RELATIVE DEMAND FOR SKILLS IN SWEDISH MANUFACTURING: TECHNOLOGY OR TRADE?

By

Pär Hansson

Trade Union Institute for Economic Research (FIEF)

February 2000

Abstract

The rate of change in the share of skilled labor has increased steadily over the past 35 years in Swedish manufacturing. A closer inspection of the period after 1970 indicates that while relative supply changes of skilled labor seem to have been the main driving force behind the growing skill shares in manufacturing industries over the period 1970-85, an acceleration in the relative demand for skills appears to have propelled higher skill shares during the late 1980s and in the beginning of the 1990s. Consistent with such a development is the finding of an increasing degree of complementarity between knowledge capital and skilled labor and that Swedish manufacturing firms, in recent years, have invested heavily in R&D. There is also some support for the belief that intensified competition from the South has increased the relative demand for skilled labor. However, the impact appears to be small and essentially driven by the textile industry.

JEL classification: F14**,** J31**,** O33
Keywords: Skill upgrading, knowledge capital, import competition, outsourcing

Financial support from the Swedish Council for Research in the Humanities and Social Sciences and the Swedish Council for Work Life Research is gratefully acknowledged. I have benefited from comments and suggestions from Linda Andersson, Lars Lundberg, Erik Mellander, Eva Oscarsson, Johnny Zetterberg, two anonymous referees and participants at the conference on Trade and Labor Market Adjustment in Nottingham.
Correspondence should be addressed to Pär Hansson, FIEF, Wallingatan 38 4 tr, SE-111 24 Stockholm, Sweden; e-mail: p.hansson@fief.se

1. Introduction

A striking feature in most OECD countries is a sharply growing share of skilled labor in the labor force. A clear result from several decompositions of the changes in skill shares (shift-share analyses) in various countries[1] is that the bulk of the increase is driven by rapid within-industry changes in skill utilization rather than between-industry employment shifts. This precludes explanations involving shifts in production from less-skill intensive industries to more-skill intensive industries as the main causes of the significant skill upgrading.

Two factors put forward, consistent with within-industry increases in skill shares, are skilled-biased technological change and increased globalization pressure. Skilled-biased technological change means technical progress that reduces the need for unskilled labor. The prime suspect for widespread recent technological changes that could have led to drastic changes in the relative demand for skills is the diffusion of computers and related technologies. Another factor that may have accelerated technological changes is the larger R&D expenditure we observe in many OECD countries.

Increased globalization pressure may affect the relative demand for skills within industries through increased competition from the South. We will show that industries, even if they are defined on the lowest level of industry aggregation, are by no means composed of activities with similar skill shares. Increased exposure to competition from the South may then lead to switches from domestic low-skill producers to foreign suppliers in countries abundantly endowed with unskilled labor. Outsourcing is another possibility, which means that firms in developed countries find it profitable to offload the most unskilled-labor intensive activities to overseas production in countries where unskilled labor is relatively cheap. The relative demand for skilled workers increases in the developed countries since the remaining activities then, on average, become more skill-intensive.[2]

The purpose of this paper is an attempt to quantify the relative importance of these factors in Swedish manufacturing over the past 25 years. The paper is in a vein emanating from Berman, Bound & Griliches (1994). We estimate a reduced form model on industry level originating from a labor demand function derived from a translog cost function. We assume that technological changes can be related to investment in physical capital and knowledge. New technologies are often embodied in new machinery and the latest production methods are usually put into practice in newly set-up plant. As in several other similar studies we can establish a positive relationship between accumulation of physical capital and demand for skills.[3]

Investments in R&D are expected to result in technological improvements. By cumulating R&D expenditure we construct knowledge capital stocks. The knowledge stocks can be smoothly integrated into our analytical framework and make it possible to examine whether knowledge capital and skilled labor are relative complements. Our findings show that they are, and that the rapid growth in knowledge capital in Sweden is a major explanation of the increased relative demand for skills in Swedish manufacturing over the last decade. Moreover, we find that the degree of complementarity between knowledge capital and skill has strengthened over time. We also try to evaluate the impact of international technology spillovers and our results indicate some influence on the relative demand for skills.

Many studies have examined the hypothesis that trade has led to deterioration in the position of less-skilled workers. Generally, growth rates in the shares of imports and exports in consumption (production) are included as explanatory variables of shifts in skill structures. [4] We argue that growth in the share of imports in consumption is an indicator of increased import competition. In order to investigate the influences of increased competition from the South more rigorously we have to disaggregate the imports by country of origin; in our analysis we let the import share be based solely on imports from non-OECD countries.[5] We observe a small, positive impact of increased Southern import competition on the relative demand for skills in Swedish manufacturing. A closer examination of individual sectors shows that this result is essentially driven by the textile industry.

Finally, we broaden our horizon outside manufacturing. We discuss what has happened to Swedish manufacturing as a whole in relation to other sectors. Has the manufacturing share of total employment been shrinking in Sweden as in other OECD countries? A reasonable consequence of a falling manufacturing share due to increased competition from the South would be a decrease in employment of less skilled labor in manufacturing. Such a development may in turn have effects on the skill intensity in the less trade-exposed non-manufacturing sector. In this respect we compare the employment pattern of the skilled and less skilled in Swedish manufacturing and non-manufacturing sectors in the late 1980s up to the mid-1990s. An indicator of the position of skilled and less skilled workers on the labor market, in particular in the European countries, is the relative unemployment rate. We investigate its development in Sweden since the beginning of 1970s and compare with the situation in other OECD countries.

The plan of the paper is as follows. In section 2, we outline the analytical framework and suggest different technology indicators. In section 3.1, we analyze the technology impact on skill upgrading in Swedish manufacturing over the last decade. Section 3.2 deals with whether we can observe acceleration in the relative demand for skills. Section 3.3 examines the effects of competition from the South on skill upgrading. Sector 3.4 widens the analysis to the whole Swedish economy; we discuss employment patterns in the manufacturing and non-manufacturing sectors and the relative unemployment rate of skilled and less skilled workers. Section 4 concludes.

2. Analytical framework

We follow the standard setup in this literature and derive our econometric specification from a non-homothetic translog cost function.[6] Skilled and less skilled labor are variable factors and physical capital K and knowledge capital S are treated as fixed factors. Cost minimization implies that we obtain the share of skilled labor cost in total wage cost by employing Shephard's lemma. The cost share of skilled labor P^W is

$$P^W = b_0 + b_1 \ln\left(w_s / w_u\right) + b_2 \ln Y + b_3 \ln K + b_4 \ln S + b_5 T \qquad (1)$$

where w_s and w_u are wage rates of skilled and less skilled workers, Y is real output and T is an index of the state of technology.

Differentiating (1) with respect to time, assuming the parameters to be invariant across industries i and appending an error term ε_i gives our basic regression model

$$\Delta P_i^W = \beta_0 + \beta_1 \Delta \ln\left(w_s / w_u\right)_i + \beta_2 \Delta \ln Y_i + \beta_3 \Delta \ln K_i + \beta_4 \Delta \ln S_i + \beta_5 \Delta T_i + \varepsilon_i \qquad (2)$$

The sign of β_1 depends on whether the elasticity of substitution between skilled and less skilled labor σ is greater or less than one; β_1 is negative when σ is larger than one.[7] Despite an opportunity to calculate relative wages -- by using the sum of labor income and the number of employed divided into skilled and less skilled categories on industry level -- we never estimate β_1. The reason is that it is questionable whether such relative wages can be considered exogenous. According to Berman, Bound & Griliches (1994) some of the relative wage changes depend on cross-sectional differences in skill upgrading, which means that we confound price changes with quality changes. On the whole, compositional changes (due to age and education) of the skilled and less skilled groups may largely affect our calculated relative wages. Moreover, there is a definitional relationship between our dependent variable and our measure of relative wage.

If we instead assume labor to be perfectly mobile across industries, the wage of the skilled is equalized across industries, as well as the wage of the less skilled, and $\Delta \ln\left(w_s / w_u\right)_i$ is a constant. The exclusion of the relative wage variable will then only affect the intercept β_0 or the coefficients of the time dummies in a panel study.

The estimate of β_2 shows whether the growth in output is related to changes in the wage bill share of skilled labor. If $\beta_2 = 0$, we cannot reject the hypothesis that the production function is homothetic.

The coefficient of $\Delta \ln K$ indicates whether skilled labor is complementary ($\beta_3 > 0$) or substitute ($\beta_3 < 0$) to physical capital in the production process. We assume that new machinery and equipment make use of the latest technologies and that modern methods of production are practiced in newly built plants. Technology innovations alter the demand in favor of better-educated workers because they have a comparative advantage in implementing new technology.[8] Computerization and other information technology upgrade the work force by automating toilsome and manual tasks and giving workers more time to concentrate on conceptual and decision-making tasks. Other may argue that new technology de-skills the work force. Mass production and other radical technological advances in the 19th century led to the substitution of highly skilled artisans with physical capital, raw materials and unskilled labor.[9]

Similar arguments also apply to knowledge capital and the estimate of β_4 shows whether skilled labor is complementary ($\beta_4 > 0$) or substitute ($\beta_4 < 0$) to knowledge capital. To calculate knowledge capital stocks we use time series of R&D expenditure. Following Hall & Mairesse (1995) we use the formula

$$S_{it} = (1-\delta_s)S_{it-1} + RD_{it-1} \quad (3)$$

where S_{it} is the knowledge (R&D) capital stock in industry *i* at the beginning of period *t*, RD_{it-1} is expenditure on R&D, industry *i*, time $t-1$, in constant prices and δ_S is the rate of depreciation of knowledge, i.e. the rate at which knowledge becomes obsolete. A benchmark S_{i1} is obtained as

$$S_{i1} = \frac{RD_{i1}}{g+\delta_s} \quad (4)$$

where *g* is the rate of growth of R&D (assumed constant over time). We assume a depreciation rate of knowledge δ_S of 15 percent (cf. Hall & Mairesse 1995) and a presample growth in R&D expenditure of 6 percent. We also assume that investments in research add to the stock of productive knowledge with a lag of three years.[10]

As alternative measures of $\Delta \ln S$ we employ the R&D intensity, i.e. R&D expenditure as a share of value added, $(RD/Y)^{Sweden}$, which has been frequently used in other similar studies, or the share of technicians among the employees, *TECH*. New technologies are continuously introduced at a high rate in R&D intensive industries and a high share of technicians enhances the ability to develop, adopt and implement new technologies.

