DISCUSSION PAPER SERIES

IZA DP No. 664

Skill Upgrading and Rigid Relative Wages: The Case of Danish Manufacturing

Jan Rose Skaksen
Anders Sørensen

December 2002

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

Skill Upgrading and Rigid Relative Wages: The Case of Danish Manufacturing

Jan Rose Skaksen
CEBR, University of Southern Denmark
and IZA Bonn

Anders Sørensen
CEBR and SAIS, Johns Hopkins University

Discussion Paper No. 664
December 2002

IZA

P.O. Box 7240
D-53072 Bonn
Germany

Tel.: +49-228-3894-0
Fax: +49-228-3894-210
Email: iza@iza.org

IZA Discussion Paper No. 664
December 2002

ABSTRACT

Skill Upgrading and Rigid Relative Wages: The Case of Danish Manufacturing*

Relative wages have been remarkably rigid for the last two decades in Danish manufacturing despite large shifts in relative employment from unskilled labor towards skilled and educated labor. Assuming capital-skill complementarity and fixed relative wages as a consequence of labor market institutions, we argue that skill upgrading is more pronounced during downturns than upturns. This prediction is supported by a high positive and significant correlation between changes in relative employment of skilled labor and changes in the unemployment rate. Furthermore, we show that international outsourcing has played an important role in explaining the shift in relative labor demand.

JEL Classification: J31, J51, E32, F02, O39

Keywords: rigid relative wages, skill upgrading, business cycle, outsourcing, skill biased technological changes

Corresponding author:

Jan Rose Skaksen
Centre for Economic and Business Research
Langelinie Allé 17
2100 Copenhagen
Denmark
Tel.: +45 6550 2121
Fax: +45 6615 8790
E-mail: jrs@sam.sdu.dk

* The paper was presented at the IZA conference on "European Integration and Labor Market Performance", April 2002, and at the EPRU conference on "Danish and International Economic Policy", May 2002. We gratefully acknowledge comments from participants at the conferences, and from Nikolaj Malchow-Møller. We thank Bertel Schjerning for efficient research assistance. Jan Rose Skaksen gratefully acknowledges support from the Danish Social Science Research Council. The usual disclaimer applies.

1 Introduction

The deterioration of the relative wage for unskilled workers in the United States and the United Kingdom are often explained by large relative demand shifts towards skilled labor. Two potentially important driving forces for these shifts are globalization and skill biased technological changes (SBTC), see e.g. Feenstra and Hanson (2001). These forces have occurred simultaneously in most developed countries, see for example Berman, Bound, and Machin (1998).

Even though SBTC and globalization are general phenomena in the developed world, the relative wages for unskilled labor have been more stable in continental Europe. A possible explanation for this observation is that labor market institutions in the two regions are di¤erent. For instance Blau and Kahn (1996) and Acemoglu (2002) argue that the in‡uence on relative wages from trade unions may be important in continental Europe. When the institutional setting on the labor market implies that relative wages are constant, labor markets adjust through changing quantities, whereas labor markets adjust through changing prices under ‡exible relative wages.

The purpose of this paper is to study skill upgrading when the institutional setting implies that relative wages are rigid. By skill upgrading we mean increases in the relative employment of skilled and educated workers. Our point of departure is the Danish labor market where more than 75 percent of the work force is organized in trade unions (see e.g. Calmfors et al., 2001). It is shown that the relative wage between skilled and unskilled labor in manufacturing is virtually constant over the last two decades. Furthermore, the relative wage between educated and unskilled labor is broadly constant. This is the case even though immense skill upgrading has taken place. Moreover, we …nd that unskilled workers have su¤ered through reduced employment rates during the period under investigation, i.e. the labor market has adjusted through changing quantities. Based on these observations, we conclude that the institutional setting of the Danish labor market leads to rigid relative wages.[1]

[1] This conclusion is supported by Acemoglu (2002). An alternative explanation for the di¤erence in the development of relative wage in the two regions is that relative supply of skilled labor in continental Europe has kept up with the relative demand shift towards skilled labor. This hypothesis is tested and it is found that larger increases in the relative supply of skilled labor in European countries explain some of the di¤erence. However, for some countries - for instance Denmark - changes in relative supply of skilled labor do not explain stable relative wages of skilled workers.

With the above conclusion in mind, we set up a simple theoretical model to analyze relative labor demand when relative wages are …xed. An important feature of the model is capital-skill complementarity, which is supported by for example Krusell et al. (2000). Another important feature of the model is that we are able to distinguish between skill upgrading in the short run (i.e. over the business cycle) and skill upgrading in the long run. Our analysis illustrates that ongoing skill upgrading may be a result of SBTC or international outsourcing. Moreover, it is shown that skill upgrading is more pronounced during downturns than upturns. In the case with ‡exible relative wages the cyclical development of skill upgrading is less straightforward.

In the empirical section we analyze skill upgrading in Danish manufacturing. Motivated by the theoretical model, it is investigated to what extent an increasing unemployment rate leads to skill upgrading. Furthermore, we study explanations for ongoing increases in the relative demand for skilled and educated labor, and in particular to what extent these shifts can be assigned to international outsourcing and SBTC.

The main …nding is a high positive and signi…cant correlation between changes in relative employment of skilled labor and changes in the unemployment rate. This supports the prediction of the theoretical model, namely, that changes in the relative demand for skilled labor varies over the business cycle when relative wages are rigid. We also consider data for the US labor market to study an economy with ‡exible relative wages. In this case, the close relationship between skill upgrading and unemployment is not established. This business cycle e¤ect of skill upgrading under rigid relative wages has not to our knowledge been identi…ed in the literature.

In a formal regression analysis, we …nd that increasing relative demand for skilled labor is partly explained by international outsourcing.[2] More speci…cally, our results indicate that Danish industries outsource activities that use unskilled labor intensively, while headquarter activities that use educated labor intensively remain in Denmark.

[2] The applied panel data set covers 50 Danish manufacturing industries covering the period 1980-1998. We want to emphasize that our data on international outsourcing are not "constructed" data as those used by for instance Feenstra and Hanson for the US (see e.g. Feenstra and Hanson, 2001) as our measures builds on input-output tables for the import.

We identify one important difference between the cyclical effect on skill upgrading and the effect from outsourcing. While skill upgrading as a consequence of outsourcing takes place between unskilled and educated labor, the cyclical effect is characterized by replacement of unskilled with skilled labor in downturns. The former type of skill upgrading is consistent with the idea that industries outsource production that is intensive in unskilled labor. The latter type is consistent with the existence of capital-skill complementarity in the production of final goods.

