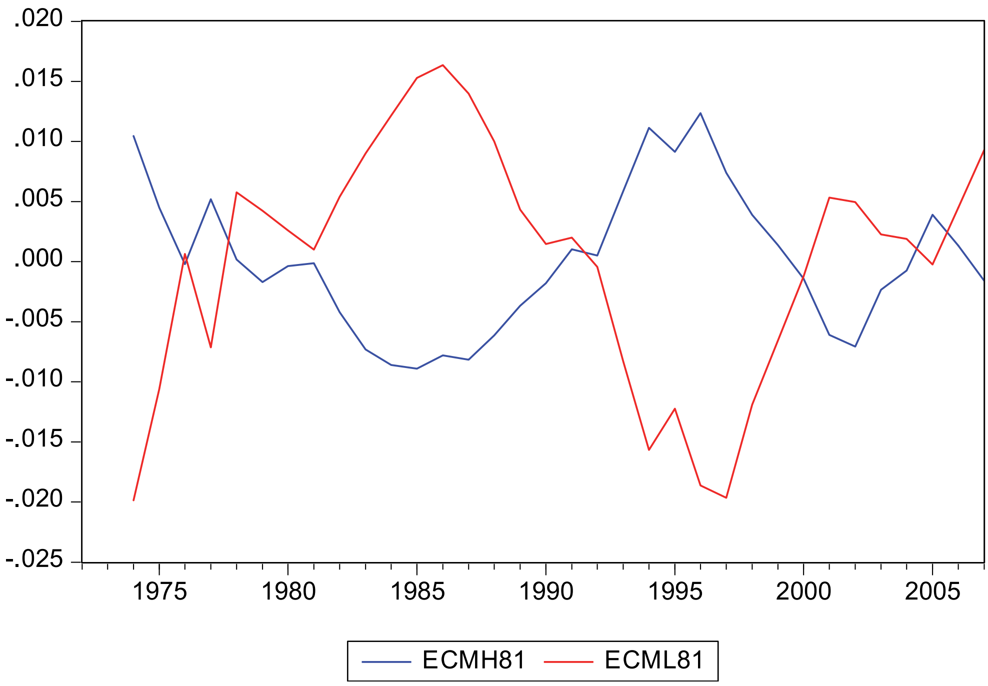
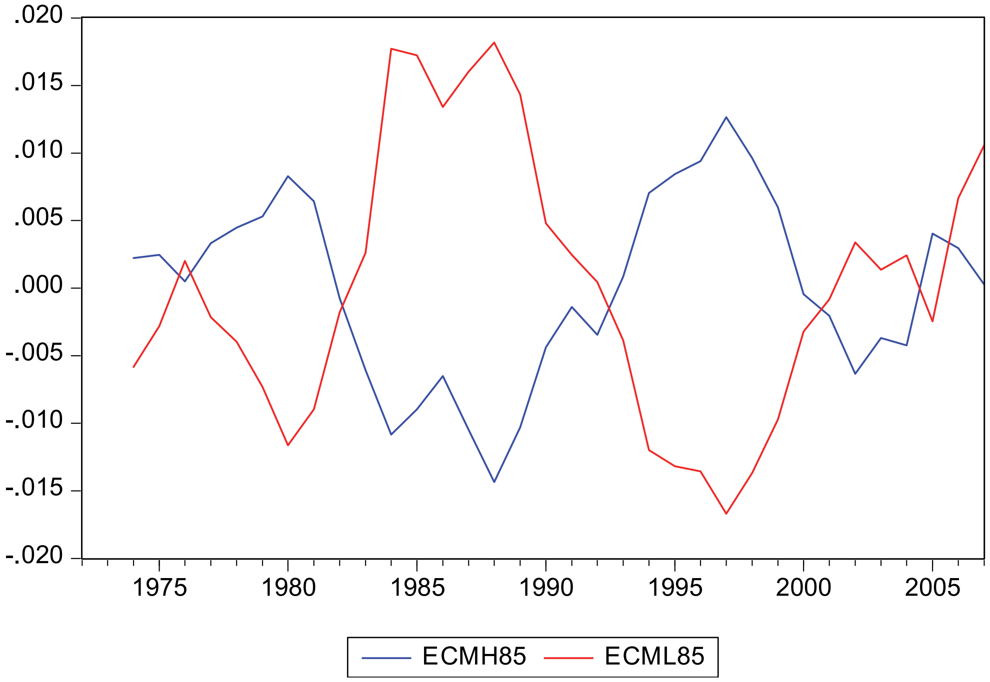


Figure B.13: Ecm-terms in industry 85



Appendix C: Detailed estimation results

In the estimation output, D (Δ) represents change from the previous year, i.e D(Y)= $\Delta Y=Y_t - Y_t$. Delta terms correspond to short term effects. Lags are in parentheses, so Y(-1) indicates that Y is lagged one period, i.e. Y_{t-1}. In the estimations, D(SHIGHk) and D(SLOWk) are the dependent variables in industry k, referring to $\Delta S_{H,k}$ and $\Delta S_{L,k}$ from the terminology in Section 3. LOGWLk refers to (the log of) high skilled relative wages, i.e $\log(W_{Lk}/W_{Mk})$ and correspondingly LOGWHk is (the log of) low skilled relative wages, i.e $\log(W_{Lk}/ W_{Mk})$. The capital intensity, $\log(K_{k,t-1}/Y_t)$ is denoted by KINTk. Impulse dummies are represented by DUMXX, where XX indicates the year. The dummies are 1 in year X and 0 otherwise.