ΔT includes technological changes not captured by changes in the industry's own physical or knowledge capital stock. One would expect a higher rate of technological change in industries where the potential for international technology spillovers is large. Following Machin & Van Reenen (1998) we construct a spillover pool simply by calculating the world wide (13 OECD countries excluding Sweden) R&D intensity, $(RD/Y)^{OECD}$ for each industry.[11]

In our models we use various types of technology indicators measuring different aspects of technological change.[12] Therefore, it could be of interest to show the correlation among these indicators. We calculate a correlation matrix for our technology indicators in a panel of 19 industries for the period 1986-95. A complete description of the data -- definitions and sources -- is given in the Appendix.

Table 1 Correlation matrix: Technology indicators

Most of the variables in the correlation matrix in *Table 1* are positively correlated and the R&D intensity in Sweden $(RD/Y)^{Sweden}$ and the share of technicians *TECH* are very strongly correlated (0.80). In our analysis we will use these two variables interchangeably; *TECH* has the advantage of being available in industries at low levels of aggregation. Other variables that are strongly correlated are $(RD/Y)^{Sweden}$ and the R&D intensity in other OECD countries $(RD/Y)^{OECD}$. Yet the correlation is far from one (0.69), which indicates that it is not exactly the same industries that are R&D intensive in Sweden and in other OECD countries. Finally, the R&D intensity in Sweden $(RD/Y)^{Sweden}$ and the relative growth in the knowledge stock $\Delta \ln S$ are not particularly correlated (0.50); the R&D intensity may underestimate (overestimate) knowledge capital accumulation in ”low-tech” (”high-tech”) industries.[13]

3. Empirical results

3.1 Technology and skill upgrading

In the econometric analysis we estimate various specifications based on the model in equation (2). Due to the availability of data we use two different datasets.[14] The first is a panel of 19 manufacturing industries for the period 1986-95. In the second the time period is extended, 1970-93, and we pool data for two time periods, 1970-85 and 1986-93, for which we have calculated average annual changes. Here, we use two levels of aggregation: the same 19 industries as in the 1986-95 panel and a more disaggregated one, consisting of 34 manufacturing industries. Our definition of skilled labor is based on educational attainment.[15] We define skilled labor as employed workers with a post-secondary education, i.e. with more than 12 years of education. The dependent variable in the 1986-95 panel study is changes in skilled labor wage bill shares ΔP^W and in the pooled 1970-93 dataset the dependent variable is changes in skilled labor employment shares ΔP^E.[16] The results from the 1986-95 panel are given in *Table 2* and from the 1970-93 pooled model in *Table 6*.

Table 2 Wage bill share equations based on a 19 manufacturing industry panel in Sweden 1986-95.

As a comparison with similar studies, in particular Machin & Van Reneen (1998),[17] we start in specification (i) by using the R&D intensity in Sweden in period $t-1$ $(RD/Y)^{Sweden}$ as a technology indicator. We use lagged R&D intensity[18] to take into account that new knowledge will not be implemented immediately (cf. the construction of knowledge stocks). Another reason is that we want to avoid picking up an identity between R&D expenditure and changes in the share of skilled labor; most R&D spending is made up of the employment cost of scientists and other skilled workers. On the other hand, the number of R&D workers in manufacturing is relatively small.[19]

Our results conform to other studies. We find that the coefficient on the changes in physical capital is positive and significant in specification (i) and in all other specifications in *Table 2*. This implies complementarity between physical capital and skilled labor. The coefficient is also positive, and strongly significant, on Swedish R&D intensity that means that over the last decade R&D intensive industries have been more likely to increase their skill shares.[20]

In columns (ii) and (iii), we replace Swedish R&D intensity with changes in knowledge capital. The yearly variation in skill shares and technology measures tend to be small and therefore in (iii) we use longer frequency differences, three-year differences instead of one-year differences. Moreover, such a specification is more useful on comparisons with some of the later results.

From the results in columns (ii) and (iii) we can evaluate and compare the impact of investment in new plants and machinery and investment in knowledge on the relative demand for skills in Swedish manufacturing during the late 1980s and the beginning of 1990s.[21] The coefficient on the growth in knowledge capital is less than the coefficient on the growth in physical capital but from column (v) we notice that the knowledge capital has grown faster than the physical capital. Using this in a back-of-the-envelope calculation in column (v) (the regression coefficients are from specification (iii)) we find that the growth in knowledge capital ”explains” almost 17 percent of the overall change in the skill structure in manufacturing while the contribution of physical capital is 14 percent.[22]

Since the change in knowledge capital $\Delta \ln S$ is a key variable we also check whether outliers drive our estimates on the coefficient of $\Delta \ln S$. *Figure 1*, which shows the partial association between change in skilled labor wage share and change in knowledge capital, indicates that this is not the case.[23]

Figure 1 Partial association between change in skilled labor wage bill share and change in knowledge capital

The effect of potential international technology spillovers is positive and significant on 10 percent level in (ii), while we get a lower, and statistically insignificant, coefficient, when we, in column (iii), base our estimates on longer frequency differences. According to the evaluation in column (v) international technology spillovers seem to have some economic impact. Another interesting observation is that an exclusion of $(RD/Y)^{OECD}$ will bias the coefficients on $\Delta \ln S$ and $\Delta \ln K$ upwards;[24] they pick up some of the effects of international technology spillovers.

Table 3 Physical and knowledge capital investments in Sweden and in OECD 1986-95

The results in *Table 2* indicate that, in particular, investment in knowledge capital, i.e. growth in R&D stocks, seems to have played an important role in explaining the increased relative demand for skills in Swedish manufacturing over the last decade. This impression is strengthened by the fact that until the beginning of the 1980s the R&D intensity in Sweden and the R&D intensity in other OECD countries developed in similar pattern. By the mid-1980s the Swedish R&D intensity was slightly larger, but then the gap between them has widened. The investment ratios, on the other hand, have fluctuated around the same level (15 percent) over the period 1973-94.[25] Calculations of the annual growth in the physical and the knowledge capital stocks in manufacturing, presented in *Table 3*, indicate that the growth rate in knowledge capital has been about one percentage point higher in Sweden than in other OECD countries and the growth rate in physical capital more than two percentage points lower. The lower rate of physical capital accumulation, despite an average OECD investment ratio in Sweden over the period studied, can be explained by the fact that Sweden had a fairly high physical capital-output ratio in the middle of the 1980s.[26] Consequently, a great deal of the investments in buildings and machinery are replacements of depreciated capital.

3.2 Acceleration in skill upgrading

One intriguing question is whether we can observe acceleration in the relative demand for skills during the last few decades.[27] To analyze this we have to extend the period under study. The educational attainment of the employees in manufacturing has increased continuously over the past thirty-five-year period. The share with post-secondary education has increased from 2.6 percent 1970 to 16.3 percent 1995 and the share with post-secondary education of more than three years from just over 1 percent 1960 to a little less than 6.4 percent 1993.[28] If we calculate the average annual changes in the manufacturing skill share over different periods and we find that the rate of change has increased over time.[29]

Partly, the shift over the period 1970-85 may be explained by growing relative demand for skills but, as put forward by Edin & Holmlund (1995), an increase in the supply of labor with higher education seems to have played the more important role. According to *Table 4*, the relative wages of skilled labor fall over the period 1970-85. This implies that firms had an incentive to substitute less skilled labor with skilled. Moreover, the changes in the international specialization pattern of Swedish manufacturing are consistent with a Rybczynski effect: the large increase in the supply of skilled labor led to shifts in specialization towards more production in skilled-labor intensive industries.[30]

Table 4 Skilled-based relative wages in Sweden 1968-91

Table 4 also documents a moderate rise in the relative wages of skilled labor from 1984 until at least 1991. Edin & Holmlund (1995) argue that even over this period the explanations for the relative wage changes are found on the supply side; a slowdown in the supply of educated workers in the mid-1980s. One argument against this is the increased rate of change in the manufacturing skill share, despite slightly rising relative wages of skilled labor. In their analysis the demand side is modeled in a rudimentary fashion. A time trend, which is positive and significant, is used to pick up influences of technological changes in a regression on relative wages.[31] Furthermore, they examine the extent to which employment has shifted towards skill-intensive industries (cf. the between-industry component below) and find that the allocation between industries was less favorable to skilled labor in the late 1980s.

Table 5 Between- and within-industry decomposition of the changes in the employment structure in Swedish manufacturing 1970-96.

However, recent studies have decomposed the change in the share of skilled labor into two components, where one captures reallocations between industries and the other the effect of changing skill ratios within industries. In *Table 5* we make this type of analysis on the changes in the employment structure in Swedish manufacturing 1970-96. We observe the same pattern as in other studies, namely that the bulk of the increase in the manufacturing skill share has occurred within-industries. The result is not dependent on the aggregation level of industries; the within-industry component is large even on a fairly low level of industry aggregation. This emphasizes the importance of trying to explain the within-industry shifts in skill shares in order to understand skill share trends in Swedish manufacturing.

