FIEF Working Paper Series 1999 ISSN 1651-0852

No. 152

Relative Demand for Skills in Swedish Manufacturing: Technology or Trade?*

by

Pär Hansson

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 concentrated to the 1970s and the beginning of the 1980s.

Keywords: Skill upgrading; Knowledge capital; Import competition; Outsourcing
JEL codes: F14; J31; O33

April 29, 1999

---

*This paper is part of a research project, Technology, Economic Integration and Social Cohesion, within the TSER programme of the European Commission. Financial support from the Swedish Council for Research in the Humanities and Social Sciences is gratefully acknowledged. I have benefited by comments from Linda Andersson, Lars Lundberg, Erik Mellander and Johnny Zetterberg. Correspondence should be addressed to Pär Hansson, FIEF, Wallingatan 38 4 tr, S-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[2] 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 to 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 which 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 in at least two different ways, through increased competition from the South and defensive innovation. We will show that industries, even if they are defined on the lowest level of industry aggregation, by no means are 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 shed off the most unskilled-labor intensive activities to overseas production in countries where unskilled labor is relatively cheap. The relative demand for skilled workers increase in the developed countries since the remaining activities then on average become more skill-intensive.[3] Defensive innovation implies that actual or threatened import competition

[2] 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.
[3] The outsourcing argument has been elaborated and examined for the US in Feenstra & Hanson (1996, 1997).

cause producers to rationalize production facilities and invest in unskilled labor-saving techniques.[4]

The purpose of the 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 & Grilliches (1994) deriving a labor demand function from a translog cost function and testing the effects of technology and trade at the industry level. 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.[5]

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 to 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 other factors that may influence the rate of technological change, such as international technology spillovers and defensive innovation. Many studies have examined the hypothesis that trade has deteriorated the position of less-skilled workers. Generally, growth rates in the shares of imports and exports in consumption (production) are included as explaining variables of shifts in skill structures. [6] We argue that growth in the share of imports in consumption is an indicator of increased import competition and we use this variable to examine the impact of defensive innovation. To test the influences of increased competition from the South more rigorously we have to disaggregate the import by country of

[4] The concept was coined in Wood (1994). He asserts that, essentially, it is import competition from the South that have these effects. We argue, however, basing our arguments on the X-efficiency literature, that it is increased import competition in general that give rise to this process.
[5] For example, Autor, Katz & Kreuger (1998) and Machin & Van Reenen (1998).

origin; in our analysis we let the import share be based solely on import from non-OECD countries.[7] We observe a small, positive impact of increased Southern import competition on the relative demand for skills in Swedish manufacturing. A common view, emphasized in Wood (1998), is that the increased globalization has accelerated the relative demand for skilled labor. However, the effect we find of growing Southern import penetration in Swedish manufacturing appears to be concentrated to the 1970s and the early 1980s.

Potentially, outsourcing could be a large threat to less-skilled in Swedish manufacturing since multinational enterprises are the dominating employers. We discuss this in the light of the localization pattern of Swedish multinationals and how the expansion of their foreign activities have affected the demand for labor at home.

The plan of the paper is as follows. In section 2, we outline the analytical framework and discuss 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 an acceleration in the relative demand for skills. Section 3.3 examines the effects of outsourcing and competition from the South on skill upgrading. 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.[8] Skilled and unskilled 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

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

[6] Among others, Author, Katz & Kreuger (1998), Bernard & Jensen (1997), Hansson (1997) and Machin & Van Reenen (1998).
[7] Surprisingly few studies have up to now disaggregated import by country of origin, as far as we know Anderton & Brenton (1998), Desjonqueres et. al. (1997) and Machin & Van Reneen (1998).
[8] A complete derivation is given in, e.g. Berndt (1991) Chapter 9.4.

where w_s and w_u are wage rates of skilled and unskilled 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 e_i gives our basic regression model

$$\Delta P_i^W = b_0 + b_1 \Delta \ln\left(w_s / w_u\right)_i + b_2 \Delta \ln Y_i + b_3 \Delta \ln K_i + b_4 \Delta \ln S_i + b_5 \Delta T_i + e_i \qquad (2)$$

The sign of b_1 depends on whether the elasticity of substitution between skilled and unskilled labor s is greater or less than one; b_1 is negative when s is larger than one.[9] Despite an opportunity to calculate relative wages -- by using the sum of labor income and the number of employed divided into skilled and unskilled categories on industry level -- we never estimate b_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 price changes are confounded with quality changes. On the whole, compositional changes (due to age and education) of the skilled and unskilled 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 unskilled, 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 b_0 or the coefficients of the time dummies in a panel study.

---

[9] Katz & Murphy (1992) get a point estimate of s 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 are 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 gymnasial and university education. According to Freeman (1986) earlier estimates of σ tend to be between 0.5 and 2.5. Thus an assumption of $s = 1$, which implies that $b_1 = 0$, is possible, but probably too low.

The estimate of b_2 shows whether the growth in output is related to changes in the wage bill share of skilled labor. If $b_2 = 0$, we cannot reject the hypothesis that the production function is homothetic.