Table C.1: Industry 15, wage share for high skilled:

Dependent Variable: D(SHIGH15)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002200	0.000307	7.163838	0.0000
ECMH15(-1)	-0.174258	0.062149	-2.803868	0.0088
DUM94+DUM05	0.006172	0.001245	4.955888	0.0000

R-squared	0.516004	Mean dependent var	0.002625
Adjusted R-squared	0.483738	S.D. dependent var	0.002375
S.E. of regression	0.001707	Sum squared resid	8.74E-05
F-statistic	15.99199	Durbin-Watson stat	1.491266

Table C.2: Industry 15, wage share for low skilled:

Dependent Variable: D(SLOW15)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.009898	0.000677	-14.62981	0.0000
ECML15(-1)	-0.082429	0.049545	-1.663701	0.1066
DUM94-DUM06	-0.009648	0.002763	-3.492055	0.0015

R-squared	0.353037	Mean dependent var	-0.009925
Adjusted R-squared	0.309906	S.D. dependent var	0.004677
S.E. of regression	0.003885	Sum squared resid	0.000453
F-statistic	8.185241	Durbin-Watson stat	1.374125

Table C.3: Industry 25, wage share for high skilled:

Dependent Variable: D(SHIGH25)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004927	0.000627	7.855958	0.0000
ECMH25(-1)	-0.115601	0.091933	-1.257450	0.2183
D(LOGWH25)	0.057732	0.027129	2.128056	0.0417

R-squared	0.159781	Mean dependent var	0.004553
Adjusted R-squared	0.103767	S.D. dependent var	0.003648
S.E. of regression	0.003454	Sum squared resid	0.000358
F-statistic	2.852491	Durbin-Watson stat	1.657788

Table C.4: Industry 25, wage share for low skilled:

Dependent Variable: D(SLOW25)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.011914	0.000947	-12.58312	0.0000
ECML25(-1)	-0.097279	0.067609	-1.438842	0.1613
D(LOGWL25(-1))	0.238588	0.094242	2.531657	0.0172
DUM80	-0.009646	0.005170	-1.865895	0.0726
DUM06+DUM07	0.012414	0.003708	3.347360	0.0023

R-squared	0.445940	Mean dependent var	-0.011955
Adjusted R-squared	0.366789	S.D. dependent var	0.006359
S.E. of regression	0.005060	Sum squared resid	0.000717
F-statistic	5.634014	Durbin-Watson stat	1.322124

Table C.5: Industry 30, wage share for high skilled:

Dependent Variable: D(SHIGH30)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003888	0.000867	4.484379	0.0001
ECMH30(-1)	-0.383100	0.130727	-2.930531	0.0064
DUM00	-0.010194	0.005155	-1.977334	0.0573

R-squared	0.253057	Mean dependent var	0.003589
Adjusted R-squared	0.203261	S.D. dependent var	0.005490
S.E. of regression	0.004900	Sum squared resid	0.000720
F-statistic	5.081853	Durbin-Watson stat	1.710026

Table C.6: Industry 30, wage share for low skilled:

Dependent Variable: D(SLOW30)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.013566	0.001120	-12.11114	0.0000
ECML30(-1)	-0.120188	0.064073	-1.875799	0.0708
D(LOGWL30)	0.404855	0.123252	3.284784	0.0027
DUM77+DUM81-DUM06	-0.018595	0.003865	-4.810545	0.0000

R-squared	0.535936	Mean dependent var	-0.014269
Adjusted R-squared	0.487929	S.D. dependent var	0.008929
S.E. of regression	0.006389	Sum squared resid	0.001184
F-statistic	11.16378	Durbin-Watson stat	1.312469

Table C.7: Industry 40, wage share for high skilled:

Dependent Variable: D(SHIGH40)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002661	0.000959	2.774147	0.0097
ECMH40(-1)	-0.327171	0.103809	-3.151672	0.0038
D(LOGWH40)-D(LOGWL40)	0.312645	0.044255	7.064659	0.0000
DUM88	-0.018062	0.005496	-3.286284	0.0027
DUM94	0.022563	0.005385	4.189913	0.0003

R-squared	0.776207	Mean dependent var	0.003492
Adjusted R-squared	0.744237	S.D. dependent var	0.010464
S.E. of regression	0.005292	Sum squared resid	0.000784
F-statistic	24.27892	Durbin-Watson stat	2.207478

Table C.8: Industry 40, wage share for low skilled:

Dependent Variable: D(SLOW40)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.008845	0.001587	-5.575046	0.0000
ECML40(-1)	-0.276857	0.099090	-2.793988	0.0088

R-squared	0.201162	Mean dependent var	-0.008772
Adjusted R-squared	0.175393	S.D. dependent var	0.010035
S.E. of regression	0.009113	Sum squared resid	0.002574
F-statistic	7.806370	Durbin-Watson stat	1.580921

Table C.9: Industry 45, wage share for high skilled:

Dependent Variable: D(SHIGH45)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002564	0.000655	3.916942	0.0005
ECMH45(-1)	-0.309355	0.093177	-3.320093	0.0024
D(LOGWL45)-D(LOGWL45(-1))	0.206310	0.072354	2.851380	0.0079
DUM02+DUM06	-0.008524	0.002675	-3.186581	0.0034

R-squared	0.485787	Mean dependent var	0.002174
Adjusted R-squared	0.432592	S.D. dependent var	0.004833
S.E. of regression	0.003640	Sum squared resid	0.000384
F-statistic	9.132269	Durbin-Watson stat	1.314364

Table C.10: Industry 45, wage share for low skilled:

Dependent Variable: D(SLOW45)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.005088	0.001259	-4.042613	0.0004
ECML45(-1)	-0.215887	0.054359	-3.971510	0.0005
D(LOGWL45(-1))	0.274942	0.110340	2.491764	0.0189
D(SLOW45(-1))	0.555052	0.083311	6.662404	0.0000
DUM93-DUM06	-0.024016	0.003400	-7.063450	0.0000

R-squared	0.821102	Mean dependent var	-0.010877
Adjusted R-squared	0.795545	S.D. dependent var	0.010477
S.E. of regression	0.004737	Sum squared resid	0.000628
F-statistic	32.12851	Durbin-Watson stat	2.055511

Table C.11: Industry 50, wage share for high skilled:

Dependent Variable: D(SHIGH50)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003456	0.000978	3.532281	0.0014
ECMH50(-1)	-0.290525	0.077786	-3.734909	0.0009
D(LOGWL50)	0.313385	0.112754	2.779376	0.0096
DUM89-DUM93	0.019141	0.003899	4.909195	0.0000
DUM97	-0.023124	0.005613	-4.119710	0.0003

R-squared	0.720533	Mean dependent var	0.003169
Adjusted R-squared	0.680609	S.D. dependent var	0.009739
S.E. of regression	0.005504	Sum squared resid	0.000848
F-statistic	18.04771	Durbin-Watson stat	1.481194