Table 6 Employment share equations in Swedish manufacturing 1970-93

The rate of the within-industry shift towards higher skill shares has been increasing over time and it is particularly strong during the late 1980s and in the beginning of the 1990s.[32] To explain this pattern we estimate our preferred model in Table 2 (specification (iii)) for the two time periods 1970-85 and 1986-93 on the same 19 (18) manufacturing industries as in the 1986-95 panel study and we allow the coefficients to vary between the periods. We find that the only variable of importance for which the coefficient differs significantly between the two periods is the knowledge capital accumulation $\Delta \ln S$. Therefore, in specification (i), we restrict all other coefficients to being equal across the two time periods. The result is quite interesting since knowledge capital accumulation has a significantly larger effect on the relative demand for skills in the recent period.[33] One interpretation is that the degree of complementarity between knowledge capital and skills has increased over time.

In some contrast to our results in the panel study, potential international technology spillovers have a positive and clearly significant impact on the relative demand for skills. This is a reasonable outcome given the fact that Sweden is a small open economy and is in line with other studies on international technology spillovers, e.g. Coe & Helpman (1995).[34] The influence of physical capital accumulation is insignificant, however, yet still positive. The back-of-the envelope calculations in column (iv) indicate that there is a considerable contribution to the relative demand for skills from international technology spillovers and knowledge capital accumulation in the recent period, and also to some extent from physical capital accumulation.

In specification (ii) we use the more disaggregated dataset (34 manufacturing industries). On this level of aggregation we have no access to data on R&D expenditures. The correlation matrix in Table 1 demonstrates, however, strong correlation on industry level between the R&D intensity in Sweden $(RD/Y)^{Sweden}$, the R&D intensity in other OECD countries $(RD/Y)^{OECD}$ and the share of technicians *TECH*. In specification (ii) we replace $\Delta \ln S$ and $(RD/Y)^{OECD}$ with *TECH* and the coefficient on *TECH* is positive and strongly significant.[35] A notable difference in comparison with specification (i) is the coefficient on physical capital accumulation, which is larger and clearly significant in specification (ii).

3.3 Skill upgrading and competition from the South

One argument advanced against international trade as an explanation of increased relative demand for skills is the outcome from decomposition studies such as those presented in *Table 5*. It has been argued that, in a developed country, increased competition from less-developed and newly industrialized countries (LDCs and NICs) shift employment from low-skill to high-skill industries, while changes in the within-industry shares are a result of technological changes. Since the bulk of the increased skill share has occurred within industries, the conclusion has been that international trade played a minor role in explaining the increased relative demand for skills. From *Table 5* it appears that Sweden is no exception in this respect; even on the lowest level of industry aggregation the contribution of the between-industry component is less than 20 percent.

However, trade may just as well affect the within-industry share. Theoretically, industries are often assumed to be homogeneous with respect to factor intensities. In practice, they are composed of a wide range of activities, in which final and intermediate products are produced with varying factor intensities. *Table 7* shows the variation in skill shares among plants within industries defined on the lowest level of industry aggregation in Swedish manufacturing.

Table 7 Analysis of variance in skill shares among Swedish manufacturing plants within industries defined on the lowest level of industry aggregation

In the analysis of variance the *F*-values indicate that there are significant differences in skill shares between industries. Yet the variations among plants within industries are substantial. Between 60 and 70 percent of the total variance in skill shares are within industries, even though we observe a tendency towards decreasing variances within industries. This means that there has been, and still is, a great potential for specialization with respect to skill shares within-industries.

One example of such specialization is outsourcing. In many firms different stages of production are heterogeneous with respect to skill intensity. Firms in developed countries may then, in response to competition from low-wage countries, move their low-skill intensive production abroad. Modern production techniques and improvements in communication technology have made it easier to split up the manufacturing process of production into separate activities performed in different countries. By moving the low-skill intensive part of the production, for example assembly of components, overseas, but continuing to carry out the high-skill intensive activities themselves, a firm can take advantage of lower wages for the less skilled. Once the low-skilled activities have been accomplished the goods are imported back, either to be used as intermediate inputs or sold as finished goods. Hence, a reasonable variable to proxy the impact of outsourcing on the relative demand for skills within an industry is the change in imports from non-OECD countries as a share of consumption. Such a variable captures more than just the effect of outsourcing. Narrowly defined outsourcing takes place within multinationals. Nevertheless, increased competition from low-wage countries also entails that domestic consumers and producers may switch from buying low-skill intensive final or intermediate goods from domestic producers to foreign suppliers in countries like the LDCs and the NICs.

In our econometric analysis we use a similar approach as in Feenstra & Hanson (1996, 1997) to analyze the effect of outsourcing on the relative demand for skills within industries. We append the variable $\Delta(M/C)^{Non-OECD}$, the average annual change in import competition from non-OECD countries, to the regression models we previously estimated. Feenstra & Hanson (1996) proxy outsourcing by the share of imports from all countries (including imports from advanced industrialized countries) in US shipment plus import. There is no reason, however, to expect that Swedish multinationals would outsource low-skill activities to other countries where less skilled labor is expensive or that increased competition from nations with abundant supply of high-skill labor would severely affect the situation of the low-skilled in Sweden. *Table 8* presents the results from this analysis.

Table 8 Effects of increased competition from the South on skill upgrading in Swedish manufacturing, 1970-93

In both specifications in *Table 8* we use the most disaggregated dataset (34 manufacturing industries), which means that the variables based on R&D expenditures ($\Delta \ln S$ and $(RD/Y)^{OECD}$) are replaced with the share of technicians, *TECH*.[36] In column (i), the coefficient on $\Delta(M/C)^{Non-OECD}$ is positive and significant.[37]

An interesting hypothesis set out by Wood (1998) is that most of the recent acceleration in the growth rate of the relative demand for skilled labor is caused by increased globalization. The reasons are reduced policy barriers to international transactions (less restrictions on trade and foreign direct investment) and technical changes resulting in lower transport and communication costs. Moreover, many less-developed countries have shifted development strategies from import substitution to export promotion, and large countries, such as China and India, and the former Soviet bloc countries have become more outward oriented. A simple test of the hypothesis is to allow the coefficient on $\Delta(M/C)^{Non-OECD}$ to vary between the two periods. Contrary to Wood's hypothesis the estimate on $\Delta(M/C)^{Non-OECD}$ in column (ii) is only significant for the earlier period (1970-85). However, it is not significantly different from the coefficient in the later period (1986-93).[38]

Figure 2 Partial association between change in skill share and change in non-OECD import competition over the periods 1970-85 and 1986-93.

The partial association plot in *Figure 2*, using the coefficients from column (ii), shows that many of the results in Table 8 are driven by development in the textile industry.[39] The non-OECD import competition has increased sharply in textiles over the whole period, while employment has fallen precipitously.[40] From the plot we observe that the average relative size of the textile industry is larger in the 1970-85 period (circle) than in the 1986-93 period (square). Since our regressions are weighted, the impact of the textile industry is larger on the estimate on $\Delta(M/C)^{Non-OECD}$ in the 1970-85 period. Furthermore, the changes in non-OECD import competition on industry level are more scattered over the latter period, which may give rise to the less precise estimate we get on $\Delta(M/C)^{Non-OECD}$ in the 1986-93 period; in *Figure 2*, the standard error (in parentheses) is larger for the 1986-93 period.

Evidently the results in *Table 8* give some support for a statistically significant impact of increased import competition from the South on the relative demand for skills in Swedish manufacturing industries. How important is this effect economically? Feenstra & Hanson (1996) detect considerable influences on skill upgrading of increased import competition in US manufacturing using the same method we practice in Table 2 and Table 6 to evaluate the contribution of different independent variables. They estimate that the growth of imports explains between 15 to 33 percent of the increase in the non-production (skilled) labor share over the period 1979-87. Since the magnitude of the contribution is determined by the development of the non-OECD imports (together with the coefficient on $\Delta(M/C)^{Non-OECD}$) we begin our evaluation by demonstrating, in *Figure 3*, how the non-OECD import competition progressed in Swedish manufacturing between 1970 and 1994. As a benchmark we show the development of the non-OECD manufacturing imports in the US and in OECD-Europe (excluding Sweden)[41] over the same period.

Figure 3 Non-OECD manufacturing import share of consumption in Sweden, the US and OECD-Europe 1970-94

In *Figure 3*, we observe that, in the beginning of the 1970s, Sweden has a larger non-OECD import share than the US and OECD-Europe. One explanation may be that Sweden was more free-trade oriented; the tariffs were lower than in most other developed countries.[42] However, the non-OECD imports in Sweden have grown less than in the US, while the development in Sweden is more in accordance with the development in OECD-Europe.

Not surprisingly, we find, in *Table 8* column (iv), that the contribution of increased import competition from the South on the relative demand for skilled labor has been of minor importance in comparison with physical capital accumulation and technological change. Just over 5 percent of the increase in skill shares is ”explained” by intensified competition from the South. The corresponding figures for physical capital accumulation and our technology indicators are 30 percent and 35 percent.

3.4 Non-manufacturing employment and relative unemployment rate of skilled and less skilled labor

So far, we have, as in most other similar studies, focused on variations across industries within the manufacturing sector. However, increased competition from the South may involve contracting employment of less skilled in the manufacturing sector, resulting in excess supply of less skilled labor. We would then expect to find increased employment of less skilled in the non-manufacturing sector or, since the relative wage between skilled and less skilled has been fairly constant (Table 4), higher unemployment rate among the less skilled.