The coefficient of $\Delta \ln K$ indicates whether skilled labor is complementary ($b_3 > 0$) or substitute ($b_3 < 0$) 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 comparative advantage in implementing new technology.[10] Computerization and other information technology upgrade the work force by automating toilsome and manual tasks and give workers more time to concentrate on conceptual and decision-making tasks. Other may argue that new technology de-skill the work force. Massproduction and other radical technological advances in the 19th century led to substitution of highly skilled artisans with physical capital, raw materials and unskilled labor.[11]

Similar arguments also applies to knowledge capital and the estimate of b_4 shows whether skilled labor is complementary ($b_4 > 0$) or substitute ($b_4 < 0$) to knowledge capital. To calculate knowledge capital stocks we use time series of R&D expenditure. Following Hall & Mairesse (1995) we use the formula

$$S_{it} = (1 - d_s) S_{it-1} + RD_{it-1} \tag{3}$$

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 d_S is the rate of depreciation of knowledge, i.e. the rate at which knowledge becomes obsolete. A benchmark S_{i1} is obtained as

[10] 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.

[11] 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.

$$S_{i1} = \frac{RD_{i1}}{g + d_s} \tag{4}$$

where g is the rate of growth of R&D (assumed constant over time). We assume a depreciation rate of knowledge d_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.[12]

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 of 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.[13]

Another factor that may boost technological changes is increased import competition. A theoretical underpinning can be found in the literature on X-efficiency.[14] The basic idea here 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

[12] 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.

[13] An alternative, more elaborated, 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.

[14] See Leibenstein (1966) and Horn, Lang & Lundgren (1995).

eliminating excess labor or by introducing unexploited labor-saving techniques. Changes in the import share of consumption $\Delta(M / C)^{All}$ would capture this effect.

In our models we use various types of technology indicators measuring different aspects of technological change. 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 to be available in industries at low levels of aggregation. Other strongly correlated variables are $(RD / Y)^{Sweden}$ and the R&D intensity in other OECD countries $(RD / Y)^{OECD}$. Yet the correlation is far from one (0.68), which indicates that it is not exactly the same industries that are R&D intensive in Sweden and are R&D intensive 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.[15]

[15] 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: $\Delta \ln S = (RD / Y)(Y / S) - d$. Since we assume the depreciation rate of knowledge d 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.

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. 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 annual changes. Our definition of skilled labor is based on educational attainment.[16] We define skilled labor as employees with a post-secondary education, i.e. with more than 12 years of education. The dependent variable in the panel study is changes in skilled labor wage bill shares ΔP^{W} and in the pooled dataset the dependent variable is changes in skilled labor employment shares ΔP^{E}.[17] The results from the panel are given in *Table 2* and from the pooled model in *Table 4*.

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)[18], we start in specification (i) by using the R&D intensity in Sweden in period $t-1$ as a technology indicator. We use lagged R&D intensity[19] 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

---

[16] Most likely, such a division of labor into skilled and unskilled 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.

[17] 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.

[18] 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.

[19] Other studies, for example Machin (1996), have shown that the precise dating (*t-1* or *t-2*) is not important but produce very similar results.

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.[20]

Our results conform with 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, which means that over the last decade R&D intensive industries have been more likely to increase their skill shares.

In specifications (ii) and (iii), we replace the Swedish R&D intensity with changes in knowledge capital. Then 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. The coefficient on the growth in knowledge capital is larger than the coefficient on the growth in physical capital and from column (v) we can see that the knowledge capital has grown faster than the physical capital. Using this in a back-of-the-envelope calculation in column (vi) we find that the growth in knowledge capital "explains" almost 20 percent of the overall change in the skill structure in manufacturing and the contribution of physical capital is a little less than 9 percent.[21]

The effects of potential international technology spillovers and increased import competition on the relative demand for skilled labor are positive but statistically insignificant. According to the evaluation in column (vi) international technology spillovers seem to have some economic impact while the influence of increased import competition is negligible.

In specification (iv) we replace our technology indicators with the share of technicians of the employed in the beginning of each period, *TECH*, which is positive and strongly significant. The labor demand is more skilled-biased in technology intensive industries.

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

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

Figure 1 R&D expenditures as a share of value added in manufacturing in Sweden and in OECD 1973-94

Source: OECD (1997) and OECD (1996)

Figure 2 Gross capital formation as a share of value added in manufacturing in Sweden and in OECD 1973-94

Source: OECD (1996)

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 own 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 *Figures 1* and *2; Figure 1* shows the R&D intensity in Sweden and in OECD (excluding Sweden) and *Figure 2* the investment ratio (gross capital formation as a share of value added). The gap between the R&D intensity in Sweden and the R&D intensity in other OECD countries has widened, whereas the investment ratios have fluctuated around the same level (15 percent). Calculations of the annual growth in the physical and the knowledge capital stocks in manufacturing, presented in *Table 3*, point out 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 studied period, can be explained by the fact that Sweden had a fairly high physical capital-output ratio in the middle of the 1980s.[22] Consequently, a great deal of the investments in buildings and machinery are replacements of depreciated capital.

[22] $\Delta \ln K = (K/Y)(I/Y) - d$ 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 15).