The available data set does not permit estimation of the exact role played by SBTC for skill upgrading. A measure for SBTC is extremely difficult to provide. One candidate measure that is sometimes used in the literature is the R&D intensity, see e.g. Berman, Bound and Machin (1998) and Machin and Van Reenen (1998). However, the R&D intensity is not found to have a significant effect on the increasing relative demand for skilled labor. One explanation for this may be that R&D data only exist for a relatively short period, namely the period 1987-1998. Another candidate measure is the price of equipment capital, especially prices of ICT capital. However, we do not have suitable data for this variable either.

The paper is organized as follows. In section 2, we present a number of important indicators for the development in the Danish labor market. In section 3, a simple model is build in order to analyze labor market adjustment when relative wages are rigid. In section 4, the empirical analysis of skill upgrading in the Danish manufacturing sector is presented. Section 5 concludes.

2 The labor market

The natural starting point for this analysis is to investigate relative wage rates across skill groups. In Figure 1, we present the wages of skilled and educated labor relative to the wage of unskilled labor in the manufacturing sector.[3]

<Figure 1 around here>

[3] Unskilled labor contains persons with elementary school or vocational high school, skilled labor contains persons with vocational or short further education, and educated labor contains persons with a medium and long further education.

It is striking how uniform relative wages are over the period 1980-98.[4] This is, especially, pronounced for the relative wage of skilled labor that is virtually constant throughout the period. The relative wage of educated labor varies more, but develops differently from the US experience where relative wages for educated labor has increased since 1980, see e.g. Feenstra and Hanson (2001). Based on Figure 1, it seems reasonably to say that relative wages in Denmark have been roughly constant.

Even though relative wages are constant, skill upgrading has been pronounced during the period 1980-98. In Figure 2, the employment shares of unskilled, skilled and educated labor are presented.

<Figure 2 around here>

There has been ongoing skill upgrading with increasing employment shares of skilled and educated labor, whereas the employment share of unskilled labor has declined. The size of these changes are immense. For example the employment share for unskilled labor has decreased by almost 15 percent point over 18 years. Furthermore, the employment share of skilled labor has increased by 10 percent points and that of educated labor has almost doubled from 4.4 percent to 8.5 percent.

The combination of rigid relative wages and skill upgrading is different from the development in the US and the UK where falling relative wages of unskilled labor and skill upgrading have been predominant. Why has the relative wage for unskilled labor in Denmark been roughly constant? We can think of two main candidate reasons. First, relative wages could be constant because of the institutional setting of the labor market. Second, the increase in labor supply could have been relatively high in Denmark which have kept the relative wage down. If the former explanation is more relevant, labor markets adjust through changing quantities as opposed to changing prices.

To address the relevance of the two explanations we present two quantity measures for the labor market. These are unemployment and employment rates. If either of these indicators experience ongoing changes over the period under investigation, this suggests that labor markets adjust through quantity changes and that the institutional setting gives rise to rigid relative wages.

[4] It also seems to be the case that there is much less variation in the relative wages in our data period compared to previous periods, see Risager (1993).

In Figure 3 unemployment rates for unskilled, skilled and educated workers are presented.

<Figure 3 around here>

It is evident that the unemployment rate is lower, the higher the level of education. It is interesting to note that despite the ongoing tendency for skill upgrading, there has been no tendency for increasing relative unemployment for unskilled labor.[5] Consequently, Figure 3 does not support the hypothesis that the relative position of unskilled labor has worsened during the last two decades.

Figure 4 presents the difference in employment rates between skilled and unskilled labor as well as educated and unskilled labor. The employment rate is defined as employment in full-time equivalents as a share of the population in the group.[6]

<Figure 4 around here>

The employment rates of skilled labor and educated labor relative to unskilled labor display continuous increases. This illustrates that it has become increasingly difficult for unskilled labor to obtain employment compared to skilled and educated labor.[7] This in turn supports the hypothesis that labor market adjustment in Denmark takes place through quantity adjustments, which suggests that relative wages are rigid as a consequence of the institutional setting on the Danish labor market.[8]

[5] After 1994 the unemployment rates for unskilled and skilled labor seem to catch up on that of educated labor. It should be stressed that the possibility for retirement was extraordinarily good for this period, especially for unskilled labor.

[6] The fraction of unskilled persons that is employed exhibits a negative trend during the period 1980-98. The fraction was about 65 percent in 1980.

[7] Figure 4 is based on persons between the age of 25 and 54 to avoid effects from changing pension rules. The development illustrated in the figure is not a consequence of a changing age composition.

[8] In economies with flexible relative wages such as the US, the relative wage and relative supply of unskilled labor have both decreased. It follows that relative demand changes must have played a dominant role. In the Danish economy with constant relative wages, the relative employment rate and relative supply of unskilled labor have both decreased. It also follows that relative demand changes must have played a dominant role.

3 A simple theoretical model

In this section, we set up a simple theoretical model to study labor market effects of relative demand shifts under rigid relative wages.[9] Final output (Y) is produced using unskilled labor (L), skilled labor (S) and capital (K):

$$Y = \left[L^{\sigma} + (K^{\rho} + (aS)^{\rho})^{\sigma/\rho} \right]^{1/\sigma}, \quad \rho < \sigma < 1. \tag{1}$$

The elasticities of substitution between capital and skilled labor and between unskilled labor and the aggregate of capital and skilled labor equal $1/(1-\rho)$ and $1/(1-\sigma)$, respectively. An important assumption is capital-skill complementarity, i.e. $1/(1-\sigma) > 1/(1-\rho)$ or $\sigma > \rho$. a is an index of skilled labor augmenting technological change which is related to SBTC or international outsourcing (time subscripts are suppressed for simplicity). The production function could easily be reformulated to include parameters indexing the share of work activities allocated to the specific type of labor. This formulation is to a higher degree related to international outsourcing (see Feenstra and Hanson, 2001). Furthermore, productivity variables for unskilled labor and for capital could easily be introduced. In the rest of this section, we refer to a change in a as SBTC.

The focal point is relative inputs of the three production factors, implying that no assumptions concerning the final goods market are needed. Because implications for skill upgrading of business cycles is addressed below, we implicitly assume that Y depends on the level of demand for final goods. Finally, the price of capital is assumed to be exogenous and equal to r, which could be determined on the world capital market.

Motivated by the empirical evidence for Denmark the relative wage between unskilled and skilled labor is fixed to $\theta < 1$. This implies a non-competitive labor market in the sense that wage rates do not necessarily clear the markets for the two types of labor. The wage level is exogenously given (for instance determined by trade unions), implying that the wage rate for skilled labor equals w, whereas the wage rate for unskilled labor equals θw.