Table 9 Employment of skilled and less skilled labor in Swedish manufacturing and non-manufacturing 1986 and 1996

The development of manufacturing employment as a share of total employment shows almost the same pattern in Sweden as in OECD; in Sweden, the share has fallen from around 29 percent in 1970 to less than 19 percent 1994. [43] Since there seems to be a robust relationship among the OECD countries between increased non-OECD imports and falling employment in manufacturing,[44] one would hypothesize that increased competition from the South has increased the skilled labor employment shares more in the more trade-exposed manufacturing sector than in the non-manufacturing sector.[45] Yet *Table 9* indicates that this does not appear to be the case in Sweden. Certainly, over the period 1986-96, the relative increase in skilled labor employment and the relative decrease in less skilled labor employment are larger in manufacturing, and also, the share of skilled labor employment has almost doubled in manufacturing. However, the absolute increase in the share of skilled labor employment is less in manufacturing than in non-manufacturing.[46]

Figure 4 Unemployment rates by skills in Sweden 1971-98

Finally, if we look at the unemployment rates by skills, in *Figure 4*, we notice that the unemployment rate of the less skilled is higher and seems to be more responsive to business cycles. Between 1975 and 1990 the unemployment rate of the skilled is more or less tied to 1 percent, whereas the unemployment rate of the less skilled varies between 2 and 4 percent. Over the period 1971-91, the Swedish unemployment rate is low in comparison with other OECD countries, but the macroeconomic shock that hit Sweden in the early 1990s pushed the unemployment rates up to an average OECD level.[47] If we use the data in Figure 4 to calculate the ratio of and the difference between the unemployment rates[48] we find that, whereas the ratio fluctuates around 2.6, the difference has an upward sloping trend.[49] The latter means that the gap between the unemployment rates of the skilled and less skilled has widened over the last 25 years. The pattern is comparable with many other OECD countries[50] and indicates that the position of the less skilled has deteriorated on the Swedish labor market.

4. Concluding remarks

We have observed a steady increase in the rate of change towards higher skill shares in Swedish manufacturing over the 35-year period between 1960-1995. Contrasting the development over the periods 1970-85 and 1986-93, the falling relative wages of skilled labor during the period 1970-85 suggests that the relative supply of skilled labor grew faster than the relative demand for skills. On the other hand, slightly rising relative wages over the more recent period of 1986-93, together with increased rate of skill upgrading, indicate acceleration in the relative demand for skills in Swedish manufacturing. In accordance with this are the findings that the degree of complementarity between knowledge capital and skills appears to have strengthened over time and that Sweden has been a heavy investor in R&D in the late 1980s and in the beginning of 1990s. Another factor behind acceleration in the relative demand for skills may be the rapid diffusion of computer technology. Autor, Katz & Krueger (1998) establish a strong positive relation between computer usage and skill upgrading and according to SCB (1995) computer usage among the employed in Sweden has doubled between 1984 and 1995.

Given the fact that Sweden is a small, open economy we are not surprised by the finding that international technology spillovers affect the relative demand for skills positively. We also obtain some support for the belief that intensified competition from the South has increased the relative demand for skilled labor. However, the economic impact appears to be small; increased import competition from non-OECD countries ”explains” relatively little of the skill upgrading. Furthermore, the textile industry plays a crucial role for the outcome

Lastly, we conclude that in most respects the Swedish experiences are similar to many other OECD countries. In particular, that applies to our main result, i.e. that both technology and trade matter for the deterioration of the less skilled, but the former is more important.

References

Anderton, B, & Brenton, P. (1998), Did ‘Outsourcing’ to Low-Wage Countries Hurt Less-Skilled Workers in the UK? in Brenton, P. & Pelkmans, J. (eds), *Global Trade and European Workers*, London: Macmillan.

Autor, D, Katz L. & Krueger, A. (1998), Computing Inequality: Have Computers Changed the Labor Market. *Quarterly Journal of Economics*, 113, 1169-1213.

Berman, E, Bound, J. & Griliches, Z. (1994), Changes in the Demand for Skilled Labor Within U.S. Manufacturing: Evidence From the Annual Survey of Manufactures, *Quarterly Journal of Economics*, 109, 367-98.

Bernard, A. & Jensen, B. (1997), Exporters, Skill Upgrading, and the Wage Gap. *Journal of International Economics*, 42, 3-31.

Berndt, E. (1991), *The Practice of Econometrics. Classic and Contemporary*. New York: Addison-Wesly.

Braverman, H. (1974), *Labor and Monopoly Capital*. New York: Monthly Review Press.

Coe, D. & Helpman, E. (1995), International R&D Spillovers. *European Economic Review*, 39, 859-887.

Desjonqueres, T, Machin, S. & Van Reenen J. (1997), Another Nail in the Coffin? Or Can the Trade Based Explanation of Changing Skill Structures Be Resurrected? Forthcoming in *Scandinavian Journal of Economics*.

Edin, P-A & Holmlund, B. (1995), The Swedish Wage Structure: The Rise and Fall of Solidarity Wage Policy, in Freeman, R. & Katz L. (eds), *Differences and Changes in Wage Structures*. University of Chicago Press and NBER.

Feenstra, R. & Hanson, G. (1996), Foreign Investment, Outsourcing and Relative Wages, in Feenstra, R, Grossman, G. & Irwin D. (eds), *The Political Economy of Trade Policy: Papers in Honour of Jagdish Bhagwati*, Cambridge: MIT Press.

Feenstra, R. & Hanson, G. (1997), Productivity Measurement and the Impact of Trade and Technology on Wages: Estimates for the U.S., 1972-1990, *NBER Working Paper 6052*.

Freeman, R. (1986), The Demand for Education, in Ashenfelter, O. & Layard, R. (eds) *Handbook of Labor Economics, Volume 1*. Amsterdam: North-Holland.

Hall, B.H. & Mairesse, J. (1995), Exploring the Relationship Between R&D and Productivity in French Manufacturing Firms. *Journal of Econometrics*, 65, 263-293.

Hansson, P. & Lundberg L. (1995), *Från basindustri till högteknologi? Svensk näringsstruktur och strukturpolitik* (From Natural Resource Processing to Hi-Tech? Industrial Structure and Industrial Policy in Sweden). Stockholm: SNS-förlag.

Hansson, P. (1997), Trade, Technology and Changes in Employment of Skilled Labor in Swedish Manufacturing, in Fagerberg, J. et. al. (eds), *Technology and Trade*, Cheltenham: Edward Elgar.

Hansson, P. (1999), Relative Demand for Skills in Swedish Manufacturing: Technology or Trade? *FIEF Working Paper 152*. Downloadable at http://www.fief.se.

Holmlund, B. (1997), Löneskillnader och arbetslöshet (Wage Differences and Unemployment), in Bergström, V. (ed), *Arbetsmarknad och tillväxt* (Labor Market and Growth). Stockholm: Ekerlids förlag.

Horn, H, Lang, H. & Lundgren, S. (1995), Managerial Effort, Incentives, X-inefficiency and International Trade, *European Economic Review*, 39, 117-138.

Katz, L. & Murphy, K. (1992), Changes in Relative Wages, 1963-1987: Supply and Demand Factors. *Quarterly Journal of Economics*, 107, 35-78.

Keller, W. (1997), Trade and the Transmission of Technology. *NBER Working Paper 6113*.

Leamer, E. (1994), Trade, Wages and the Revolving Door Ideas. *NBER Working Paper 4716*.

Leibenstein, H. (1966), Allocative Efficiency versus 'X-efficiency'. *American Economic Review*, 56, 392-415.

Lundberg, L. (1976), *Handelshinder och handelspolitik* (Trade Barriers and Trade Policy) Stockholm: Almqvist & Wiksell.

Machin, S. (1996), Changes in the Relative Demand for Skill in the UK, in Booth, A. & Snower, D. (eds), *Acquiring Skills*. Cambridge: Cambridge University Press.

Machin, S. & Van Reenen, J. (1998), Technology and Changes in Skill Structures: Evidence from Seven OECD Countries. *Quarterly Journal of Economics*, 113, 1215-1244.

Marx, K. (1867), *Capital. Volume 1*. London: Lawrence & Wishart.

Mendenhall, W, Wackerly, D. & Scheaffer, R. (1990), *Mathematical Statistics with Applications*. Fourth Edition. Belmont: Duxbury Press.

Mishel, L. & Bernstein, J. (1996), Inside the Black Box: Estimating Technology's Impact on Wage Inequality Trends, 1973-94. Economic Policy Institute, Washington DC

Nickell, S. & Bell B. (1996), Changes in the Distribution of Wages and Unemployment in OECD Countries. *American Economic Review*, 86, 302-308.

OECD (1997), Trade, Earnings and Employment: Assessing the Impact of Trade with Emerging Economies on OECD Labor Markets. *Employment Outlook*. Paris: OECD.

Saeger, S. (1997), Globalization and Deindustrialization. Myth and Reality in the OECD. *Weltwirtschaftliches Archiv*, 133, 579-608.

SCB (1995), *Datorvanor 1995* (Computer usage 1995). Stockholm: Nordstedts.

U.S. Bureau of Labor Statistics (1989), *The Impact of Research and Development and Productivity Growth*. Bulletin 2331, Washington DC.

Wood, A. (1994), *North-South Trade, Employment and Inequality: Changing Fortunes in a Skill-Driven World*. Oxford: Clarendon Press.

Wood A. (1998), Globalisation and the Rise in Labor Market Inequalities. *Economic Journal*, 108, 1463-1482.

Appendix: Definitions and data sources

1. The panel of 19 manufacturing industries 1986-95

Until 1993 data were classified according to SNI69. After 1993 a new system of classification SNI92 was introduced. It is possible to achieve concordance at a fairly high level of aggregation. Hansson (1999) gives more details about the concordance between SNI69 and SNI92.

Variables

Wage incomes W: Total wage incomes for employees with post-secondary education.
Source: SCB Regional Labor Statistics.

Wage incomes skilled labor W^S : Wage incomes for employees with post-secondary education.
Source: SCB Regional Labor Statistics.

Skilled labors' share of the wage bill P^W: $P^W = W^S / W$

Employment E: Number of employees. Source: SCB Regional Labor Statistics.

Technicians T: Employees with technical post-secondary education. Source: SCB Regional Labor Statistics.

Share of technicians TECH: $TECH = T / E$

Physical capital K:* Stocks of fixed assets at replacement costs, 1991 prices. Source: SCB (1996a).

Real output Y:* Value added, 1991 prices. Source: SCB (1997) and SCB (1995).