3.2 Acceleration in skill upgrading

An intriguing question is whether we can observe an acceleration in the relative demand for skills over the last decades.[23] To analyze this we have to extend the period under study. *Table 4* shows the development of the skill share in manufacturing between 1960 and 1995. We notice that 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 more than three years from just over 1 percent 1960 to a little less than 6.4 percent 1993.[24]

Table 4 Skill shares and annual changes in skill shares in Swedish manufacturing 1960-95

In *Table 4* we also 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. 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), increased supply of labor with higher education seems to have played the more important role. According to *Table 5*, the relative wages of skilled labor are falling over the period 1970-85. This implies that firms had an incentive to substitute unskilled 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.[25]

Table 5 Skilled-based relative wages in Sweden 1968-91

Table 5 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 to the relative wage changes are found on the supply side; a slowdown in the supply of educated workers in the mid-1980s. Against this tells the increased rate of change in the manufacturing

[23] See, for example, Mishel & Bernstein (1996) and Autor, Katz & Krueger (1998).
[24] We use the share with post-secondary education more than three years to obtain a comparable measure of skills that includes the 1960s.
[25] Hansson & Lundberg (1995) Chapter 3.

skill share (*Table 4*), despite slightly rising relative wages of skilled labor. In their analysis the demand side is rudimentary modeled. A time trend, which is positive and significant, is used to pick up influences of technological changes in a regression on relative wages.[26] Furthermore, they examine to what extent the 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 6 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 6*, we carry out such an 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 the skill share development in Swedish manufacturing.

Table 7 Employment share equations in Swedish manufacturing 1960-93

The rate of the within-industry shift towards higher skill shares has also been increasing over time and it is particularly strong during the late 1980s and in the beginning of the 1990s. This is shown in *Table 6* and is even more evident in *Table 7*, columns (i) and (ii). In column (i) we employ a dataset consisting of 21 manufacturing industries for three time periods 1960-70, 1970-86 and 1986-93 and in column (ii) the dataset is made up of 34 manufacturing industries and two time periods 1970-85 and 1986-93.[27] Using these datasets, we examine whether the annual average rate of growth in skill shares within-industries differs between the time

---

[26] They estimate the following model: $\ln\left(W_u / W_g\right) = b_0 + b_1 T + b_2 \ln\left(L_u / L_g\right)$. Their dependent variable is the university/gymnasium log wage differential among male white-collar workers in mining, manufacturing and construction. $L_u\left(L_g\right)$ is the number of labor force participants with university (gymnasium) education and T is a time trend.

[27] Due to the new industry classification we have to end the analysis in 1993.

periods.[28] The result in column (i) implies that, in comparison with the 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. In column (ii) we obtain a similar result; the rate of growth in skill shares within-industries is significantly higher during the more recent period.

To explain this pattern we estimate our preferred model in Table 3 (specification (ii)) for the two time periods 1970-85 and 1986-93 on the same 19 manufacturing industries as in the 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 (iii), we restrict all other coefficients to be 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. An interpretation is that the degree of complementarity between knowledge capital and skills has increased over time.

In contrast to our results in the panel study potential international technology spillovers have a positive and significant impact on the relative demand for skills. The influence of physical capital accumulation is insignificant, however, still yet positive. Finally, as in the panel study increased import competition has no effect on skill upgrading. The back-of-the envelope calculations in column (vi) indicate that there is a considerable contribution on the relative demand for skills from international technology spillovers and knowledge capital accumulation in the recent period, but also to some extent from physical capital accumulation.

In specification (iv) we use a 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 demonstrated, 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 (iv) we replace $\Delta \ln S$ and

[28] Notice that the definition of skilled labor differs between the two datasets: in column (i) employees with post-secondary education more than three years (1960-93) and in column (ii) all employees with some post-secondary education (1970-93).

$(RD/Y)^{OECD}$ with *TECH* and the coefficient on *TECH* is positive and strongly significant.[29] A notable difference in comparison with specification (iii) is the coefficient on physical capital accumulation, which in specification (iv) is larger and clearly significant.

3.3 Skill upgrading and competition from the South

An argument advanced against international trade as an explanation of increased relative demand for skills is the outcome from decomposition studies, such as we presented in *Table 6.* One has 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 6* 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, where final and intermediate products are produced with varying factor intensities. *Table 8* shows the variation in skill shares among plants within industries defined on the lowest level of industry aggregation in Swedish manufacturing.

Table 8 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

[29] 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 on the variables in specification (iv).

there has been, and still is, a great potential for specialization with respect to skill shares within-industries.

An 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 continue to carry out the high-skill intensive activities themselves, a firm can take advantage of lower wages of unskilled. 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 from domestic producers of low-skill intensive final or intermediate goods 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 in Table 2 and Table 7. 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 unskilled 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 9* presents the results from this analysis.

Table 9 Effects of increased competition from the South on skill upgrading in Swedish manufacturing, 1970-95

In column (i), we substitute $\Delta(M/C)^{Non-OECD}$ for $\Delta(M/C)^{All}$ in our preferred specification in the panel study of the period 1986-95 (column (iii) in Table 2). In columns (ii) and (iii), we do the same in our models in Table 7 of the period 1970-93. In columns (i) and (ii), the coefficient has the expected positive sign, but is not significant. In column (iii), where we use the more disaggregated dataset (34 manufacturing industries) and the variables based on R&D expenditures ($\Delta \ln S$ and $(RD/Y)^{OECD}$) are replaced with the share of technicians, *TECH,* the coefficient on $\Delta(M/C)^{Non-OECD}$ is positive and significant.[30]

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. A simple test of the hypothesis is to allow the coefficient on $\Delta(M/C)^{Non-OECD}$ to vary in specification (ii) and (iii) between the two periods. Contrary to Wood's hypothesis the estimates on $\Delta(M/C)^{Non-OECD}$ in columns (iv) and (v) are only significant for the earlier period (1970-85). They are, however, not significantly different from the coefficients in the later period (1986-93).