Table C.12: Industry 50, wage share for low skilled:

Dependent Variable: D(SLOW50)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.013234	0.002605	-5.081026	0.0000
ECML50(-1)	-0.350778	0.169764	-2.066269	0.0472

R-squared	0.121053	Mean dependent var	-0.013030
Adjusted R-squared	0.092700	S.D. dependent var	0.015696
S.E. of regression	0.014951	Sum squared resid	
F-statistic	4.269466	Durbin-Watson stat	1.367237

Table C.13: Industry 55, wage share for high skilled:

Dependent Variable: D(SHIGH55)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000779	0.000321	2.429503	0.0218
ECMH55(-1)	-0.156820	0.063438	-2.472006	0.0198
ECML55(-1)	0.091108	0.021789	4.181373	0.0003
D(LOGWH55)	0.175031	0.019058	9.184057	0.0000
D(LOGWL55(-1))	-0.123284	0.039145	-3.149425	0.0039

R-squared	0.776817	Mean dependent var	0.001370
Adjusted R-squared	0.744934	S.D. dependent var	0.003357
S.E. of regression	0.001695	Sum squared resid	8.05E-05
F-statistic	24.36439	Durbin-Watson stat	1.443191

Table C.14: Industry 55, wage share for low skilled:

Dependent Variable: D(SLOW55)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.002899	0.001928	-1.503175	0.1432
ECML55(-1)	-0.181766	0.081865	-2.220298	0.0341
D(SLOW55(-1))	0.746599	0.123538	6.043462	0.0000

R-squared	0.567268	Mean dependent var	-0.011974
Adjusted R-squared	0.538419	S.D. dependent var	0.010004
S.E. of regression	0.006797	Sum squared resid	0.001386
F-statistic	19.66345	Durbin-Watson stat	2.069685

Table C.15: Industry 63, wage share for high skilled:

Dependent Variable: D(SHIGH63)
Sample: 1976 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.005991	0.001564	3.829520	0.0007
ECMH63(-1)	-0.086997	0.041202	-2.111460	0.0441
D(LOGWH63)-D(LOGWL63)	0.271999	0.031669	8.588846	0.0000
D(KINT63(-1))	-0.060817	0.018270	-3.328718	0.0025
D(SHIGH63(-1))	0.433824	0.120961	3.586476	0.0013

R-squared	0.736786	Mean dependent var	0.008529
Adjusted R-squared	0.697791	S.D. dependent var	0.012487
S.E. of regression	0.006865	Sum squared resid	0.001272
F-statistic	18.89450	Durbin-Watson stat	1.889211

Table C.16: Industry 63, wage share for low skilled:

Dependent Variable: D(SLOW63)
Sample (adjusted): 1976 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.006625	0.001490	-4.446715	0.0001
ECML63(-1)	-0.053842	0.039989	-1.346411	0.1894
D(LOGWH63)-D(LOGWL63)	-0.281421	0.030066	-9.360005	0.0000
D(KINT63(-1))	0.039130	0.016981	2.304310	0.0291
D(SLOW63(-1))	0.325054	0.114650	2.835193	0.0086

R-squared	0.770884	Mean dependent var	-0.008854
Adjusted R-squared	0.736940	S.D. dependent var	0.012416
S.E. of regression	0.006368	Akaike info criterion	-7.132360
Sum squared resid	0.001095	Sum squared resid	0.001095
F-statistic	22.71101	Durbin-Watson stat	1.584192

Table C.17: Industry 64, wage share for high skilled:

Dependent Variable: D(SHIGH64)
Sample: 1976 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003971	0.002037	1.949080	0.0617
ECMH64(-1)	-0.312299	0.101681	-3.071377	0.0048
D(KINT64)	0.045597	0.019221	2.372189	0.0251
D(KINT64(-1))	0.032978	0.012993	2.538026	0.0172
D(SHIGH64(-1))	0.484263	0.104724	4.624167	0.0001

R-squared	0.646447	Mean dependent var	0.008906
Adjusted R-squared	0.594069	S.D. dependent var	0.015224
S.E. of regression	0.009699	Sum squared resid	0.002540
F-statistic	12.34193	Durbin-Watson stat	1.976551

Table C.18: Industry 64, wage share for low skilled:

Dependent Variable: D(SLOW64)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.003615	0.000916	-3.945883	0.0005
ECMH64(-1)	0.122684	0.053468	2.294527	0.0301
ECML64(-1)	-0.482041	0.099148	-4.861821	0.0000
D(LOGWH64)	-0.089550	0.037829	-2.367214	0.0256
D(KINT64)	0.038180	0.007018	5.440535	0.0000
DUM92	0.012359	0.005047	2.449029	0.0214
DUM89	0.009854	0.005144	1.915586	0.0665

R-squared	0.690349	Mean dependent var	-0.002604
Adjusted R-squared	0.618891	S.D. dependent var	0.007698
S.E. of regression	0.004752	Sum squared resid	0.000587
F-statistic	9.660925	Durbin-Watson stat	2.126207

Table C.19: Industry 71, wage share for high skilled:

Dependent Variable: D(SHIGH71)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003312	0.001562	2.120169	0.0430
ECMH71(-1)	-0.152915	0.063296	-2.415890	0.0225
D(LOGWH71)-D(LOGWL71)	0.251004	0.114538	2.191440	0.0369
D(KINT71)	-0.024177	0.014239	-1.697882	0.1006
D(SHIGH71(-1))	0.510537	0.161975	3.151960	0.0038

R-squared	0.396818	Mean dependent var	0.005451
Adjusted R-squared	0.310649	S.D. dependent var	0.006600
S.E. of regression	0.005479	Sum squared resid	0.000841
F-statistic	4.605120	Durbin-Watson stat	2.196162

Table C.20: Industry 71, wage share for low skilled:

Dependent Variable: D(SLOW71)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.008137	0.001433	-5.676713	0.0000
ECMH71(-1)	0.171620	0.072657	2.362072	0.0259
ECML71(-1)	-0.907673	0.215933	-4.203496	0.0003
D(LOGWH71)	0.602604	0.175957	3.424725	0.0021
D(LOGWL71)	-0.409510	0.179035	-2.287318	0.0306
D(LOGWH71(-1))	0.298287	0.126328	2.361204	0.0260
DUM80	-0.015940	0.006638	-2.401174	0.0238