[9] In Fosgerau, Jensen and Sørensen (2000), it is shown that almost all skill upgrading is due to changes within industries. Hence, the underlying mechanism for the relative demand shift seems to be uniform across industries.

To study effects on skill upgrading from business cycles it is a requirement to distinguish the short run from the long run. In the following, we assume that the capital stock is fixed in the short run and flexible in the long run. Input of skilled and unskilled workers are fully flexible at all points in time. The assumptions defining the short run may seem restrictive. In order to obtain the qualitative results presented below, however, input of capital only need to be less flexible then the input of the two labor types. Moreover, it could be argued that skilled labor is less flexible than unskilled labor. However, input of unskilled labor varies more than input of skilled labor as presented below. This implies that our qualitative results are strengthen if skilled labor is less flexible than unskilled labor.

3.1 The long run

Cost minimization implies that the relative marginal product between any two production factors equals the relative price of the two production factors:

$$\frac{\partial Y/\partial K}{\partial Y/\partial S} = \frac{r}{w}, \tag{2}$$

$$\frac{\partial Y/\partial L}{\partial Y/\partial S} = \theta. \tag{3}$$

Capital input relative to effective skilled labor, aS, equals

$$\frac{K}{aS} = \left(\frac{ar}{w}\right)^{\frac{1}{\rho-1}}, \tag{4}$$

using (1) and (2). If the price of capital (r) decreases relative to the price on effective skilled labor (w/a), capital input increases relative to the input of effective skilled labor.

Relative employment of skilled labor is derived using (1), (3) and (4):

$$\frac{S}{L} = \theta^{\frac{1}{1-\sigma}} a^{\frac{\sigma}{1-\sigma}} \left[\left(\frac{ar}{w}\right)^{\frac{\rho}{\rho-1}} + 1\right]^{\frac{\sigma-\rho}{\rho(1-\sigma)}}. \tag{5}$$

An increase in the relative wage of unskilled labor, θ, increases the relative employment of skilled labor. There are two channels through which skill

upgrading occurs. First, a decrease in the price of capital relative to the cost of skilled labor increases skill upgrading:

$$\frac{\partial (S/L)}{\partial (r/w)} < 0. \tag{6}$$

The sign of (6) depends on the capital-skill complementarity feature, i.e. $\sigma > \rho$. The use of capital increases when the relative cost of capital falls. Because of the capital-skill complementarity, employment of skilled labor increases relative to that of unskilled labor. Second, SBTC measured by an increase in a also leads to skill upgrading

$$\frac{\partial (S/L)}{\partial a} > 0. \tag{7}$$

The latter result in (7) is general and does not rest on the assumption that $\sigma > \rho$.

3.2 The short run

According to the applied de…nition, the capital stock is …xed in the short run, $K = \overline{K}$. Cost minimization implies that (3) also holds in the short run because inputs of skilled and unskilled labor are fully ‡exible. However, the relative employment of skilled labor equals

$$\frac{S}{L} = \theta^{\frac{-1}{1+\sigma}} a^{\frac{\sigma}{1+\sigma}} \left(\frac{\overline{K}}{aS} \right)^{\rho} + 1 \Bigg)^{\frac{\sigma+\rho}{\rho(1+\sigma)}}. \tag{8}$$

When the economy is in a downturn, the representative …rm produces less than in the long run equilibrium. Using (8) it is easily veri…ed that inputs of both unskilled and skilled labor are reduced.[10] Similarly, …rms employ more of both inputs during upturns.

It is easy to see that

$$\frac{\partial (S/L)}{\partial S} < 0. \tag{9}$$

[10] In a downturn (Y decreases), it must be the case that either L and/or S decrease, but (8) implies that L increases (decreases) when S increases (decreases).

Consequently, there is skill upgrading (i.e. S/L increases) during downturns (i.e. S and L decrease), whereas there is skill downgrading (i.e. S/L decreases) during upturns. This business cycle e¤ect on the relative employment of skilled and unskilled labor arises because of capital-skill complementarity, i.e. $\sigma > \rho$. Since the capital stock is …xed in the short run, any change in the level of production is to a larger extent achieved through a change in the employment of unskilled labor than through a change in the employment of skilled labor.

To summarize, the long run version of the model illustrates that a decreasing price of capital, SBTC and international outsourcing give rise to skill upgrading. In the short run, skill upgrading are a¤ected by the business cycle: skill upgrading is pronounced during downturns, whereas it slows down during upturns. The business cycle e¤ect is generated by two characteristics: rigid relative wages and capital-skill complementarity. In a competitive labor market where wage rates are fully ‡exible, the relative employment of skilled and unskilled labor simply re‡ects the relative labor supply of skilled and unskilled labor. Hence, skill upgrading simply re‡ects the change in the relative supply of the two kinds of labor. In this case, the cyclical development of skill upgrading is less straightforward.

4 Empirical results

In this section we present empirical results for increasing relative demand of skilled labor in Danish manufacturing. First, the relationship between skill upgrading and increasing unemployment is studied. Second, ongoing e¤ects on relative demand for skilled and educated labor are investigated.

4.1 Skill upgrading and unemployment

In the theoretical model, the hypothesis that skill upgrading is more pronounced during downturns was formulated. This result was derived assuming a …xed relative wage. If relative wages were ‡exible, the cyclical behavior of skill upgrading is less straightforward and a change in the relative wage may tend to correct the asymmetric employment development for the two types of labor. One simple way to study the di¤erences of distinct labor market institutions is to compare data for Denmark and data for the US. We expect that skill upgrading is more sensitive to changes in the unemployment rate in Denmark than in the US.

Figure 5 presents the correlation between the change in the (log) unemployment rate and the change in the (log) employment of skilled and educated labor relative to unskilled labor.

<Figure 5 around here>

The result is remarkably clear. The relationship between unemployment and skill upgrading is clearly signi…cant for the Danish labor market with a correlation coe¢cient of 0.83 that is signi…cant at the one percent level. This is not the case in the US where the coe¢cient is insigni…cant and equal to 0.19.[11]

4.2 Ongoing skill upgrading

The fact that skill upgrading varies over the business cycle does not explain the underlying causes for skill upgrading. In other words, it does not elucidate mechanisms that drive ongoing changes in relative labor demand away from unskilled labor and towards skilled and educated labor. As discussed above, two candidates explaining these changes are international outsourcing and SBTC. Below, the importance of these candidates for skill upgrading in Denmark is investigated.