Evidently, the results in *Table 9* 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, at least during the 1970s and in the beginning of the 1980s. How important is this effect economically? Feenstra & Hanson (1996) detect considerable influences

---

[30] Notice that the coefficient on $\Delta(M/C)^{All}$ in Table 7 column (iv) is insignificant (positive). 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 low-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 et.al. (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. 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

on skill upgrading of increased import competition in US manufacturing using the same method we practice in Table 2 and Table 5 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 imports (together with the coefficient on $\Delta(M/C)^{Non-OECD}$), we begin our evaluation by demonstrating, in the *Figures 3* and *4*, how import competition progressed in Swedish manufacturing between 1970 and 1994. As a benchmark we show the development of imports in OECD (excluding Sweden)[31] manufacturing over the same period. *Figure 3* describes the share of total manufacturing import in consumption and *Figure 4* pictures the share of non-OECD manufacturing import.

Figure 3 Total manufacturing import share in consumption in Sweden and in OECD, 1970-94

Figure 4 Non-OECD manufacturing import share in consumption in Sweden and in OECD, 1970-94

In *Figure 3*, we observe a substantial increase in the share of manufacturing import in Sweden, as well as in other OECD countries. Concerning the non-OECD import share, in *Figure 4*, we see that Sweden differs from other OECD countries; the growth in the non-OECD import share has been slower. Accordingly, the increase in the non-OECD import share in total manufacturing import is negligible in Sweden (from 11 percent 1970 to 12 percent in 1994), whereas the rise is considerable in other OECD countries (from 16 percent in 1970 to 27 percent in 1994).[32]

Not surprisingly, we find, in *Table 9* column (vii), 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

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.

[31] OECD is the same 12 countries as in Table 1.

[32] In the US, this development is particularly pronounced. The non-OECD import share increased from 1 percent 1970 to 7 percent 1994 and the non-OECD import share in total manufacturing import from 23 percent 1970 to 41 percent 1994.

South. The corresponding figures for physical capital accumulation and our technology indicators are 30 percent and 35 percent.

Table 10 Employment in Swedish manufacturing and employment in Swedish MNE with affiliates abroad, 1990 and 1996.

Table 11 Employment of Swedish MNE in Sweden, in their OECD and non-OECD affiliates as a share of total Swedish manufacturing employment, 1990 and 1996. Percent.

Swedish-owned multinational enterprises (MNE) are the dominating employers in Swedish manufacturing and their role have strengthened over the past years. According to *Table 11*, a majority of the employed in Swedish manufacturing are working in Swedish MNEs (58 percent) and their share has been growing over the 1990s. *Table 10* shows that the bulk of the employment in Swedish MNEs is localized abroad (56 percent) and a decreasing share is employed in Sweden. Apparently, Swedish manufacturing firms are getting more involved in foreign production and their activities are increasing abroad.

The outsourcing hypothesis means that the effects of foreign production on the relative demand for skilled labor depend on characteristics of the host country. The conventional idea is that within the firms (unskilled) labor-intensive activities are allocated to low-wage countries. In *Table 11*, we see that Swedish MNEs have relatively little production in non-OECD countries. The great majority of their affiliates’ employment is concentrated to the high-income OECD countries. Hence, we would expect outsourcing to have small impact on the relative demand for skilled labor in Swedish manufacturing.

The results in Blomström, Fors & Lipsey (1997) are consistent with this conjecture. They study how an increase in the foreign activities of Swedish and US multinationals affect their demand for labor at home. They find that Swedish parents employ more labor at home, given the size of home production, when they invest more abroad. The positive association between employment at home and expansion abroad suggests either a need for more supervisory and other auxiliary employment within the parent or an allocation of labor-intensive production to the parent. The production of Swedish multinationals abroad seems to be complementary with employment of workers at home. For US multinationals, which have a relatively large share of their production in developing countries[33], foreign sales reduces employment at home, while controlling for sales in the parent firm. This indicates that their more labor-intensive activities have been allocated to affiliates in developing countries and thereby reduced the labor-intensity in their home production.

Accordingly, Feenstra (1998) concludes that outsourcing poses much less of a threat to unskilled labor in Sweden than is the case in the US. *Table 10* shows, however, a recent increase of the employment in Swedish affiliates in non-OECD countries. The main reason behind this development is an expansion in Central and Eastern Europe which may have affected the demand for labor within Swedish MNEs differently.

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 an 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 an acceleration in the relative demand for skills may be the rapid diffusion of computer technology. Author, Katz & Kreuger (1998) establish a strong positive relation between computer usage and skill upgrading and according to SCB (1995) the computer usage among the employed in Sweden has doubled between 1984 and 1995.

We 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 effect seems to be stronger in the 1970s and in the beginning

[33] See Braunerhjelm & Lipsey (1998)

of the 1980s; opposite to the idea that the recent globalization has spurred the relative demand for skills. Even though Swedish manufacturing is dominated by multinationals, their localization pattern, with the bulk of their foreign employment in other OECD countries, suggest that so far the impact of outsourcing on the relative demand for skills has been negligible. However, the recent expansion of Swedish MNE employment in Central and Eastern Europe may qualify such a conclusion.

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.

Author, D, Katz L. & Kreuger, 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.

Blomström, M, Fors, G. & Lipsey, R. (1997), Foreign Direct Investment and Employment: Home Country Experience in the United States and Sweden, *Economic Journal*, 107, 1787-1797.

Braunerhjelm, P. & Lipsey, R.E. (1988), The Geographical Specialization of US and Swedish FDI Activity, in Ekholm K. & Braunerhjelm, P., *The Geography of Multinational Firms*. Dordrecht: Kluwer.