R-squared	0.472083	Mean dependent var	-0.011672
Adjusted R-squared	0.350257	S.D. dependent var	0.007874
S.E. of regression	0.006347	Sum squared resid	0.001047
F-statistic	3.875034	Durbin-Watson stat	1.797224

Table C.21: Industry 74, wage share for high skilled:

Dependent Variable: D(SHIGH74)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004054	0.000453	8.948872	0.0000
(ECMH74(-1))+(ECML74(-1))	-0.324626	0.070369	-4.613163	0.0001
D(LOGWL74(-1))	-0.147026	0.052860	-2.781411	0.0093

R-squared	0.448679	Mean dependent var	0.004254
Adjusted R-squared	0.411924	S.D. dependent var	0.003380
S.E. of regression	0.002592	Sum squared resid	0.000202
F-statistic	12.20737	Durbin-Watson stat	1.732587

Table C.22: Industry 74, wage share for low skilled:

Dependent Variable: D(SLOW74)
Sample: 1976 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.009027	0.000897	-10.05926	0.0000
ECML74(-1)	-0.220980	0.080406	-2.748303	0.0104
D(LOGWL74(-1))	0.358970	0.107661	3.334249	0.0024
D(KINT74(-1))	-0.049884	0.017629	-2.829734	0.0085

R-squared	0.463401	Mean dependent var	-0.008200
Adjusted R-squared	0.405908	S.D. dependent var	0.006294
S.E. of regression	0.004851	Sum squared resid	0.000659
F-statistic	8.060150	Durbin-Watson stat	1.529287

Table C.23: Industry 81, wage share for high skilled:

Dependent Variable: D(SHIGH81)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003855	0.000486	7.926586	0.0000
ECMH81(-1)	-0.149645	0.080049	-1.869425	0.0717
DUM77	0.009350	0.002751	3.399046	0.0020
DUM01	-0.005800	0.002753	-2.106530	0.0439

R-squared	0.404741	Mean dependent var	0.003955
Adjusted R-squared	0.343162	S.D. dependent var	0.003340
S.E. of regression	0.002707	S.E. of regression	0.000213
F-statistic	6.572752	Durbin-Watson stat	1.566133

Table C.24: Industry 81, wage share for low skilled:

Dependent Variable: D(SLOW81)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001737	0.001191	-1.458049	0.1564
ECML81(-1)	-0.152107	0.058938	-2.580774	0.0156
D(LOGWL81)	0.149399	0.025987	5.748993	0.0000
D(LOGWL81(-1))	-0.131997	0.024503	-5.387062	0.0000
D(SLOW81(-1))	0.687770	0.134949	5.096526	0.0000
DUM77	-0.016676	0.003357	-4.968150	0.0000

R-squared	0.759165	Mean dependent var	-0.007186
Adjusted R-squared	0.714566	S.D. dependent var	0.006118
S.E. of regression	0.003269	Sum squared resid	0.000288
F-statistic	17.02200	Durbin-Watson stat	1.981587

Table C.25: Industry 85, wage share for high skilled:

Dependent Variable: D(SHIGH85)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003161	0.000720	4.387962	0.0001
ECMH85(-1)	-0.191749	0.095214	-2.013861	0.0534
D(LOGWH85)-D(LOGWL85)	0.165151	0.058264	2.834539	0.0083
DUM90	0.007432	0.003709	2.003681	0.0545

R-squared	0.365230	Mean dependent var	0.002357
Adjusted R-squared	0.299564	S.D. dependent var	0.004203
S.E. of regression	0.003518	Sum squared resid	0.000359
F-statistic	5.561953	Durbin-Watson stat	1.562152

Table C.26: Industry 85, wage share for low skilled:

Dependent Variable: D(SLOW85)
Sample: 1975 to 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.002383	0.001141	-2.089418	0.0453
ECML85(-1)	-0.195401	0.086265	-2.265115	0.0309
D(SLOW85(-1))	0.473955	0.156009	3.037992	0.0049

R-squared	0.291868	Mean dependent var	-0.004725
Adjusted R-squared	0.244659	S.D. dependent var	0.005455
S.E. of regression	0.004741	Sum squared resid	0.000674
F-statistic	6.182480	Durbin-Watson stat	1.898682

Appendix D: Residual misspecification tests

The tables show three important tests for the crucial assumption of normally distributed errors of regression in the different cost share equations. The Jarque-Bera test for normality is a goodness-of-fit test of whether errors of regression have the skewness and kurtosis matching a normal distribution. The Jarque-Bera statistic has a χ_2 distribution with two degrees of freedom under the null hypothesis of normally distributed errors and the columns marked as Prob. are significance probabilities and show that this the tests are not rejected at the five per cent significance level in any of the equations.

The second test is the Breusch-Godfrey LM-test where the null hypothesis is that there is no serial correlation up to lag two. If the error term is serially correlated, the estimated OLS standard errors are
invalid and the estimated coefficients will be biased and inconsistent due to the presence of a lagged dependent variable on the right-hand side. The Breusch-Godfrey LM-test does not reject the null hypothesis of no serial correlation up to order two for any of the equations at five per cent significance level.

The ARCH test for heteroskedasticity in the residuals regress the squared residuals on squared residuals, lagged 1 and 2 periods, and a constant. In the presence of heteroskedasticity, ordinary least squares estimates are still consistent, but the conventional computed standard errors are no longer valid. The null hypothesis of no heteroskedasticity is not rejected in any of the equations. Overall, heteroskedasticity does not appear to pose a large problem in any of the equations.