We draw on several data sources. The labor market data are drawn from the IDA data base from Statistics Denmark (2000). The data on international outsourcing and production values are based on input-output tables, Statistics Denmark (2002). Combining the labor market data and the input-output data results in a panel data set for 50 industries covering the period 1981-98.[12] The R&D data originate from the ANBERD database, OECD (2001). In this data set the applied industry structure is ISIC Revision 3, which is compatible with the industry classi…cation used in the databases from Statistics Denmark when using a higher level of aggregation. This implies that the number of manufacturing industries is reduced from 50 to 15.

[11] The data period used for Denmark and the US is not the same. For the overlapping period, 1981-1992, the correlation coe¢cient for Denmark equals 0.72, and it is signi…cant at the one percent level. For the US the correlation coe¢cient equals -0.01 and it is insigni…cant.

[12] The manufacturing sector is classi…ed in 55 manufacturing industries. 5 industries are excluded because IDA data only permit that employment data is classi…ed after 50 industries until 1993.

Furthermore, the R&D data grouped after the ISIC Revision 3 only exist from 1987-98.

It is an open question how international outsourcing should be measured. One candidate measure is imported intermediate goods. Obviously, it is not all imported intermediate goods that should be classi…ed as international outsourcing, and therefore we use two di¤erent measures. We use a "narrow measure" ($out1_i$) and a "broad measure" ($out2_i$). $out1_i$ is de…ned as import of intermediate goods from the same industry abroad as the importing industry relative to the production value of the importing industry, whereas $out2_i$ is de…ned as the import of manufacturing inputs to industry i relative to the production value in industry i. Using weighted averages an ongoing tendency for increasing international outsourcing is documented.[13] The measures have increased from 3.6 percent in 1980 to 5.6 percent in 1998 and from 15.4 percent in 1980 to 20.2 percent in 1998, respectively.

Besides measures of international outsourcing, we want to include an indicator capturing technological changes. The purpose is to assess whether SBTC are present. Such a measure is, however, extremely di¢cult to procure. One candidate that is sometimes used in the literature is the R&D intensity de…ned as the ratio of the ‡ow of R&D expenditures to value added, see for example Berman, Bound, and Machin (1998) and Machin and Van Reenen (1998). For industry i, this variable is referred to as $R\&D_i/Y_i$. The measure applying for the total manufacturing has increased from 2 percent in 1980 to 5.6 percent in 1998. Unfortunately, industry data is only accessible for the period 1987-98.

In summary, there has been tendencies for skill upgrading, increasing international outsourcing as well as increasing R&D intensity. It is possible that international outsourcing and SBTC have both been driving forces for the increasing relative demand for skilled and educated labor. In the following, this hypothesis will be tested.

Our point of departure is (5) which shows that an increase in the relative productivity of skilled labor gives rise to skill upgrading. Now, an increase in industry speci…c R&D intensity or international outsourcing is expected to

[13] $out1_i = m_i^i/pv_i$, where m_i^i is the import of intermediate goods from industry i to industry i. pv_i is the production value in industry i. $out2_i = \frac{m_i}{pv_i}$, where m_i is the import of manufactured intermediate goods to industry i. The weighted averages are determined using pv_i/pv as weights, where pv is the aggregated production value of the 50 manufacturing industries.

result in skill upgrading of industry i. To test this hypothesis, the following equation is used for estimation purposes:

$$d\left(\frac{w_{e,i,t}L_{e,i,t}}{w_{i,t}L_{i,t}}\right) = \alpha_0 + \alpha_1 d(out1_{i,t}) + \alpha_2 d(out2_{i,t} - out1_{i,t}) + \alpha_3 d(R\&D_{i,t}/Y_{i,t}) + \alpha_4 d\log(pv_{i,t}) + \delta_{1981}D_{1981} + ... + \delta_{1997}D_{1997} + \varepsilon_{i,t} \quad (10)$$

where $L_{e,i,t}$ ($w_{e,i,t}$) denotes employment (the wage rate) of educational group e (unskilled, skilled and educated labor) in industry i at time t. $w_{i,t}L_{i,t}$ is the total wage sum in industry i, i.e. $w_{i,t}L_{i,t} = \sum_e w_{e,i,t}L_{e,i,t}$. As there is an increasing trend in all variables, first differences are applied. Hence, the left hand side measures the change in the share of the total wage sum which goes to educational group e in industry i in period t (i.e. the change from period $t-1$ to t). In order to diminish problems from aggregating labor with different productivity (and to follow what has become standard in the literature), the share of the wage sum is used as dependent variable instead of the employment shares of each educational group.[14] We include both measures of international outsourcing in the estimations, but since $out1_{i,t}$ is included in $out2_{i,t}$, the former is subtracted from the latter.

To control for differences between contracting and expanding industries, we have included the change in the (log) real production value ($pv_{i,t}$), and to control for common time specific differences we apply a full set of time dummies. Finally, ε is an error term.

The regression equation (10) is estimated using panel data as described above, and it is estimated using common intercepts over industries and Pooled Least Square. We do not apply feasible GLS using estimated cross section residuals as weights to control for cross section heteroscedasticity, because the cross-section dimension of the data set is large compared to the time dimension.[15]

In the following, we do not report any results including $R\&D_i/Y_i$ because this variable does not enter significantly. We expect this to be due to the short time dimension for which the variable is included, 1987-98. Machin and Van Reenen (1998) establish a significant positive relationship between

[14] The expression in (5) can easily be rewritten in wage shares by dividing by θ on each side of the equation.

[15] If we applied feasible GLS, the 50 estimated cross-section variances would be based on a time dimension of 18 years only.

changing employment shares and R&D intensities for Danish manufacturing for an earlier time period using an older version of the ANBERD database that is based on the obsolete industry classi…cation, ISIC Revision 2. By excluding $R\&D_i/Y_i$ from our regressions, we have data for 50 industries covering the period 1980-98.

The estimation results are presented in Table 1.