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? Unpublished Paper, University College, London.

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*.

Feenstra, R. (1998), New Technology and Trade: A Threat to Low-Skilled Workers. *Swedish Economic Policy Review*, 5, 137-160.

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? Swedish Industrial Structure and Industrial Policy). 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.

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.

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

SCB (1995), *Datorvanor 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 are classified according to SNI69. After 1993 a new system of classification SNI92 is introduced. Concordance is possible to achieve on a fairly high level of aggregation.

Table A1 The 19 manufacturing industries

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)
To obtain capital stocks in industry no 5, 6, 12, 13, 15, 16 and 17 (Table A1) we break down stocks at higher level of aggregation in SCB (1996a) by means of unpublished book values of buildings and machinery from SCB Financial Accounts.

Real output Y: Value added, 1991 prices. Source: SCB (1997) and SCB (1995).
To get data for industry no 5, 6, 12, 13, 15, 16 and 17 (Table A1) we break down data on constant priced value added in SCB (1997) and SCB (1995) by means of data on value added at lower level of aggregation from various issues of SOS Manufacturing.

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:

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

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).
d_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

Table A2 The 34 manufacturing industries

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 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)

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

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).
d_S: Depreciation rate of knowledge (0.15)
Benchmark year 1967

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

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

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.

SCB (1998), Swedish owned enterprises having subsidiaries abroad 1993-1996. Nv15 SM 9801. Statistics Sweden, Örebro.

Table 1 Correlation matrix: Technology indicators

	$\Delta \ln K$	$\Delta \ln S$	$(RD/Y)^{Sweden}$	$TECH$	$(RD/Y)^{OECD}$	$\Delta(M/C)^{All}$
$\Delta \ln K$	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	
$\Delta(M/C)^{All}$	–0.131	–0.041	–0.074	–0.097	–0.027	1.000

Variable definition:

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

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, United Kingdom and United States.
Four extreme outliers for the variable $\Delta(M/C)^{all}$ have been excluded (ISIC 3841 1992-95 and ISIC 3845 1994-95).

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 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 2 Wagebill share equations based on a 19 manufacturing industry panel in Sweden 1986-95

Variables	(i) Regression	(ii) Regression	(iii) Regression	(iv) Regression	(v) Mean Value	(vi) Contribution
Dependent						
ΔP^W					0.800 (0.97)	
Independent						
$\Delta \ln Y$	–0.005 [–0.74]	0.002 [0.29]	0.003 [0.41]	–0.003 [–0.40]	2.105 (10.01)	0.8 %
$\Delta \ln K$	0.034 [2.34]	0.034 [2.23]	0.034 [2.19]	0.032 [2.13]	2.093 (5.02)	8.9 %
$\Delta \ln S$		0.041 [3.83]	0.041 [3.68]		3.811 (5.12)	19.5 %
$(RD/Y)^{Sweden}$	0.015 [2.92]				9.504 (14.34)	
TECH				0.040 [3.10]	7.976 (5.77)	
$(RD/Y)^{OECD}$		0.006 [0.51]	0.006 [0.50]		6.237 (7.35)	4.7 %
$\Delta(M/C)^{All}$			0.008 [0.45]	5.0×10^{-4} [0.03]	0.623 (4.22)	0.6 %
Time dummies	8.72 /0.00/	11.03 /0.00/	10.70 /0.00/	8.08 /0.00/		65.5 %
$\bar{R}^2$	0.484	0.496	0.499	0.492		
Observations	169	169	165	165		

Notes:
All regressions and mean values are computed over 19 industries for the period 1986-1995 and are weighted by the average industry share of the manufacturing wage bill. Four extreme outliers for the variable $\Delta(M/C)^{all}$ have been excluded (ISIC 3841 1992-95 and ISIC 3845 1994-95). In the regressions square brackets [ ] give White's heteroskedasticity-consistent *t* statistics and slashes / / the significance level of the *F*-test. The fifth column contains mean values and in parentheses ( ) are standard deviations of the dependent and independent variables. The sixth column shows the contribution of each of the independent variables in specification (iii).

Variable definition:

ΔP^W 100 × the change in the skilled labors' share in the wage bill

$\Delta \ln Y$ 100 × 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 4 Skill shares and annual average changes in skill shares in Swedish manufacturing 1960-95.

Year	Skill share		Period	Annual average change in skill share	
	Post-secondary ≥ 3 years	All post-gymnasial		Post-secondary ≥ 3 years	All post-gymnasial
1960	1.01		1960-70	0.051	
1970	1.51	2.56	1970-86	0.151	
1985		9.20	1986-95	0.272	
1986	3.93	9.02	1970-85		0.442
1990	4.69	12.49	1985-90		0.659
1993	6.15	15.43	1990-95		0.779
1995	6.38	16.30			

Notes:
The annual average changes are multiplied by 100. Data on employment before 1986 is from SCB (1991) and the source from 1986 onwards is SCB Regional Labor Statistics.