R&D intensity in Sweden and in OECD: $(RD/Y)^{Sweden}$ *and* $(RD/Y)^{OECD}$

RD: Expenditure on R&D, current prices: Source: OECD (1997)
Y: Value added, current prices: Source: OECD (1996)

Knowledge capital S:

$$S_{it} = (1-\delta_s)S_{it-1} + R_{it-1}$$

S_{it}: Knowledge capital (R&D) stock, industry *i* at time *t*, 1991 prices

R_{it}: Expenditure on R&D, industry *i* at time *t*, 1991 prices.
R&D expenditure are simply deflated by the manufacturing sector level value added deflator. Source: OECD (1996) and OECD (1994).

δ_S: Depreciation rate of knowledge (0.15)

Benchmark year 1976

Import competition $(M/C)^{All}$ *and* $(M/C)^{Non-OECD}$*:*

Import M^{All} *and* $M^{Non-OECD}$: Total import and import from non-OECD countries.
Source: 1986-93 OECD (1998) and OECD (1996) and 1993-95 SCB Foreign Trade Statistics.

Export X^{All}: Total export.
Source: 1986-93 OECD (1998) and OECD (1996) and 1993-95 SCB Foreign Trade Statistics.

Production Q: Sales value.
Source: 1986-93 SOS Manufacturing various issues and 1993-95 SCB Manufacturing.

Consumption C: $C = Q + M^{All} - X^{All}$

2. The 34 (19) manufacturing industries 1970-93

Variables

Employment E: Number of employees.
Source: 1970-85 SCB (1991) and 1986-93 SCB Regional Labor Statistics.

Skilled labor E^S: Employees with post-secondary education.
Source: 1970-85 SCB (1991) and 1986-93 SCB Regional Labor Statistics.

Technicians T:

1970-85: Employees with technical secondary education of more than two years or technical post-secondary education. Source: SCB (1991)

1986-93: Employees with technical post-secondary education. SCB Regional Labor Statistics.

Physical capital K:* Capital stock, 1980 prices.
Capital stock estimates are derived by the Perpetual Inventory Method (PIM). This implies that capital formations are added to and capital assets withdrawn are subtracted from an initial estimate of the capital stock. We assume linear depreciation, which means that the gross capital stock at time *t* is

$$K_t = K_{t-i}\left[1-(i/2a)\right] + \sum_{m=0}^{i-1} I_{t-m-1}\left[1-(m/2a)\right]$$

K_{t-i}: Capital stock in the beginning of year $t-i$, 1980 prices.

I_{t-m-1}: Gross fixed capital formation year $t-m-1$, 1980 prices

a: Average service life in manufactures.
Buildings 45 years and machinery 20 years (Meyer-zu-Schlochtern 1994).

Benchmark year 1970. SCB (1985)

Investment, constant prices. SCB (1987) and SCB (1996b)

*Real output Y:** Value added, 1980 prices. Source: SCB (1986) and SCB (1995)

The breakdown procedure of constant priced capital stocks and value added on industries on lower level of aggregation is the same as in the 19 industry panel above.

R&D intensity in OECD $(RD/Y)^{OECD}$ *: (19 industries)*

1970-85: Average 1973-84
1986-93: Average 1985-92
RD: Expenditure on R&D, current prices, US dollar: Source: OECD (1997)
Y: Value added, current prices, US dollar: Source: OECD (1996)

Knowledge capital S: (19 industries)

$$S_{it} = (1-\delta_s)S_{it-1} + R_{it-1}$$

S_{it}: Knowledge capital (R&D) stock, industry *i* at time *t*, 1980 prices
R_{it}: Expenditure on R&D, industry *i* at time *t*, 1980 prices.
R&D expenditure are simply deflated by the manufacturing sector level value added deflator. Source: OECD (1996), SCB (1995), SCB (1986), OECD (1983) and SCB (1975).
δ_S: Depreciation rate of knowledge (0.15)
Benchmark year 1967

Import competition $(M/C)^{All}$ *and* $(M/C)^{Non-OECD}$ *:*

Import M^{All} *and* $M^{Non-OECD}$: Total import and import from non-OECD countries.
Source: SCB Foreign Trade Statistics
Export X^{All}: Total export. Source: SCB Foreign Trade Statistics.
Production Q: Sales value. Source: SOS Manufacturing, various issues.
Consumption C: $C = Q + M^{All} - X^{All}$

* See also Hansson (1999)

Data sources

Meyer-zu-Schlochtern, F.J.M. (1994), An International Sectoral Database for Fourteen OECD Countries (Second Edition). Economics Department no 145, OECD Paris.

OECD (1983), Science and technology indicators. Basic statistical series. Volume D. Research and development in the business sector 1963-1979.

OECD (1993), *International Sectoral Database (ISDB)*

OECD (1994), *DSTI (STAN/ABERD Database), 1994*

OECD (1996), *DSTI (STAN Industrial Database), 1996*

OECD (1997), *DSTI(STAN/ANBERD Database), 1997*

OECD (1998), *DSTI(STAN/BTD) 1998*

SCB (1975), *Production and factor income 1950-1974*. SM N 1975:98.

SCB (1985), *Capital formation and stocks of fixed capital*. SM N 1984: 5.5.

SCB (1986), *Production and factor income*. N 10 SM 8601.

SCB (1987), *Capital formation*. N 10 SM 8601.

SCB (1991), Utbildning och produktivitet. En studie av svensk industri under de senaste decennierna. (Education and productivity. A study of the Swedish industry over the last decades) *Information om arbetsmarknaden 1991:2*, Statistics Sweden Örebro.

SCB (1995), *Production and employment 1980-1994,* detailed tables. N 10 SM 9501. Statistics Sweden, Örebro.

SCB (1996a), *Stocks of fixed assets and national wealth*. N 10 SM 9501. Statistics Sweden, Örebro.

SCB (1996b), *Expenditure of GDP*. N 10 SM 9501. Statistics Sweden, Örebro.

SCB (1997), *National accounts 1980-1995*. N10 SM 9601. Statistics Sweden, Örebro.

Table 1 Correlation matrix: Technology indicators

	$\Delta \ln K$	$\Delta \ln S$	$(RD/Y)^{Sweden}$	$TECH$	$(RD/Y)^{OECD}$
$\Delta \ln K$	1.000				
$\Delta \ln S$	0.215	1.000			
$(RD/Y)^{Sweden}$	0.318	0.495	1.000		
$TECH$	0.355	0.359	0.805	1.000	
$(RD/Y)^{OECD}$	0.564	0.325	0.687	0.715	1.000

Variable definition:

$\Delta \ln K$ 100 × the change in the log of the physical capital stock
$\Delta \ln S$ 100 × the change in the log of the knowledge capital stock
$(RD/Y)^{Sweden}$ 100 × R&D expenditure as a share of value added in Sweden
$TECH$ 100 × the share of employees with technical post-secondary education
$(RD/Y)^{OECD}$ 100 × R&D expenditure as a share of value added in OECD excluding Sweden

Notes:

The correlations are calculated on variables in the panel of 19 manufacturing industries 1986-95.
OECD is 12 countries: Australia, Canada, Denmark, Finland, France, Germany (West), Italy, Japan, the Netherlands, Norway, the United Kingdom and the United States.

Table 3 Physical and knowledge capital investments in Sweden and OECD 1986-95

Country	I/Y	RD/Y	$\Delta \ln K$	$\Delta \ln S$
Sweden	15.65	8.78	1.91	5.80
OECD	14.81	6.72	4.09	4.77

Notes:

I/Y is the average gross fixed capital formation as a share of value added for the period 1985-94 and RD/Y is the average R&D expenditure as a share of value added for the period 1983-92 $\Delta \ln K$ and $\Delta \ln S$ are the average annual changes in physical and knowledge capital between 1986-95. To calculate the physical and knowledge capital stocks we use the methods described in the Appendix. We get the benchmark physical capital stock *K* in 1986 from OECD (1993) and investments *I* in constant prices from OECD (1996). OECD is 12 countries (see Table 1).

Table 4 Skilled-based relative wages in Sweden, 1968-91

	1968	1974	1981	1984	1986	1988	1991
University/ Upper secondary	1.80	1.33	1.23	1.22	1.27	1.24	1.31

Notes:

The relative wages are based on standardized wage equations. University means 16 years of education and upper secondary 12 years of education. The table is from Holmlund (1997).

Table 5 Between- and within-industry decomposition of the changes in employment structure in Swedish manufacturing, 1970-96. Annualized changes in percentage points.

Period	Number of industries	Total change	Between-industry component	Within-industry component	Contribution of within-industry component
1970-85	34	0.442	0.040	0.402	91.0 %
1986-93	34	0.916	0.111	0.805	88.0 %
1986-93	146	0.916	0.112	0.804	87.8 %
1990-96	275	0.765	0.132	0.633	82.7 %

Decomposition of changes in skill shares:

$$\Delta P^E = \sum_{i=1}^{n} \Delta S_i \overline{P_i} + \sum_{i=1}^{n} \Delta P_i^E \overline{S_i}$$

P_i^E : share of the employees in industry i with post-secondary education

S_i : industry i's share of total employment in manufacturing

$\overline{P_i}^E$ and $\overline{S_i}$ are period averages.

The first part (the between-industry component) captures the effect of employment shifts between-industries. The second part (the within-industry component) measures the impact of changes in skill-intensities within-industries.