Table D.1: Residual misspecification tests for high skilled labour cost share equations

		Normality		Serial correlation		Heteroskadasticity	
	Dependent variable D(SH)	Jarque Bera		Breusch-Godfrey		ARCH	
	Industry	Jarque Bera	Prob.	F-stat	Prob.	F-stat	Prob.
15	Consumption goods	0.778	0.678	1.709	0.199	0.156	0.856
25	Misc. manufacturing	0.516	0.772	0.611	0.550	0.025	0.975
30	Energy intensive manufacturing	0.378	0.828	0.502	0.610	1.264	0.298
40	Petroleum refineries	0.878	0.645	1.455	0.252	0.154	0.858
45	Engineering products	1.896	0.386	2.158	0.135	3.174	0.057
50	Oil platforms and ships	0.569	0.752	0.944	0.402	0.314	0.733
55	Construction	0.140	0.932	0.832	0.446	0.069	0.933
63	Financial intermediates	1.603	0.449	0.913	0.414	1.701	0.201
64	Oil and gas exploration	1.484	0.476	0.233	0.794	0.117	0.890
71	Electricity	3.628	0.163	0.709	0.501	1.363	0.272
74	Domestic transportation	1.913	0.384	0.190	0.828	0.109	0.897
81	Wholesale and retail trade	2.293	0.318	1.648	0.211	1.026	0.372
85	Other private services	1.941	0.379	1.278	0.295	1.630	0.214

Table D.2: Residual misspecification tests for low skilled labour cost share equations

		Normality		Serial correlation		Heteroskadasticity	
	Dependent variable D(SL)	Jarque Bera		Breusch-Godfrey		ARCH	
	Industry	Jarque Bera	Prob.	F-stat	Prob.	F-stat	Prob.
15	Consumption goods	0.032	0.984	1.251	0.302	0.389	0.682
25	Misc. manufacturing	2.699	0.259	1.761	0.192	1.595	0.221
30	Energy intensive manufacturing	0.812	0.666	1.589	0.223	0.619	0.546
40	Petroleum refineries	1.791	0.408	2.154	0.134	2.154	0.134
45	Engineering products	1.685	0.431	0.185	0.832	0.508	0.607
50	Oil platforms and ships	2.455	0.293	1.654	0.209	0.616	0.547
55	Construction	2.016	0.345	0.226	0.799	1.930	0.164
63	Financial intermediates	0.997	0.607	1.340	0.280	0.835	0.445
64	Oil and gas exploration	1.392	0.498	0.208	0.814	0.166	0.848
71	Electricity	0.901	0.637	1.373	0.273	0.842	0.441
74	Domestic transportation	0.236	0.889	1.175	0.325	0.003	0.997
81	Wholesale and retail trade	1.631	0.443	0.767	0.475	0.605	0.553
85	Other private services	5.450	0.066	0.090	0.914	0.591	0.561

Appendix E: Scenarios

E.1 Increased wage differentials, industry 45 (engineering products)

As described in Section 4.3. Wages to low skilled labour is decreased by 10 per cent relative to high skilled and medium skilled labour from 1990. Total labour costs are 4-5 per cent lower, reflecting that low skilled labour consisted of a little more than 40 per cent of total labour costs in 1990.

Figure E.1.1: Increased wage differentials. Green line shows baseline, blue line alternative scenario and black line per cent deviation (scenario from baseline). Left axis measures deviation in per cent, while right axis represents wage costs in kroner per hour, total labour costs in million kroner and employment in 1000 man hours, respectively