Table 5 Skilled-based relative wages in Sweden, 1968-91

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

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

Table 6 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 Employment share equations in Swedish manufacturing 1960-93

Variables	(i) Regression	(ii) Regression	(iii) Regression	(iv) Regression	(v) Mean value	(vi) Contribution
Dependent						
ΔP^E					0.599 (0.40)	
Independent						
$\Delta \ln Y$			0.040 [3.31]	0.028 [2.35]	0.370 (3.24)	2.5 %
$\Delta \ln K$			0.014 [0.64]	0.047 [3.13]	3.010 (1.63)	7.0 %
$\Delta \ln S$ *1970-85*			0.004 [0.26]		6.409 (2.78)	2.1 %
$\Delta \ln S \times$ *Dummy 1986-93*			0.051 [2.72]		4.000 (3.96)	18.4 %*
TECH				0.030 [5.38]		
$(RD/Y)^{OECD}$			0.015 [3.28]		5.165 (7.11)	12.9 %
$\Delta(M/C)^{All}$			–0.037 [–0.76]	0.003 [0.09]	0.977 (0.80)	–6.0 %
Intercept 1970-85	1.40×10^{-3} [4.39]	4.00×10^{-3} [6.98]	2.41×10^{-3} [2.04]	-5.09×10^{-4} [–0.61]		20.1 %
Dummy 1960-70	-0.95×10^{-3} [–2.11]					
Dummy 1986-93	1.51×10^{-3} [3.35]	4.00×10^{-3} [4.94]	2.68×10^{-3} [2.40]	5.39×10^{-3} [6.09]		42.5 %*
$\overline{R}^2$	0.313	0.258	0.832	0.699		
Observations	63	68	38	68		

Notes:
All regressions and mean values are computed over 34 industries (except in column (i), 21 industries, and in specification (iii), 19 industries) for the periods 1970-85 and 1986-93 (in column (i) also 1960-70). They are weighted by the average industry share of the manufacturing employment. In the regressions, square brackets [ ] give White's heteroskedasticity-consistent *t*-statistics. The fifth column contains mean values and in parentheses ( ) are standard deviations of the dependent and independent variables. The sixth column shows the contribution of each of the independent variables in specification (iii). * The contribution is calculated for the period coefficient, i.e. 0.055 for $\Delta \ln S$ 1986-93 and 5.09×10^{-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 Analysis of variance in skill shares among Swedish manufacturing plants within industries defined on the lowest level of industry aggregation

Variable	*F*-value	$\bar{R}^2$	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 $\bar{R}^2$. A more complete description of analysis of variance is given in standard textbooks in Statistics, for example Mendenhall, Wackerly and Scheaffer (1990).

Table 9 Effects of increased competition from the South on skill upgrading in Swedish manufacturing, 1970-95.

Independent variables	(i) Regression 1986-95	(ii) Regression 1970-93	(iii) Regression 1970-93	(iv) Regression 1970-93	(v) Regression 1970-93	(vi) Mean value	(vii) Contri-bution
$\Delta \ln Y$	0.002 [0.37]	0.042 [3.35]	0.032 [3.11]	0.041 [3.27]	0.032 [3.07]	0.218 (3.53)	1.2 %
$\Delta \ln K$	0.033 [2.17]	0.024 [0.94]	0.057 [3.43]	0.020 [0.78]	0.057 [3.41]	3.181 (1.80)	30.2 %
$\Delta \ln S$	0.040 [3.66]						
$\Delta \ln S$ *1970-85*		0.005 [0.31]		0.012 [0.70]			
$\Delta \ln S$ *1986-93*		0.052 [4.87]		0.054 [4.97]			
TECH			0.029 [4.95]		0.030 [5.01]	7.298 (5.57)	35.2 %
$(RD/Y)^{OECD}$	0.006 [0.56]	0.013 [3.30]		0.013 [3.56]			
$\Delta(M/C)^{Non-OECD}$	0.013 [0.54]	0.053 [0.79]	0.116 [1.97]			0.280 (0.51)	5.4 %
$\Delta(M/C)^{Non-OECD}$ *1970-85*				0.210 [2.02]	0.178 [3.13]		
$\Delta(M/C)^{Non-OECD}$ *1986-93*				0.021 [0.31]	0.093 [1.41]		
Time dummies	10.66 /0.00/						
Intercept 1970-85		1.75×10^{-3} [1.96]	-9.13×10^{-4} [–1.12]	1.21×10^{-3} [1.25]	-1.04×10^{-3} [–1.25]		–7.6 %
Intercept 1986-93		4.50×10^{-3} [5.89]	4.25×10^{-3} [4.72]	4.66×10^{-3} [6.00]	4.32×10^{-3} [4.60]		35.4 %
$\bar{R}^2$	0.498	0.829	0.718	0.834	0.720		
Observations	165	38	68	38	68		

Notes:

Dependent variable in column (i) is the change in skilled labors' wage bill share ΔP^W and in column (ii)-(v) the change in skilled labors' employment share P^E. The regressions and the mean values are weighted by the average industry share of the manufacturing employment (wage bill). In the regressions, square brackets [ ] give White's heteroskedasticity-consistent *t*-statistics and slashes / / the significance level of the *F*-test. The sixth column contains mean values and in the parentheses ( ) are standard deviations of the independent variables in column (iii); the mean and standard deviation of the dependent variable is 0.601 (0.39). The seventh column shows the contribution of each of the independent variables in specification (iii).

Table 10 Employment in Swedish manufacturing and employment in Swedish MNEs with affiliates abroad 1990 and 1996

Year	Manufacturing in Sweden	Swedish owned manufacturing multinational enterprise groups (MNE)						
		Sweden		OECD		Non-OECD		Total
	Thousands	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands
1990	789	443	46	436	45	89	9	968
1996	644	377	44	374	44	103	12	854

Notes: Mining and quarrying are included in manufacturing.
Source: SCB (1998) and SOS Manufacturing

Table 11 Swedish MNE employment in Sweden, employment in their OECD and non-OECD affiliates as a share of total Swedish manufacturing employment 1990 and 1996. Percent.