Table 7 Analysis of variance in skill shares among Swedish manufacturing plants within industries defined on the lowest level of industry aggregation

Variable	F-value	$\overline{R}^2$	Number of plants	Number of industries
Skill share 1986 (SNI69)	135.44	0.323	40898	146
Skill share 1990 (SNI69)	140.09	0.336	39876	146
Skill share 1990 (SNI92)	79.52	0.337	41727	271
Skill share 1996 (SNI92)	90.02	0.409	35330	274

Notes:

The total variance SS_{total} in skill shares on plant level is separated into two components: the variance between averages for industries defined on the lowest level of aggregation in SNI (Swedish Standard of Industrial Classification), $SS_{between}$, and the variance within these industries, SS_{within}, i.e. $SS_{total} = SS_{between} + SS_{within}$ To establish whether skill shares differ between industries we assume that the variable F is F-distributed: $F = (SS_{between} / k-1) / (SS_{within} / N-k)$, where k is the number of industries and N is the number of plants. A measure of the between-industry variance of the total variance in skill shares is $\overline{R}^2$. A more complete description of analysis of variance is given in standard textbooks in Statistics, for example Mendenhall, Wackerly and Scheaffer (1990).

Table 2 Wage-bill share equations based on a 19 manufacturing industry panel in Sweden 1986-95

Variables	(i) Regression One-year changes	(ii) Regression One-year changes	(iii) Regression Annualized three-year changes	(iv) Mean Value	(v) Contribution
Dependent					
ΔP^W				0.798 (0.96)	
Independent					
$\Delta \ln Y$	−0.005 [−0.71]	0.001 [0.10]	0.020 [1.48]	2.213 (9.57)	5.3 %

$\Delta \ln K$	0.035 [2.35]	0.052 [2.27]	0.063 [2.00]	1.783 (3.89)	14.0 %
$\Delta \ln S$		0.025 [2.06]	0.035 [2.28]	3.800 (5.14)	16.6 %
$(RD/Y)^{Sweden}$	0.015 [2.84]				
$(RD/Y)^{OECD}$		0.026 [1.71]	0.010 [0.56]	5.552 (5.53)	7.0 %
Time Dummies	8.70 /0.00/	8.89 /0.00/	14.70 /0.00/		57.1 %
$\overline{R}^2$	0.483	0.533	0.695		
Observations	169	160	53		

Notes:
All regressions and mean values are computed over 19 industries for the period 1986-1993 and over 18 industries for the period 1993-95 (see Appendix in Hansson 1999). We exclude the observations on $(RD/Y)^{OECD}$ in ISIC 3845 Aircraft. Due to the large amount of military/government expenditure in ISIC 3845 there appear to be problems to construct reasonable R&D figures, in particular in the US and the UK, two large OECD countries that heavily influence $(RD/Y)^{OECD}$ (Machin & Van Reenen 1998). We weigh regressions and means values by the average industry share of the manufacturing wage bill. The impact in total manufacturing is larger from large manufacturing industries. Furthermore, the weighing procedure reduces the influence of noise in the data due to measurement errors particularly evident in small industries (Berman, Bound & Griliches 1994). Square brackets [ ] give White's heteroskedasticity-consistent *t* statistics and slashes / / the significance level of the *F*-test. The fourth column contains mean values and in parentheses ( ) are standard deviations of the dependent and independent variables. The fifth column shows the contribution of each of the independent variables in specification (iii).

Variable definition:

ΔP^W 100 $\times$ the change in the skilled labors' share in the wage bill

$\Delta \ln Y$ 100 $\times$ the change in the log of real output

Other variables are defined in Table 1 and the Appendix gives more details on the data

Table 6 Employment share equations in Swedish manufacturing 1970-93

Variables	(i) Regression Annualized changes 1970-93	(ii) Regression Annualized changes 1970-93	(iii) Mean value	(iv) Contribution
Dependent				
ΔP^E			0.595 (0.38)	
Independent				
$\Delta \ln Y$	0.033 [2.30]	0.028 [2.64]	0.431 (3.21)	2.4 %
$\Delta \ln K$	0.019	0.047	2.969	9.4 %

	[0.63]	[2.83]	(1.48)	
$\Delta \ln S$ *1970-85*	–0.0003 [–0.02]		6.497 (2.74)	–0.1 %
$\Delta \ln S \times$ *Dummy 1986-93*	0.047 [2.62]		3.983 (3.99)	15.6 %*
TECH		0.031 [4.80]		
$(RD/Y)^{OECD}$	0.023 [2.34]		4.491 (5.03)	17.7 %
Intercept 1970-85	2.03×10^{-3} [2.42]	-5.02×10^{-4} [–0.61]		17.0 %
Dummy 1986-93	2.50×10^{-3} [2.84]	5.44×10^{-3} [7.12]		38.0 %*
$\overline{R}^2$	0.839	0.699		
Observations	36	68		
Industries	18	34		

Notes:
We weigh the regressions and mean values by the average industry share of the manufacturing employment. As in Table 2 we exclude the observations on $(RD/Y)^{OECD}$ in ISIC 3845. Square brackets [ ] give White's heteroskedasticity-consistent *t*-statistics. The third column contains mean values and in parentheses ( ) are standard deviations of the dependent and independent variables. The fourth column shows the contribution of each of the independent variables in specification (i). * The contribution is calculated for the period coefficient, i.e. 0.047 for $\Delta \ln S$ 1986-93 and 4.53×10^{-3} for the intercept 1986-93.
Variable definition:
ΔP^E 100 × the change in the skilled labors' share in the employment
Other variables are defined in Table 1 and 2 and the appendix give more details on the data.

Table 8 Effects of increased competition from the South on skill upgrading in Swedish manufacturing 1970-93.

Variables	(i) Regression Annualized changes	(ii) Regression Annualized changes	(iii) Mean value	(iv) Contribution
Dependent				
ΔP^E			0.601 (0.39)	
Independent				
$\Delta \ln Y$	0.032 [3.11]	0.032 [3.07]	0.218 (3.53)	1.2 %
$\Delta \ln K$	0.057 [3.43]	0.057 [3.41]	3.181 (1.80)	30.2 %
TECH	0.029 [4.95]	0.030 [5.01]	7.298 (5.57)	35.2 %

$\Delta(M/C)^{Non-OECD}$	0.116 [1.97]		0.280 (0.51)	5.4 %
$\Delta(M/C)^{Non-OECD}$ *1970-85*		0.178 [3.13]		
$\Delta(M/C)^{Non-OECD}$ *1986-93*		0.093 [1.41]		
Intercept 1970-85	-9.13×10^{-4} [−1.12]	-1.04×10^{-3} [−1.25]		−7.6 %
Intercept 1986-93	4.25×10^{-3} [4.72]	4.32×10^{-3} [4.60]		35.4 %
$\overline{R}^2$	0.718	0.720		
Observations	68	68		
Industries	34	34		

Notes:
We weigh the regressions and the mean values by the average industry share of the manufacturing employment. Square brackets [ ] give White's heteroskedasticity-consistent *t*-statistics. The third column contains mean values and in the parentheses ( ) are standard deviations of the dependent and independent variables. The fourth column shows the contribution of each of the independent variables in specification (i).

Table 9 Employment of skilled and less skilled labor in Swedish manufacturing and non-manufacturing 1986 and 1996

Sector	Skilled labor			Less skilled labor			Skill share		
	1986	1996	Δ96-86	1986	1996	Δ96-86	1986	1996	Δ96-86
	Thousands		Percent	Thousands		Percent	Percent		
Manufacturing	86	128	48.8	844	623	−26.2	9.2	17.0	7.8
Non-manufacturing	679	933	37.4	2613	2090	−20.0	20.6	30.9	10.3

Source: SCB Regional Labor Statistics

Figure 1 Partial association between change in skilled labor wage bill share and change in knowledge capital

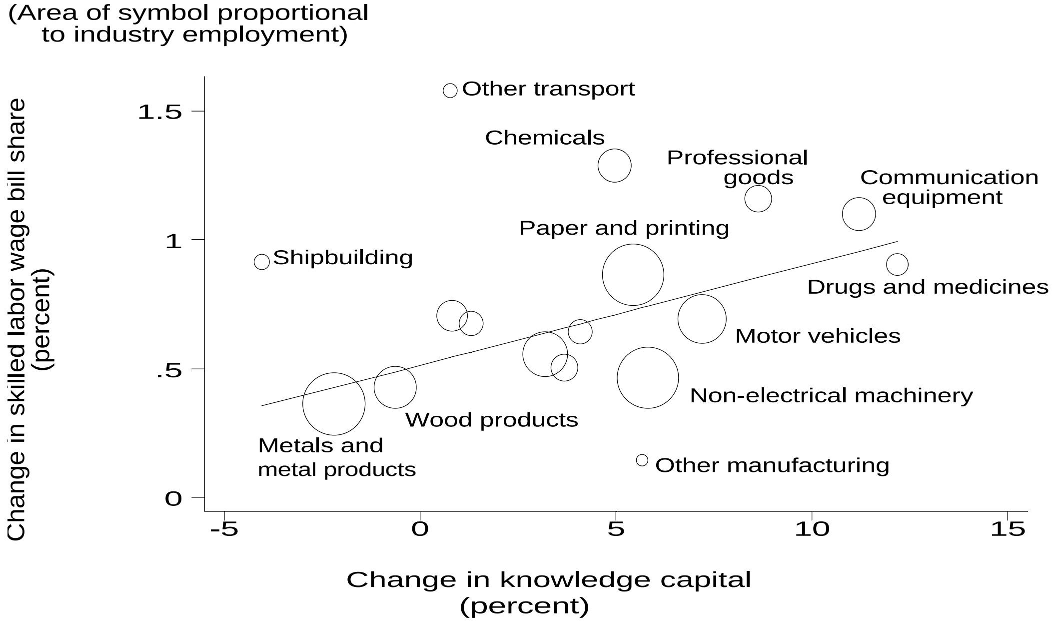


Figure 2 Partial association between change in skill share and change in non-OECD import competition over the periods 1970-85 and 1986-93