<Table 1 around here>

In Table 1, the …rst two columns refer to estimations where the left hand side variable is the change in the share of the wage sum going to unskilled labor. The next (last) two columns refer to the estimations where the left hand side variable is the change in the share of the wage sum going to skilled (educated) labor. Panel a presents the results where all variables and a full set of time dummies are included in the regression. We notice that international outsourcing tends to decrease the relative demand for unskilled labor and to increase the relative demand for educated labor. With respect to the intermediate group of skilled labor, we do not …nd a signi…cant e¤ect from international outsourcing on the demand for this kind of labor.[16]

As argued above, we expect that skill upgrading varies over the business cycle. Therefore, in Panel b we include a dummy variable indicating whether a speci…c year is a downturn year.[17] This variable is equal to one if production value growth in total manufacturing is below the average growth rate for the period 1981-98 and equal to zero otherwise. In order to be able to interpret the di¤erence between downturn years and upturn years, we do not include other time dummies in these regressions. Again, we …nd that international outsourcing tends to decrease the relative demand for unskilled labor and increase the relative demand for educated labor. Moreover, the estimated coe¢cients to international outsourcing are more or less identical to those estimated in Panel a. It is seen that falling relative demand for

[16] An alternative explanation for the cyclical e¤ect on skill upgrading is labor hoarding due to hiring and …ring costs. However, the estimated time dummies found in the regression leading to Table 1, Panel a (the dummies are not reported in the table) do not support that there is a signi…cant di¤erence between skill upgrading in the beginning of a downturn and at the end of a downturn.

[17] An "ideal" measure would be the di¤erence between actual output and potential output. However, no data exist on the latter measure.

unskilled labor is more pronounced during downturns than upturns. The increase in demand for skilled labor is much more pronounced in downturn years than in upturn years, nearly six times higher in downturns. We do not …nd any signi…cant di¤erence between downturns and upturns for educated labor. In Table 1, Panel c, the estimated coe¢cients are reported when only signi…cant variables are included. There is basically no changes in the estimated coe¢cients.

One important di¤erence between the downturn e¤ect on skill upgrading and skill upgrading due to outsourcing is evident from Table 1. While skill upgrading as a consequence of outsourcing takes place between unskilled labor and educated labor, the downturn e¤ect on skill upgrading is characterized by replacement of unskilled labor with skilled labor. The former type of skill upgrading is consistent with the idea that industries outsource production intensive in unskilled labor to foreign countries while headquarter activities are retained in Denmark. The latter type of skill upgrading is consistent with the existence of capital-skill complementarity in the production of …nal goods. This is in turn consistent with the decreasing price on capital explaining skill upgrading.

Equation (10) is also estimated based on average changes over longer time periods to investigate whether the results are robust to using shorter and longer changes. This type of analysis is often performed in the literature, see for example Machin and Van Reenen (1998) where the authors apply one- and four-year changes. The results established in Table 1 suggest that we should be careful when performing the analysis for longer changes due to the di¤erence in skill upgrading over the business cycle. Therefore, downturn periods and upturn periods are separated and a dummy variable is included that indicates whether a period is a downturn or an upturn. Consequently, data are divided into four periods: 1981-83 (downturn), 1984-86 (upturn), 1987-93 (downturn) and 1994-98 (upturn). Table 2 presents the estimation results based on average changes. The qualitative results are similar to those presented in Table 1. The only exception is for outsourcing that no longer has a signi…cant e¤ect on the relative demand for unskilled labor.

5 Conclusion

Relative wages for skilled labor have increased during the last two decades in the US and the UK. In most continental European countries, relative wages

have been more stable. In this paper the case of Denmark is considered; a country where relative wages have been remarkably rigid for the past two decades. We argue that the rigid relative wage is a consequence of the institutional setting on the Danish labor market.

In a simple theoretical model, we show that ongoing skill upgrading may be a consequence of skill biased technological change and international outsourcing. Moreover, skill upgrading should be more pronounced during downturns than during upturns. The latter result is a consequence of capital-skill complementarity and rigid relative wages.

In the empirical analysis, a signi…cant positive correlation between changes in the unemployment rate and changes in the relative employment of skilled and educated labor is found (i.e. skill upgrading). This correlation is not established for the US labor market. This is in accordance with the theory as the US labor market is characterized by ‡exible relative wages and changes in relative wages are expected to counteract changes in relative labor demand.

We analyze to what degree skill upgrading is explained by international outsourcing and skill biased technological change. In the empirical analysis only international outsourcing is documented to have a signi…cant e¤ect on skill upgrading, and Danish industries tend to outsource activities which are intensive in the use of unskilled labor. A signi…cant relationship between the R&D intensity - the applied indicator for SBTC - and skill upgrading is not established. We interpret this as a result of data shortage rather than absence of SBTC in Danish manufacturing.

References

[1] Acemoglu, D., 2002, Cross-Country Inequality Trends, NBER working paper, No. 8832.

[2] Autor, D.H., L.F. Katz and A.B. Krueger (1998), 'Computing Inequality: Have Computers Changed the Labor Market ?', Quarterly Journal of Economics, 113 (4), 1169-1213

[3] Berman, E., J. Bound and Z. Griliches, 1994, Changes in the Demand for Skilled Labor within U.S. Manufacturing: Evidence from the Annual Survey of Manufactures, Quarterly Journal of Economics, 104, 367-398.

[4] Berman, E., J. Bound, and S. Machin, 1998, 'Implications of Skill-Biased Technical Changes: International Evidence', Quarterly Journal of Economics, 1245-1280.

[5] Blau, F.D. and L.M. Kahn, 1996, International Di¤erences in Male Wage Inequality: Institutions versus Market Forces, Journal of Political Economy, 104, 791-837.

[6] Calmfors, L.A., A. Booth, M. Burda, D. Checci, R. Naylor and J. Visser (2001): The Future of Collective Bargaining in Europe. In Boeri, T., A. Brugiavini and L. Calmfors (eds.): The Role of Unions in the Twenty-First Century. Oxford University Press, Oxford.

[7] Feenstra, R.C. and G.D. Hanson, 2001, Global Production Sharing and Rising Inequality: A Survey of Trade and Wages, NBER working paper, No. 8372.

[8] Fosgerau, M., S.E. Hougaard Jensen, and A. Sørensen (2000), 'Relative Demand Shifts for Educated Labour', CEBR Discussion Paper 2000-11

[9] Krusell, P., L.E. Ohanian, J.-V. Ríos-Rull, and G.L. Violante (2000), 'Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis', Econometrica, 1029-1054

[10] Machin, S. and J. Van Reenen, 1998, 'Technology and Changes in Skill Structure: Evidence from Seven OECD Countries', Quarterly Journal of Economics, 1215-1244.