Employment	1990	1996
Sweden	56	58
OECD	55	58
Non-OECD	11	16

Source: SCB (1998)

Table A1 The 19 manufacturing industries

No	SNI69	SNI92	Industry
1	31	15+16	Food, beverages and tobacco
2	32	17+18+19	Textiles, apparel and leather
3	33	20+361	Wood products and furniture
4	34	21+22	Paper, paper products and printing
5	351+352–3522	23+24–244	Chemicals
6	3522	244	Drugs and medicines
7	353+354	*	Petroleum refining
8	355+356	25	Rubber and plastics
9	36	26	Stone, clay and glass
10	37+381	27+28	Metals and metal products
11	382	29+30	Non-electrical machinery
12	383–3832	31	Electrical machinery
13	3832	32	Communication equipment
14	3841	351	Shipbuilding
15	3843	34	Motor vehicles
16	3845	353	Aircraft
17	3842+3844+3849	352+354+355	Other transport equipment
18	385	33	Professional goods
19	39	36-361	Other manufacturing

* Petroleum refining is included in chemicals.

Table A2 The 34 manufacturing industries

No	SNI69	Industry
1	3111/2, 3116/7/8	Protected food industries
2	3113/4/5, 3119, 312	Import-competing food industries
3	313/4	Beverage and tobacco
4	32	Textile, apparel and leather
5	33111	Saw mills and planing mills
6	33 excluding 33111	Other wood industry
7	34111	Pulp
8	34112	Paper and paperboard
9	34113, 3412/9	Pulp, paper and paperboard products
10	342	Printing and publishing
11	351	Industrial chemicals
12	3522	Drugs and medicines
13	352-3522	Other chemicals
14	353	Petroleum refineries
15	354	Petroleum and coal products
16	355	Rubber products
17	356	Plastic products
18	36	Non-metallic mineral products
19	371	Iron and steal
20	372	Non-ferrous metals
21	381	Metal products
22	382	Non-electrical machinery
23	3831	Electrical industrial machinery
24	3832	Communication equipment
25	3833	Electrical appliances and housewares
26	3839	Electrical apparatus, nec
27	3841	Shipbuilding and repairing
28	3842	Railroad equipment
29	3843	Motor vehicles
30	3844	Motorcycles and bicycles
31	3845	Aircraft
32	3849	Other transport equipment
33	385	Professional goods
34	39	Other manufacturing

Figure 1 R&D expenditure as a share of value added in manufacturing in Sweden and in OECD 1973-94

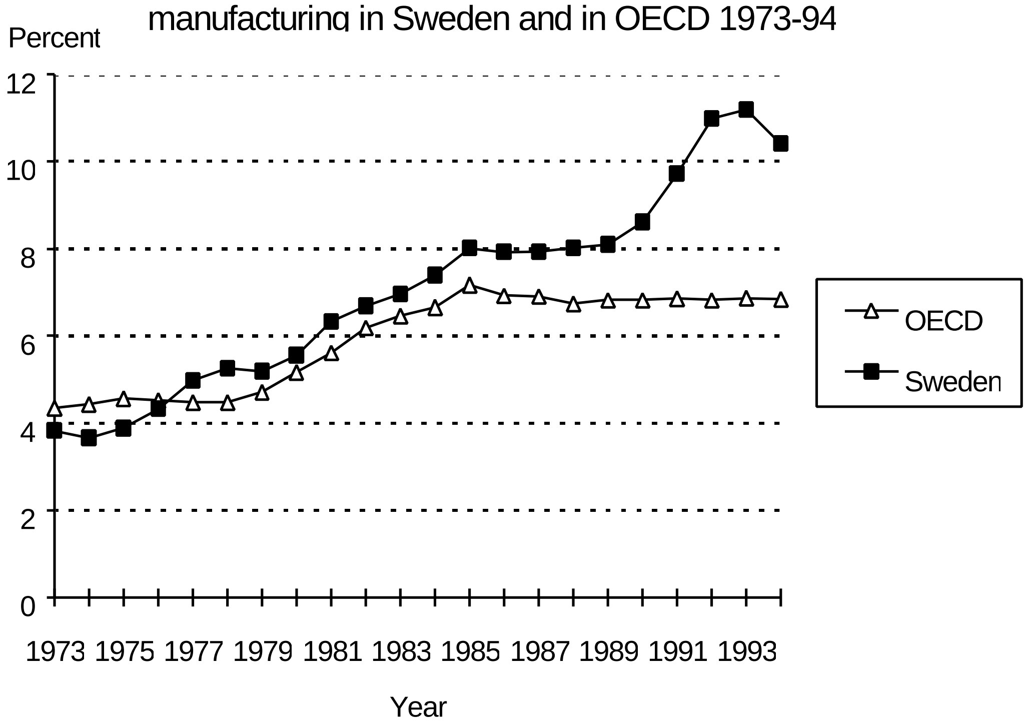
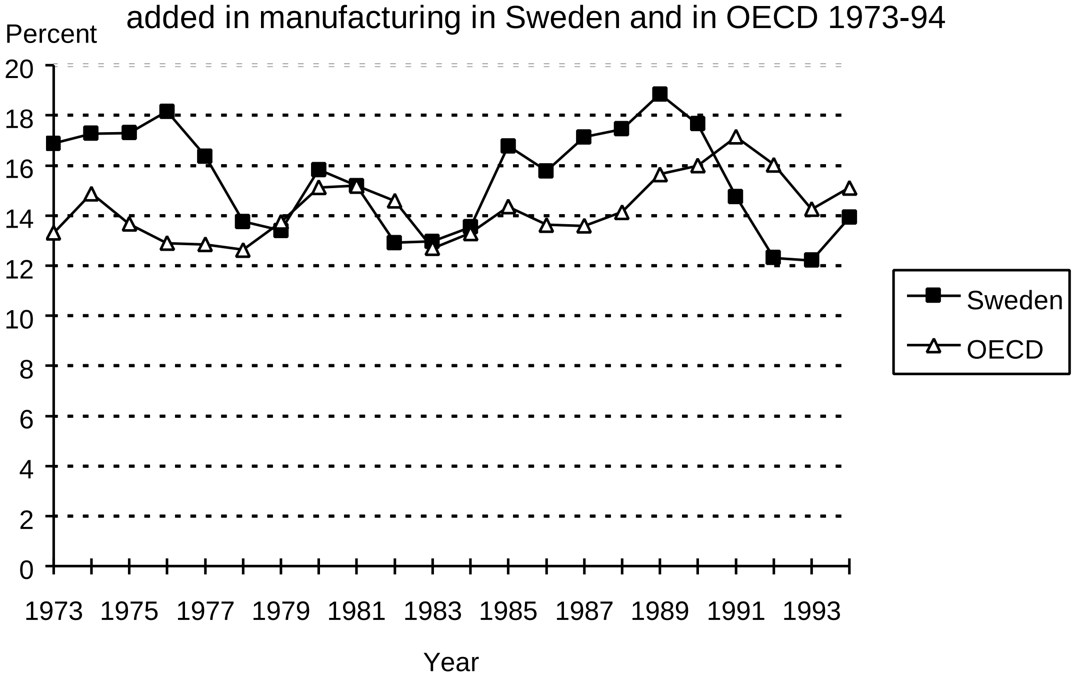