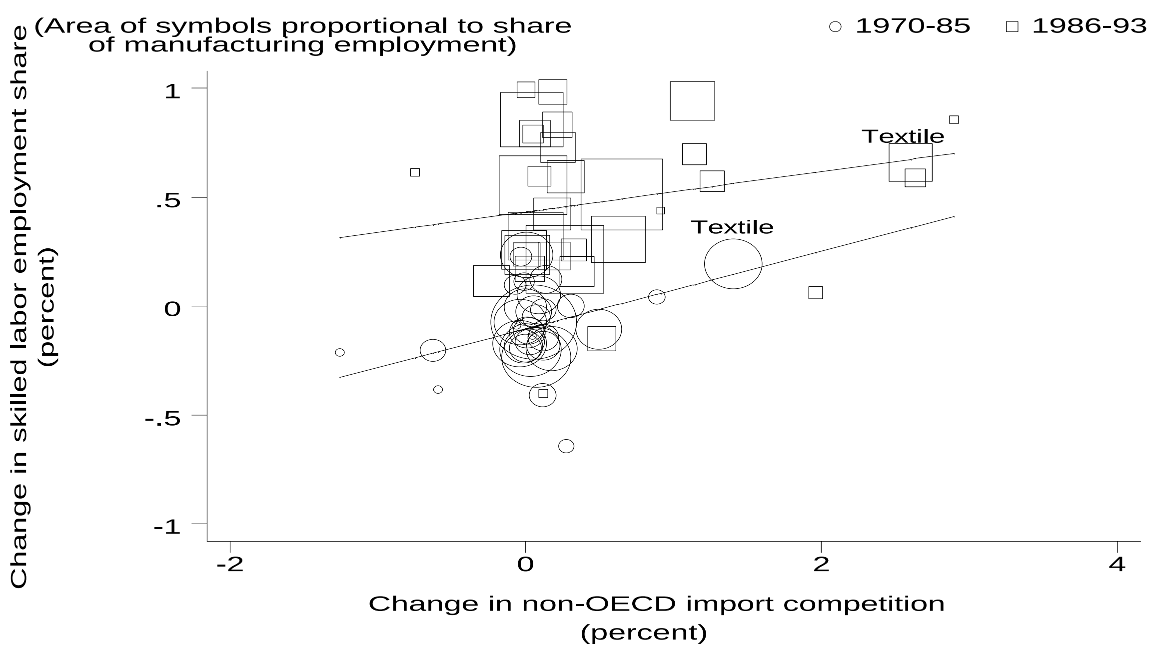
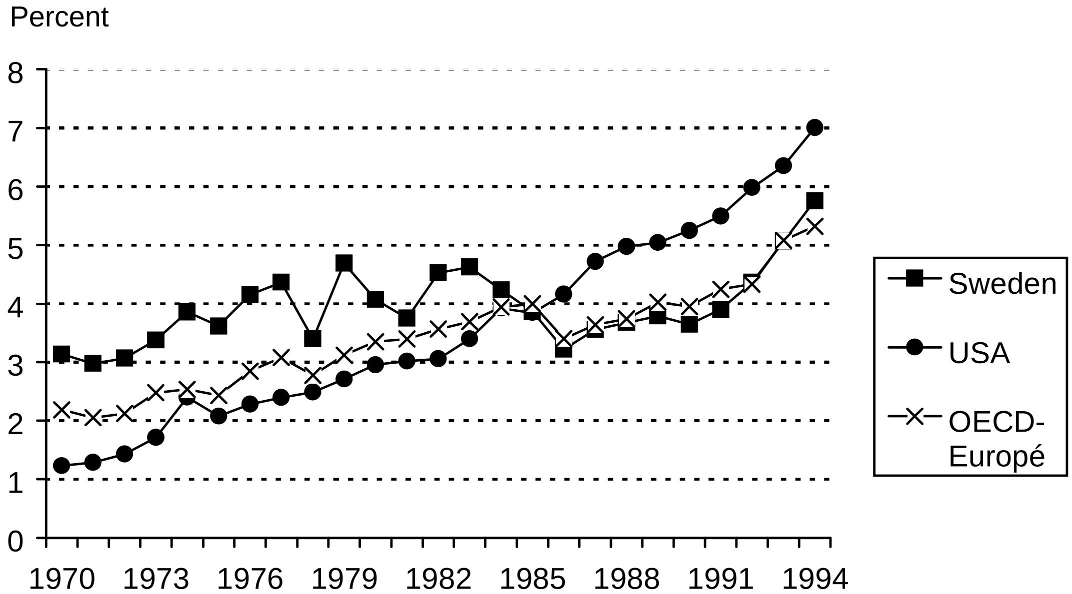
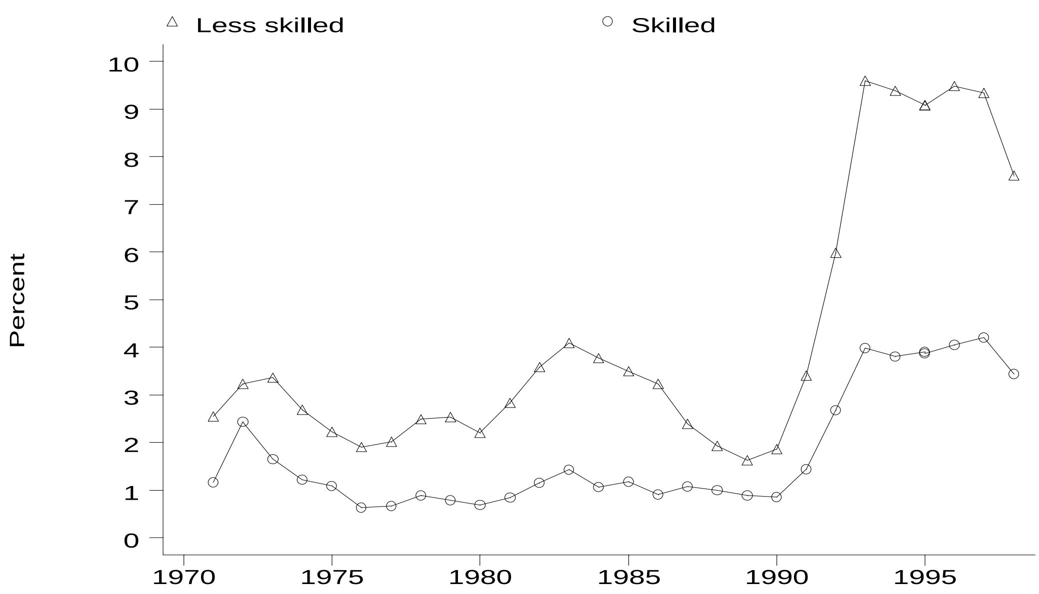


Figure 3 Non-OECD manufacturing import share in Sweden, the US and OECD-Europe 1970-94



Source: OECD (1998)

Figure 4 Unemployment rates by skill in Sweden 1971-98



Source: SCB Labor Force Survey (AKU)

Endnotes

[1] See, for example, Berman, Bound & Griliches (1994) for the US and Machin (1996) for the UK; Sweden is no exception, which is shown in Hansson (1997) and in section 3.2.
[2] The outsourcing argument has been elaborated and examined for the US in Feenstra & Hanson (1996, 1997).
[3] For example, Autor, Katz & Krueger (1998) and Machin & Van Reenen (1998).
[4] Among others, Autor, Katz & Krueger (1998), Bernard & Jensen (1997), Hansson (1997) and Machin & Van Reenen (1998).
[5] Surprisingly few studies have hitherto disaggregated imports by country of origin, as far as we know Anderton & Brenton (1998), Desjonqueres, Machin & Van Reneen (1997) and Machin & Van Reneen (1998).
[6] A complete derivation is given in, e.g. Berndt (1991) Chapter 9.4.
[7] Katz & Murphy (1992) get a point estimate of σ on aggregate level around 1.4 using U.S. annual time series information on relative wages and quantities of college- and high school equivalents. At the same time they make the reservation that there is substantial uncertainty concerning the magnitude of σ. Edin & Holmlund (1995) obtain, in a similar study on Swedish data, an estimate on σ of 2.9 between labor with upper secondary and university education. According to Freeman (1986) earlier estimates of σ tend to be between 0.5 and 2.5. Thus an assumption of $\sigma = 1$, which implies that $\beta_1 = 0$, is possible, but probably too low.
[8] The way our stocks of physical capital are constructed (see Appendix) means that we will not capture this effect in full, rather a vintage approach would have been more appropriate.
[9] The de-skilling hypothesis originates from Marx (1867) and was revived by Braverman (1974). Braverman's argument is essentially that capitalism has not changed. He asserts that work is getting more fragmented and monitored; there is a separation of conception from execution and the conceptual activities are concentrated on as few workers as possible.
[10] According to a study by the U.S. Bureau of Labor Statistics (1989) the mean lag for basic research appears to be five years and two years for applied research.
[11] An alternative, more elaborate, measure, suggested by Coe & Helpman (1995), would be to construct import-weighted R&D intensities. The idea is that trade is a mechanism through which technological knowledge is transmitted internationally. On the other hand, as Keller (1997) has noted, technology diffusion need not be related to goods trade, for example, in reverse engineering or attending conferences where the state-of-the art technology is demonstrated.
[12] Another factor that may boost technological changes is increased import competition. Some loose theoretical underpinning can be found in the literature on X-efficiency, e.g. Leibenstein (1966) and Horn, Lang & Lundgren (1995). The basic idea is that managers, in particular in oligopolistic industries, do not maximize profits. One reason may be that they prefer leisure before profit; another is that they appreciate the power and satisfaction an excess number of employees can afford. A rent-threatening disturbance, such as increased import competition, implies, however, that managers take action, for example, by eliminating excess labor or by introducing labor-saving techniques. Changes in the import share of consumption would capture this effect. However, the results in Hansson (1999) suggest that imports from all partners do not affect the relative demand for skilled workers.
[13] The R&D intensity *RD/Y* and the relative growth in knowledge stock $\Delta \ln S$ need not be highly correlated on industry level. After some manipulation of equation (3) we can show that: $\Delta \ln S = (RD/Y)(Y/S) - \delta$. Since we assume the depreciation rate of knowledge δ to be equal across industries, the relative change in the knowledge stock $\Delta \ln S$ is equal to the R&D intensity times the inverse of the knowledge-output ratio. Large knowledge-output ratios characterize R&D intensive industries. This means that $\Delta \ln S$ must not necessarily be high in R&D intensive industries.
[14] The Appendix in Hansson (1999) contains a presentation of the included industries in the two datasets.
[15] Most likely such a division of labor into skilled and less skilled is more appropriate than the often used, but criticized (e.g. Leamer 1994), non-production/production worker classification. Obviously, educational attainment has its imperfections too: it does not capture experience, it partially understates participation in further education and training, and there are variations in the quality of schooling over time and between regions/countries. However, educational attainment seems to be strongly correlated with occupation and earnings, and initial attainment is a good predictor of whether a person will participate in further education and training. Yet, with such a division into skilled and less skilled labor we miss a distinction which is very important within manufacturing, namely between skilled and less skilled manual workers; in Sweden, almost all manual workers have less than 12 years of education.
[16] Over the period 1970 to 1985, the Censuses of Population 1970 and 1985 are the only sources of data on educational attainment of the Swedish population. From 1986 onwards, there is annual data on educational attainment and wage incomes of the employees in ÅRSYS, SCB Regional Labor Statistics.
[17] Machin & Van Reneen (1998) examine a panel of 15 manufacturing industries in seven OECD countries, including Sweden, over the period 1970-90. The model setup is the same as ours but their dependent variable is