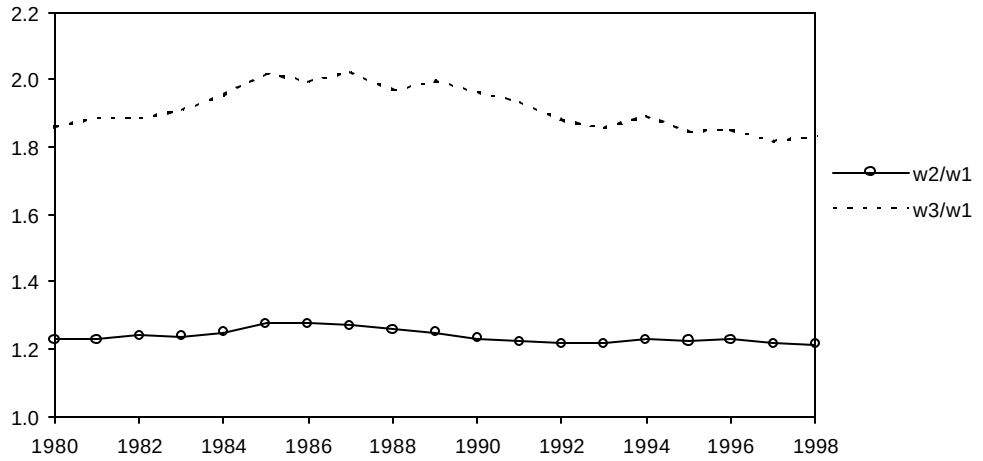
[11] OECD (2001), 'ANBERD/ANRSE Research and Development in Industry', Paris.

[12] Risager, O. (1993), Labour Substitution in Denmark, Oxford Bulletin of Economics and Statistics, 55, 123-135.

[13] Statistics Denmark (2000), 'IDA Database' Copenhagen

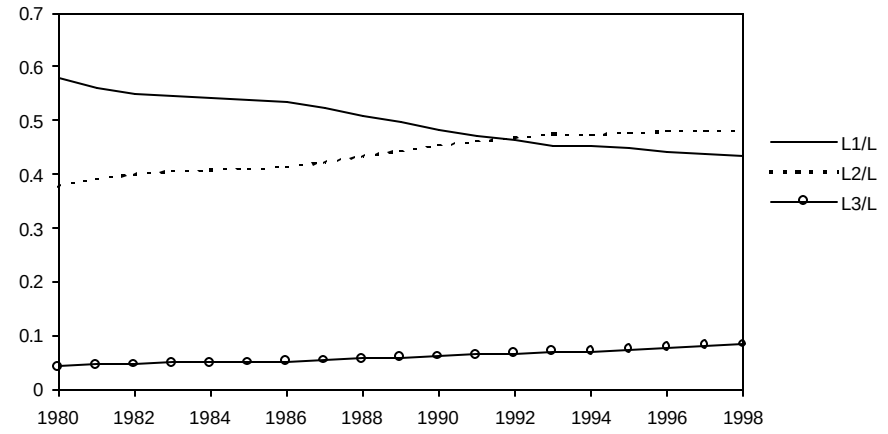
[14] Statistics Denmark (2002), 'Input-Output Tables', Copenhagen

Figure 1: Relative Wages of Skilled and Educated Workers, 1980-1998



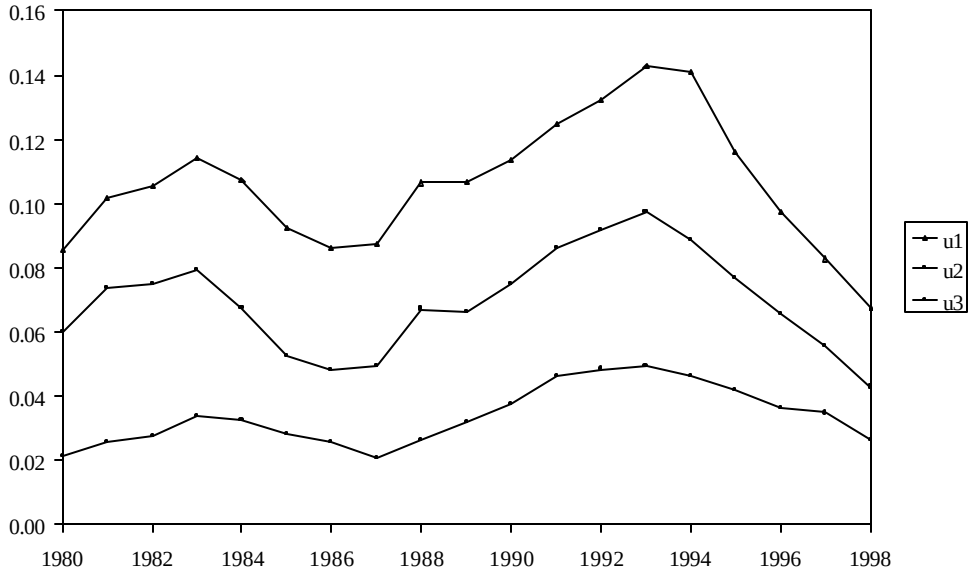
Notes: we/w1: Wage of workers in educational group *e* relative to average wage of unskilled workers (Full-time equivalents), 2: skilled labor, 3: educated labor.
Source: IDA, Statistics Denmark (2000)

Figure 2: Relative Educational Shares in Employment, 1980-1998



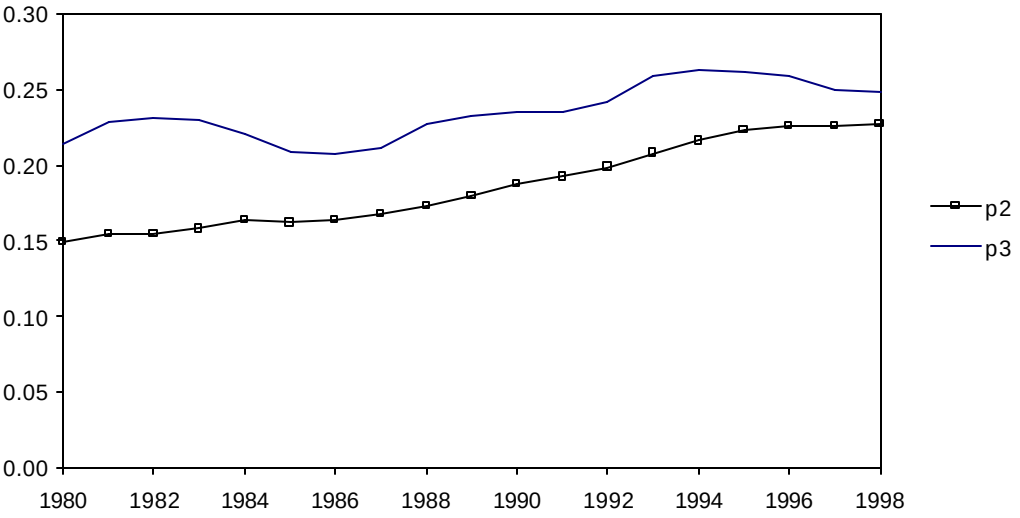
Notes: Le/L: Employment in educational group *e* relative to total employment (Full-time equivalents.), 1: unskilled labor, 2: skilled labor, 3: educated labor.
Source: IDA, Statistics Denmark (2000)