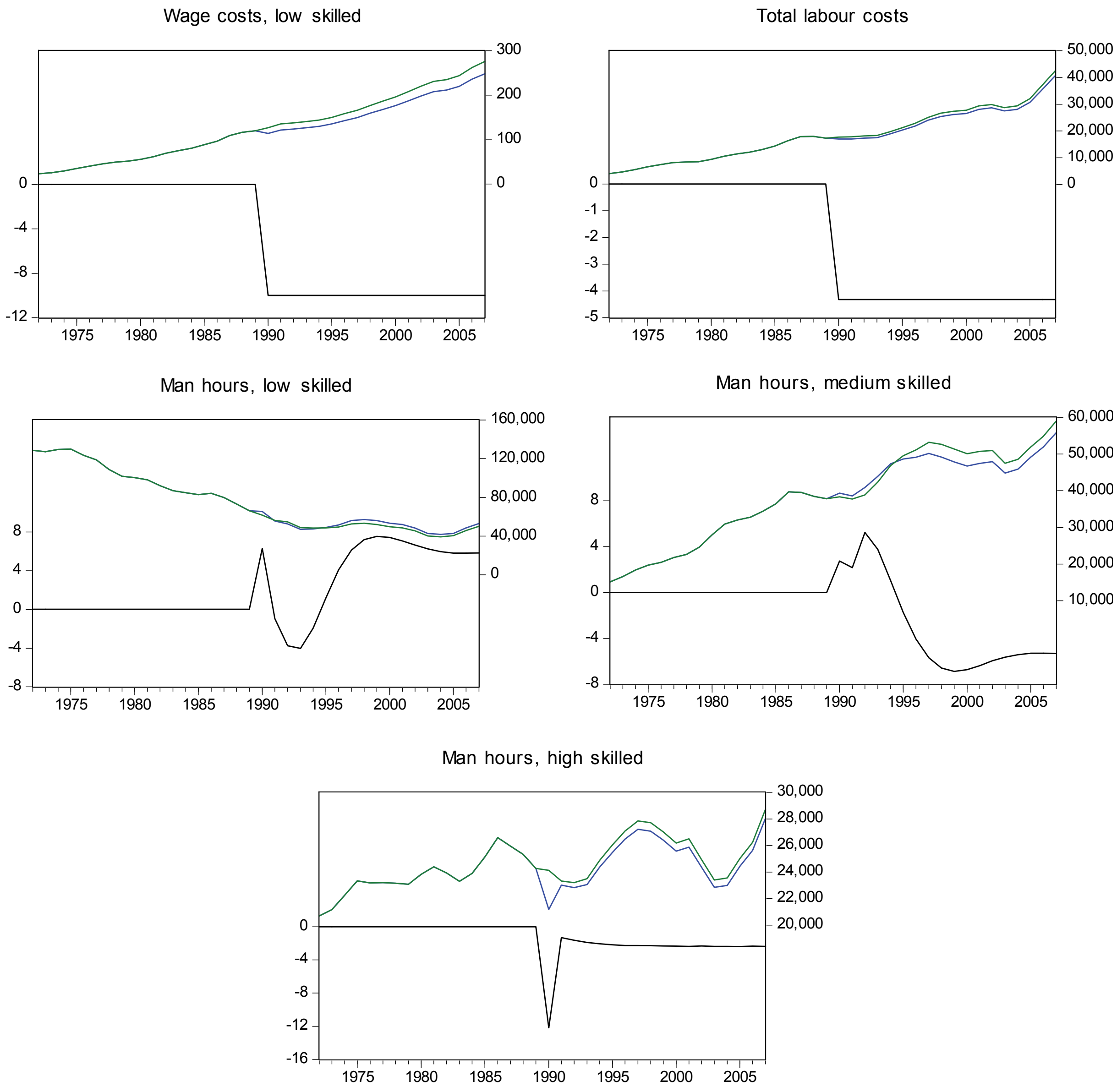
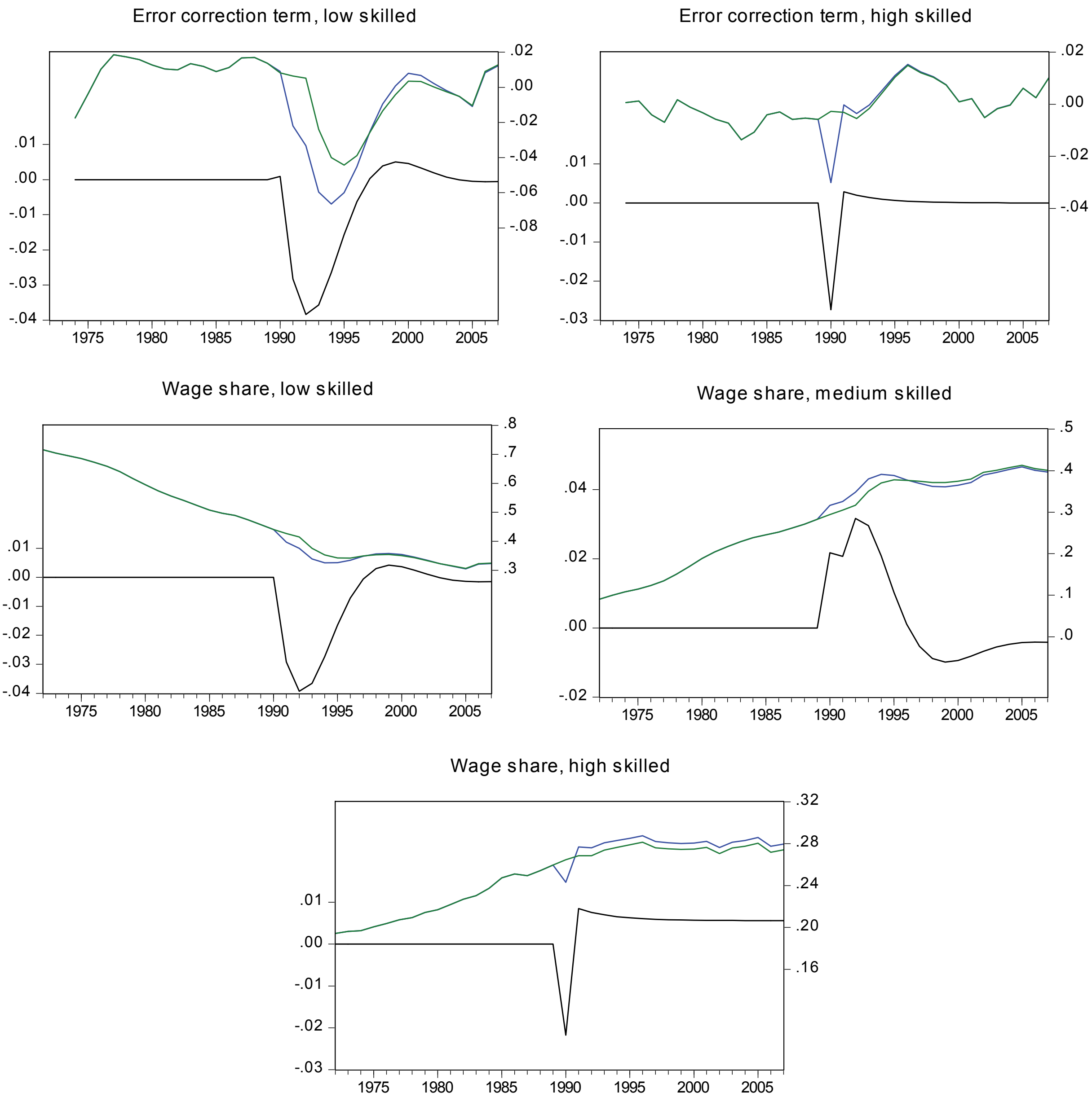


Figure E.1.2: Increased wage differentials in industry 45 (engineering products). Green line shows baseline, blue line alternative scenario and black line deviation (scenario from baseline). Left axis measures deviation in percentage points, right axis measures absolute value of variables.



E.2 Increased wage differentials, industry 85 (other private services)

As described in Section 4.3.

Figure E.2.1: Increased wage differentials in industry 85 (other private services). Green line shows baseline, blue line alternative scenario and black line per cent deviation (scenario from baseline). Left axis measures deviation in per cent, while right axis represents wage costs in kroner per hour, total labour costs in million kroner and employment in 1000 man hours, respectively.