different since they apply the non-production/production worker definition of skill. They also exclude the transport industry (ISIC 384); in Sweden 1990, the transport industry had 14.3 percent of the employment in manufacturing.

[18] We have also experimented with the R&D intensity dated *t-2* and *t-3* and like other studies, e.g. Machin (1996), the precise dating is not important but produces very similar results. This is not surprising noting that most of the variation in the R&D intensity is between industries rather than over time. If we regress the R&D intensity over the studied industries and time period on industry and time dummies, we find that the *F*-value of the industry dummies is 59.27 (0.000), whereas the *F*-value of the time dummies is 1.27 (0.263), significance level within parentheses.

[19] The number of full-time employees in R&D in Sweden 1991 was 28 961, i.e. 3.5 percent of those employed in manufacturing.

[20] As an alternative to $(RD/Y)^{Sweden}$ we use the share of technicians of the employed in the beginning of each period, *TECH*, and the coefficient is positive and strongly significant (Hansson 1999). This implies that the labor demand is more skilled-biased in technology intensive industries.

[21] In this connection it can be appropriate with a word of caution. In our econometric analysis we assume that investments in plants and machinery and R&D expenditure are exogenous variables. Most economists would argue that these variables respond to profit opportunities, i.e. they are endogenous variables. Technological changes or increased globalization may affect expected profits so that investments in physical and knowledge capital increase and at the same time give rise to skill upgrading. Then we will observe a correlation between growth in physical and knowledge capital and higher skill shares, but the correlation is not causal. We should therefore be careful when we make causal interpretations of the results.

[22] These computations simply involve taking the mean of the independent variable in column (iv) multiplying it with its regression coefficient in column (iii) and taking that as a percentage of the mean of the dependent variable.

[23] In *Figure 1*, the dependent variable equals the residuals from a regression on all independent variables in the model in Table 2, columns (ii) and (iii), except for $\Delta \ln S$. The regression line is $0.513 + 0.039 \times \Delta \ln S$ and the t-value of the slope coefficient is 1.76. Unlike columns (ii) and (iii), we estimate the model on annualized nine-year changes over the period 1986-95.

[24] If we instead, in specification (iii), exclude $(RD/Y)^{OECD}$ the coefficient on $\Delta \ln K$ is 0.067 and on $\Delta \ln S$ 0.040.

[25] See Figures 1 and 2 in Hansson (1999).

[26] $\Delta \ln K = (K/Y)(I/Y) - \delta$ which means that even though the investment ratio is rather high $\Delta \ln K$ may be low due to a high physical capital-output ratio in the beginning of the period (cf. footnote 13).

[27] See, for example, Mishel & Bernstein (1996) and Autor, Katz & Krueger (1998).

[28] We use the share with post-secondary education of more than three years to obtain a comparable measure of skills that includes the 1960s.

[29] The annual average change in skill share was 0.44 percentage points between 1970-85, 0.66 between 1985-90, and 0.78 between 1990-95. For more details see Hansson (1999).

[30] Hansson & Lundberg (1995) Chapter 3.

[31] They estimate the following model: $\ln(W_u / W_g) = \beta_0 + \beta_1 T + \beta_2 \ln(L_u / L_g)$. Their dependent variable is the university/upper secondary log wage differential among male white-collar workers in mining, manufacturing and construction. $L_u(L_g)$ is the number of labor force participants with university (upper secondary) education and *T* is a time trend.

[32] This is indicated in Table 5, and is even more evident if we examine statistically whether the annual average rate of growth in skill shares within-industries differs between time periods. Hansson (1999) presents results showing that, in comparison with a reference period 1970-86, the growth rate is significantly higher in the later period 1986-93 and significantly lower in the earlier period 1960-70.

[33] Also worthy of remark is the fact that, whereas the coefficient on $\Delta \ln S$ in the 1970-85 period is insignificant, it is positive and strongly significant in the 1986-93 period (0.047 [3.57] *t*-value in square bracket).

[34] Machin & Van Reenen (1998) also obtain a positive and significant coefficient on $(RD/Y)^{OECD}$, while the inclusion of the spillover variable drives the coefficient on own R&D, in their study measured by the R&D intensity in Sweden $(RD/Y)^{Sweden}$, to insignificance.

[35] The coefficient on *TECH* is larger in the recent period, 1986-93, but yet not significantly different from the estimate in the earlier period. A test for structural differences over time shows that we cannot reject the hypothesis of equal coefficients over the two time periods on the variables in specification (ii).

[36] Hansson (1999) gives a detailed presentation of the effects of increased Southern competition on skill upgrading using all the different datasets.

[37] The empirical support in other studies, using an approach similar to ours, of the hypothesis that increased competition from the South has impaired the situation of the less skilled is meager. Anderton & Brenton (1998) examine the effects of increased Southern import penetration on the skill intensity (share of non-manual workers) in the UK textiles and non-electrical machinery sectors 1970-83. They obtain a large positive impact in textiles, while the effect in non-electrical machinery is smaller. Desjonquers, Machin & Van Reenen (1997) estimate bivariate regressions between changes in skill intensities (share of non-production workers) and increases in Southern import penetration in 16 manufacturing industries in ten developed countries between 1970-90 and find no association. It is noteworthy that if, in specification (i) Table 8 above, we exclude the technology indicator, *TECH*, the coefficient on $\Delta(M/C)^{Non-OECD}$ is insignificant. Finally, in the study of Machin & Van Reneen (1998) on 15 manufacturing industries in seven OECD countries, the relationship in Sweden between increased competition from the South and changes in skill intensities (share of non-production workers) is positive, but insignificant. In fact, they never get a positive and significant effect -- rather, in many cases, the coefficient has a perverse negative sign.

[38] The difference between the coefficients are 0.085 [1.27], t-value in square bracket.

[39] By the textile industry we mean ISIC 32, i.e. the industry contains textile, apparel, footwear and leather. Remarkably, the coefficient on $\Delta(M/C)^{Non-OECD}$ is insignificant if we exclude the textile industry.

[40] In textile (ISIC 32), the non-OECD import share of consumption increased from 6.5 percent in 1970 to 37.4 percent in 1993, while the textile industry share of manufacturing employment dropped from 9.8 percent 1970 to 2.7 percent 1993. The corresponding figures for the OECD (the same 12 OECD countries as in Table 1) are less dramatic. The import share started out from a lower level, 2.5 percent in 1970, and increased to 20 percent in 1993, while the employment share fell from 15.1 percent 1970 to 10.6 percent 1993.

[41] OECD-Europe is Denmark, Finland, France, Germany (West), Italy, the Netherlands, Norway and the United Kingdom.

[42] See Lundberg (1976) Table 4.4.

[43] In OECD the employment share fell from 28 percent 1970 to 19 percent 1994. OECD is the same 12 countries as in Table 1.

[44] Wood (1994) and Saeger (1997).

[45] Due to increased relative supply of skilled labor, as a result of the expansion of higher education, we may find rising skill shares both in the manufacturing and non-manufacturing sectors.

[46] This is consistent with the result in Desjonqueres, Machin & van Reenen (1997). They find that even within narrowly defined non-trade (non-manufacturing) sectors there is a shift towards increased skilled labor employment shares.

[47] The shock was a coincidence of, among others things, an international recession, a particularly sharp rise in real interest rates and a drastic fall in inflated asset prices, combined with an economic policy of non-accommodation. There was no expansion of domestic demand and the devaluation, at the end of 1992, was resisted to the very last. Higher unemployment in the private sector led to a substantial budget deficit and, to put the budget on a sound basis, the government carried out spending cuts (and tax increases), which in turn reduced employment in the public sector.

[48] Assume that a neutral adverse shock reduces employment in each skill group by x percent at given relative wages. The unemployment rates by skill will then increase by an equal percentage. In a second round there may be relative wage changes which push the unemployment effects from equality of percentage-point increases towards equiproportionate increases (Nickell & Bell 1996).

[49] If we regress the difference in unemployment rates on a time trend over the whole period 1971-98 we obtain a positive and highly significant coefficient on the time trend. If we instead exclude the very turbulent period in the Swedish labor market, i.e. the late 1980s (the Swedish economy was overheated and the unemployment rates were extremely low) and the 1990s, we still get a positive and clearly significant coefficient.

[50] Nickell & Bell (1996) and OECD (1997)