Figure 3: Unemployment Rates for Educational Groups, 1980-1998



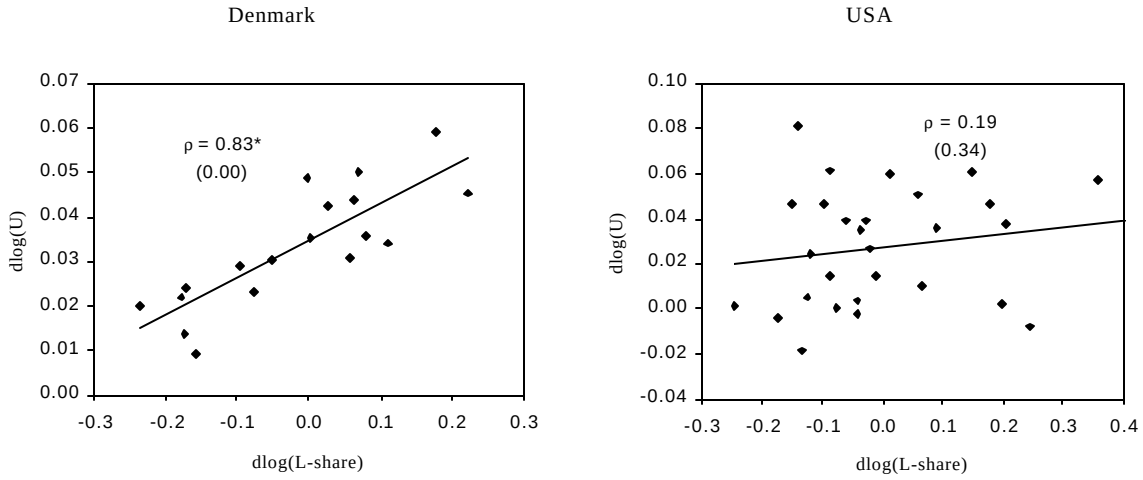
Notes: u*e*: unemployment rate in educational group *e*, 1: unskilled labor, 2: skilled labor, 3: educated labor.
Source: IDA, Statistics Denmark (2000)

Figure 4: Differences in Employment Rates, 1980-1998



Notes: The employment rate is defined as employment in full-time equivalents as a share of the population. pe: difference in employment rates between education category *e* and unskilled labor. 2: skilled labor, 3: educated labor. The population covers persons aged 25-54.
Source: IDA, Statistics Denmark (2000)

Figure 5: Changes in Unemployment Rates versus Changes in the Labor Input Ratio.



Notes: L-share (Labor input ratio): Skilled and educated workers vs. unskilled workers. Period under investigation: 1963-92 for USA and 1980-98 for Denmark. ρ presents the pairwise correlation coefficient between growth in the unemployment rate and growth in the labor input ratio. *p*-values testing the null of independence are in parentheses (an asterisk denotes significance at 0.01 level or better)
Source: IDA, Statistics Denmark (2000), Krusell, Ohanian, Ríos-Rull, and Violante (2000), and www.bls.gov, Bureau of Labor Statistics.

Table 1: Regressions for Wage Shares of Unskilled, Skilled, and Educated Labor, Annual Changes, 1981-98

Panel a	*d(W1*L1/sum(Wi*Li))*		*d(W2*L2/sum(Wi*Li))*		*d(W3*L3/sum(Wi*Li))*	
	Coefficient	*t-Statistic*	*Coefficient*	*t-Statistic*	*Coefficient*	*t-Statistic*
Constant	-0.0024	-0.99	-0.0034	-1.51	0.0058 **	4.24
d(out1)	-0.0640 *	-2.42	-0.0158	-0.55	0.0798 **	3.18
d(out2-out1)	-0.0266	-0.98	0.0276	1.07	-0.0010	-0.03
dlog(pv)	-0.0019	-0.31	0.0048	0.80	-0.0029	-0.45
R-squared	0.0815		0.1005		0.0338	
Adjusted R-squared	0.0606		0.0800		0.0118	
Durbin-Watson stat	2.0861		2.1082		2.2911	
Total panel (balanced) observations:	900		900		900	

Panel b	*d(W1*L1/sum(Wi*Li))*		*d(W2*L2/sum(Wi*Li))*		*d(W3*L3/sum(Wi*Li))*	
	Coefficient	*t-Statistic*	*Coefficient*	*t-Statistic*	*Coefficient*	*t-Statistic*
Constant	-0.0043 **	-5.92	0.0013 *	2.05	0.0030 **	4.39
d(out1)	-0.0646 *	-2.50	-0.0158	-0.58	0.0805 **	3.46
d(out2-out1)	-0.0210	-0.76	0.0209	0.79	0.0001	0.00
dlog(pv)	-0.0016	-0.27	0.0044	0.74	-0.0028	-0.43
downturn	-0.0065 **	-6.94	0.0061 **	7.47	0.0004	0.50
R-squared	0.0570		0.0588		0.0172	
Adjusted R-squared	0.0528		0.0545		0.0128	
Durbin-Watson stat	2.0650		2.0610		2.3005	
Total panel (balanced) observations:	900		900		900	

Panel c	*d(W1*L1/sum(Wi*Li))*		*d(W2*L2/sum(Wi*Li))*		*d(W3*L3/sum(Wi*Li))*	
	Coefficient	*t-Statistic*	*Coefficient*	*t-Statistic*	*Coefficient*	*t-Statistic*
Constant	-0.0044 **	-6.44	0.0015 *	2.46	0.0031 **	8.70
d(out1)	-0.0595 *	-2.35			0.0802 **	3.36
d(out2-out1)						
dlog(pv)						
downturn	-0.0064 **	-7.04	0.0060 **	7.33		
R-squared	0.0561		0.0558		0.0160	
Adjusted R-squared	0.0540		0.0547		0.0149	
Durbin-Watson stat	2.0702		2.0659		2.3030	
Total panel (balanced) observations:	900		900		900	

Notes: Dependent variable: ($w_{e,i,t}L_{e,i,t}/\Sigma w_{e,i,t}L_{i,t}$) refers to relative wage shares for educational group *e*, industry *i* at time *t*. Explanatory variables: ($out1_{i,t}$) refers to imports of intermediate goods from industry *i* to industry *i* relative to production value. ($out2_{i,t}$ -$out1_{i,t}$) refers to imports of intermediate goods from manufacturing industries outside industry *i* to industry *i* relative to production value. $\log(pv_{i,t})$ refers to log of production value. d refers to annual changes. Downturn is a dummy variable equal to one if production value growth in manufacturing is below average and equal to zero otherwise. Full set of time dummies is included in Panel a. t-statistics are White Heteroscedasticity consistent. ** Significant at 1 pct. level and * significant at 10 pct. level.