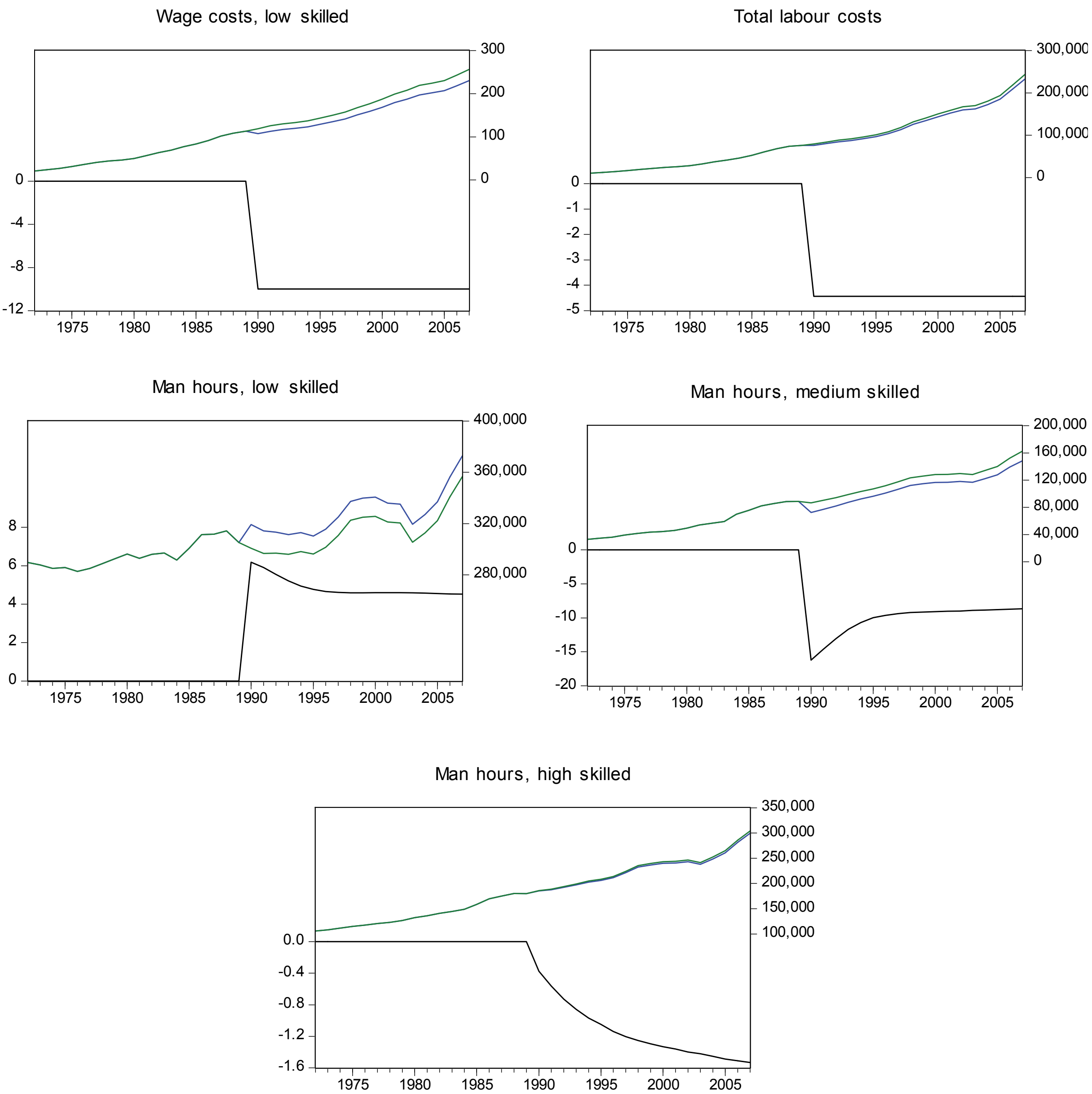
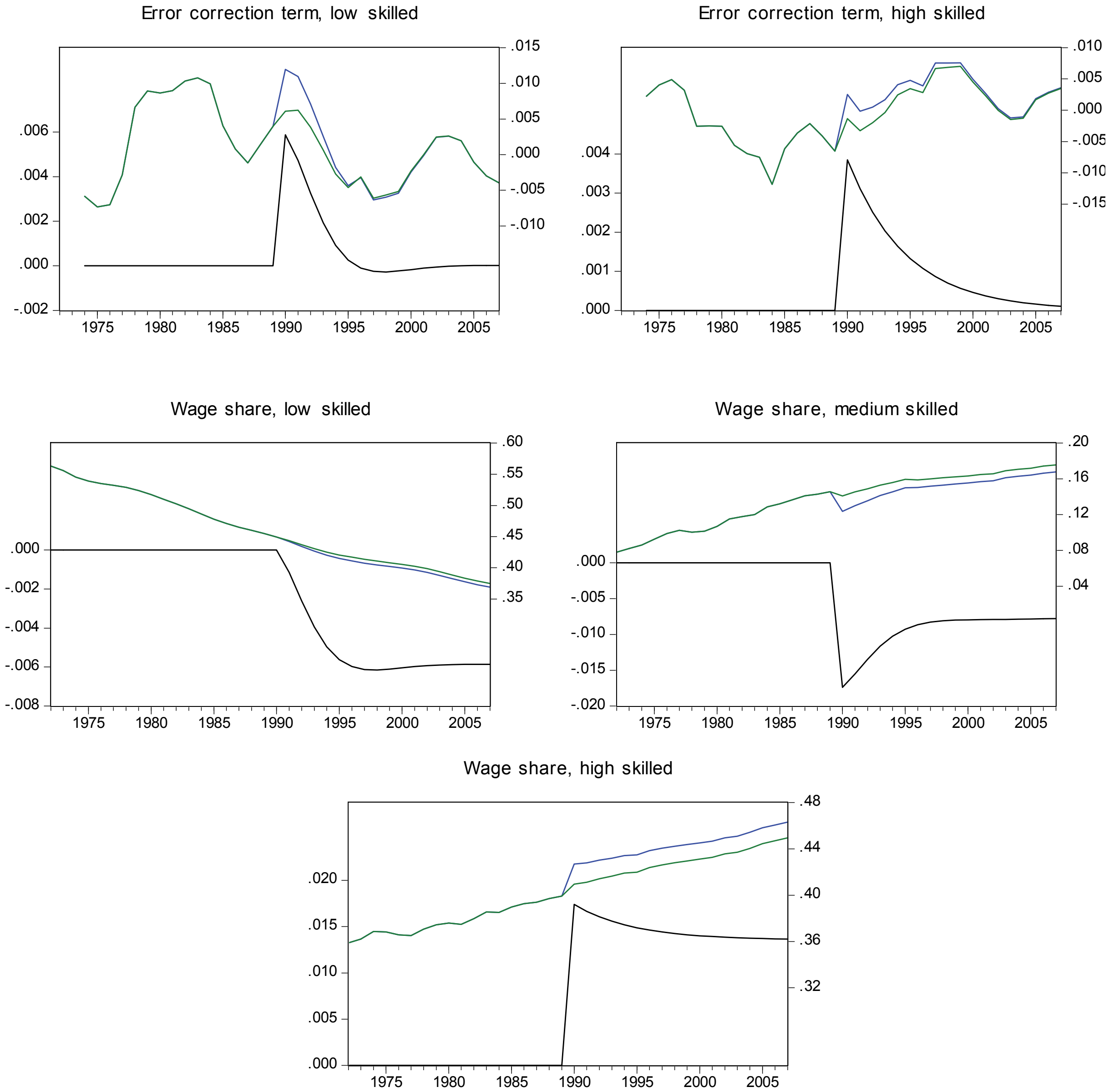