Source: Input-Output tables and IDA, Statistics Denmark (2000)

Table 2: Regressions for Wage Shares of Unskilled, Skilled, and Educated Labor, Longer Changes, 1981-98

Panel a	*d(W1*L1/sum(Wi*Li))*		*d(W2*L2/sum(Wi*Li))*		*d(W3*L3/sum(Wi*Li))*	
	Coefficient	*t-Statistic*	*Coefficient*	*t-Statistic*	*Coefficient*	*t-Statistic*
Constant	-0.0029 **	-4.36	0.0002	0.32	0.0026 **	3.61
d(out1)	-0.1048	-1.17	-0.0146	-0.18	0.1194	1.59
d(out2-out1)	0.0412	0.57	-0.0084	-0.23	-0.0329	-0.43
dlog(pv)	0.0004	0.04	-0.0098	-1.37	0.0095	0.88
R-squared	0.1740		0.2097		0.0512	
Adjusted R-squared	0.1484		0.1851		0.0217	
Durbin-Watson stat	1.9417		1.9781		1.7307	
Total panel (balanced) observations:	200		200		200	

Panel b	*d(W1*L1/sum(Wi*Li))*		*d(W2*L2/sum(Wi*Li))*		*d(W3*L3/sum(Wi*Li))*	
	Coefficient	*t-Statistic*	*Coefficient*	*t-Statistic*	*Coefficient*	*t-Statistic*
Constant	-0.0035 **	-6.76	0.0015 **	3.09	0.0021 **	5.37
d(out1)	-0.0848	-0.96	-0.0581	-0.71	0.1430 *	2.22
d(out2-out1)	0.0395	0.56	-0.0118	-0.32	-0.0277	-0.35
dlog(pv)	-0.0010	-0.09	-0.0068	-0.93	0.0078	0.73
downturn	-0.0044 **	-5.99	0.0038 **	6.15	0.0005	0.89
R-squared	0.1651		0.1756		0.0422	
Adjusted R-squared	0.1480		0.1587		0.0226	
Durbin-Watson stat	1.9436		1.9639		1.7141	
Total panel (balanced) observations:	200		200		200	

Panel c	*d(W1*L1/sum(Wi*Li))*		*d(W2*L2/sum(Wi*Li))*		*d(W3*L3/sum(Wi*Li))*	
	Coefficient	*t-Statistic*	*Coefficient*	*t-Statistic*	*Coefficient*	*t-Statistic*
Constant	-0.0036 **	-7.64	0.0013 **	2.90	0.0024 **	7.83
d(out1)					0.1521 **	2.71
d(out2-out1)						
dlog(pv)						
downturn	-0.0043 **	-6.02	0.0039 **	6.34		
R-squared	0.1546		0.1689		0.0306	
Adjusted R-squared	0.1503		0.1647		0.0257	
Durbin-Watson stat	1.9025		1.9159		1.6479	
Total panel (balanced) observations:	200		200		200	

Notes: Dependent variable: ($w_{e,i,t}L_{e,i,t}/\Sigma w_{e,i,t}L_{i,t}$) refers to relative wage shares for educational group *e*, industry *i* at time *t*. Explanatory variables: ($out1_{i,t}$) refers to imports of intermediate goods from industry *i* to industry *i* relative to production value. ($out2_{i,t}$ -$out1_{i,t}$) refers to imports of intermediate goods from manufacturing industries outside industry *i* to industry *i* relative to production value. log($pv_{i,t}$) refers to log of production value. d refers to longer changes. Downturn is a dummy variable equal to one if production value growth in manufacturing is below average and equal to zero otherwise. Longer changes are based on four time periods (1981-83, 1984-86, 1987-93, and 1994-98). Full set of time dummies is included in Panel a. t-statistics are White Heteroscedasticity consistent. ** Significant at 1 pct. level and * significant at 10 pct. level.

Source: Input-Output tables and IDA, Statistics Denmark (2000)

IZA Discussion Papers

No.	Author(s)	Title	Area	Date
648	C. Schnabel T. Schank J. Wagner	Works Councils - Sand or Grease in the Operation of German Firms?	3	11/02
649	J. van Ours J. Veenman	From Parent to Child: Early Labor Market Experiences of Second-Generation Immigrants in the Netherlands	1	11/02
650	H. Battu P. J. Sloane	Overeducation and Ethnic Minorities in Britain	2	11/02
651	E. Schlicht	Social Evolution, Corporate Culture, and Exploitation	3	11/02
652	E. Plug	How Do Parents Raise the Educational Attainment of Future Generations?	5	11/02
653	W. Groot E. Plug H. Maassen van den Brink	Money for Health: The Compensating Variation of Cardiovascular Diseases	6	11/02
654	C. Ruhm U. G. Gerdtham	Deaths Rise in Good Economic Times: Evidence From the OECD	2	11/02
655	W. Arulampalam R. A. Naylor J. P. Smith	Effects of In-Class Variation and Student Rank on the Probability of Withdrawal: Cross-Section and Time-Series Analysis for UK University Students	2	11/02
656	T. Beissinger O. Büsse	The Impact of the Unemployment Benefit System on International Spillover Effects	2	11/02
657	A. Kugler J. F. Jimeno V. Hernanz	Employment Consequences of Restrictive Permanent Contracts: Evidence from Spanish Labor Market Reforms	2	11/02
658	G. Brunello R. Winter-Ebmer	Why Do Students Expect to Stay Longer in College? Evidence from Europe	5	12/02
659	D. Byrne E. Strobl	Defining Unemployment in Developing Countries: Evidence from Trinidad and Tobago	4	12/02
660	E. Strobl R. Thornton	Do Large Employers Pay More in Developing Countries? The Case of Five African Countries	4	12/02
661	E. Strobl F. Walsh	Efficiency Wages and Effort: Are Hard Jobs Better?	3	12/02
662	E. Strobl F. Walsh	Getting It Right: Employment Subsidy or Minimum Wage?	3	12/02
663	A. B. Krueger P. Zhu	Another Look at the New York City School Voucher Experiment	6	12/02
664	J. R. Skaksen A. Sørensen	Skill Upgrading and Rigid Relative Wages: The Case of Danish Manufacturing	2	12/02