Figure E.2.2: Increased wage differentials in industry 85 (other private services). Green line shows baseline, blue line alternative scenario and black line deviation (scenario from baseline). Left axis measures deviation in percentage points, right axis measures absolute value of variables.



List of figures

2.1. Employment in 1000 man hours by skill category in the private business sector (less primary industries) ... 11
2.2. Wage per hour in kroner for the various skill groups. 1972-2007 ... 12
2.3. Hourly wage for low skilled and high skilled workers relative to medium skilled workers. 1972-2007 ... 12
2.4. The total cost by skill group relative to the total labour costs, 1972-2007 ... 13

B.1: Ecm-terms in industry 15 ... 30
B.2: Ecm-terms in industry 25 ... 30
B.3: Ecm-terms in industry 30 ... 31
B.4: Ecm-terms in industry 40 ... 31
B.5: Ecm-terms in industry 45 ... 32
B.6: Ecm-terms in industry 50 ... 32
B.7: Ecm-terms in industry 55 ... 33
B.8: Ecm-terms in industry 63 ... 33
B.9: Ecm-terms in industry 64 ... 34
B.10: Ecm-terms in industry 71 ... 34
B.11: Ecm-terms in industry 74 ... 35
B.12: Ecm-terms in industry 81 ... 35
B.13: Ecm-terms in industry 85 ... 36

E.1.1: Increased wage differentials. Green line shows baseline, blue line alternative scenario and black line per cent deviation (scenario from baseline). Left axis measures deviation in per cent, while right axis represents wage costs in kroner per hour, total labour costs in million kroner and employment in 1000 man hours, respectively ... 47
E.1.2: Increased wage differentials in industry 45 (engineering products). Green line shows baseline, blue line alternative scenario and black line deviation (scenario from baseline). Left axis measures deviation in percentage points, right axis measures absolute value of variables. ... 48
E.2.1: Increased wage differentials in industry 85 (other private services). Green line shows baseline, blue line alternative scenario and black line per cent deviation (scenario from baseline). Left axis measures deviation in per cent, while right axis represents wage costs in kroner per hour, total labour costs in million kroner and employment in 1000 man hours, respectively. ... 49
E.2.2: Increased wage differentials in industry 85 (other private services). Green line shows baseline, blue line alternative scenario and black line deviation (scenario from baseline). Left axis measures deviation in percentage points, right axis measures absolute value of variables. ... 50

List of tables

4.1. Own price elasticities for low skilled, medium skilled and high skilled labour in the unrestricted translog system (1972-2007) ... 17
4.2. Parameter estimates in the translog system of cost shares by industry. Standard errors in parentheses ... 18
4.3. Fitted cost shares and implied Allen elasticities of substitution calculated for the year 2005 ... 22
4.4. Implied own and cross price elasticities calculated for the year 2005: ... 22

A.1: Key to industries and employment shares (2005): ... 28

B.1: The Elliot-Rothenberg-Stock test statistic for ecm_H and ecm_L in the 13 industries ... 29

C.1: Industry 15, wage share for high skilled: ... 37
C.2: Industry 15, wage share for low skilled: ... 37
C.3: Industry 25, wage share for high skilled: ... 38
C.4: Industry 25, wage share for low skilled: ... 38
C.5: Industry 30, wage share for high skilled: ... 38
C.6: Industry 30, wage share for low skilled: ... 39
C.7: Industry 40, wage share for high skilled: ... 39
C.8: Industry 40, wage share for low skilled: ... 39
C.9: Industry 45, wage share for high skilled: ... 40
C.10: Industry 45, wage share for low skilled: ... 40
C.11: Industry 50, wage share for high skilled: ... 40
C.12: Industry 50, wage share for low skilled: ... 41
C.13: Industry 55, wage share for high skilled: ... 41
C.14: Industry 55, wage share for low skilled: ... 41
C.15: Industry 63, wage share for high skilled: ... 42
C.16: Industry 63, wage share for low skilled: ... 42
C.17: Industry 64, wage share for high skilled: ... 42
C.18: Industry 64, wage share for low skilled: ... 43
C.19: Industry 71, wage share for high skilled: ... 43
C.20: Industry 71, wage share for low skilled: ... 43
C.21: Industry 74, wage share for high skilled: ... 44
C.22: Industry 74, wage share for low skilled: ... 44
C.23: Industry 81, wage share for high skilled: ... 44
C.24: Industry 81, wage share for low skilled: ... 45
C.25: Industry 85, wage share for high skilled: ... 45
C.26: Industry 85, wage share for low skilled: ... 45

D.1: Residual misspecification tests for high skilled labour cost share equations ... 46
D.2: Residual misspecification tests for low skilled labour cost share equations ... 46

B

Returadresse:
Statistisk sentralbyrå
NO-2225 Kongsvinger

Statistisk sentralbyrå

41/2013

The Demand for Labour by Education

Avsender:
Statistisk sentralbyrå

Postadresse:
Postboks 8131 Dep
NO-0033 Oslo

Besøksadresse:
Kongens gate 6, Oslo
Oterveien 23, Kongsvinger

E-post: ssb@ssb.no
Internett: www.ssb.no
Telefon: 62 88 50 00

ISBN 978-82-537-8755-8 (trykt)
ISBN 978-82-537-8756-5 (elektronisk)
ISSN 0806-2056

ISBN 978-82-537-8755-8
9 788253 787558

Design: Siri Boquist

Statistisk sentralbyrå
Statistics Norway