Figure 2 Gross fixed capital formation as a share of value added in manufacturing in Sweden and in OECD 1973-94



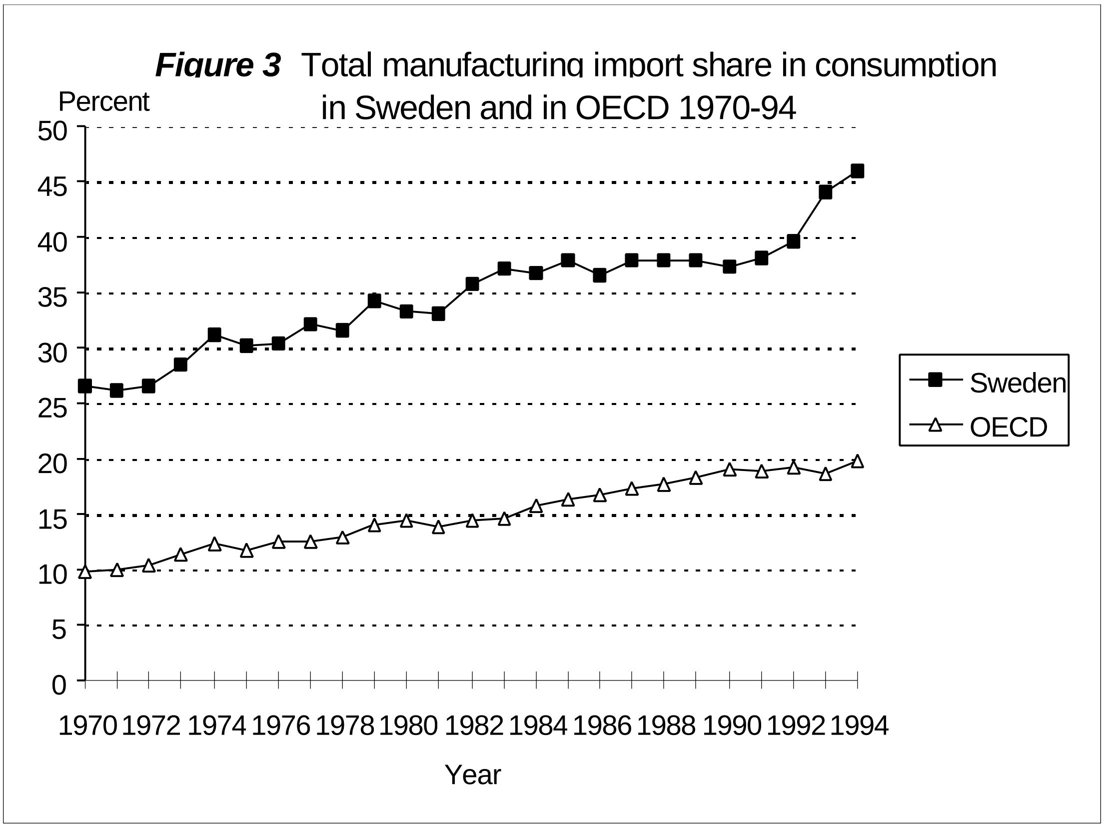


Figure 3 Total manufacturing import share in consumption in Sweden and in OECD 1970-94
Percent
50
45
40
35
30
25
20
15
10
5
0
1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994
Year
Sweden
OECD

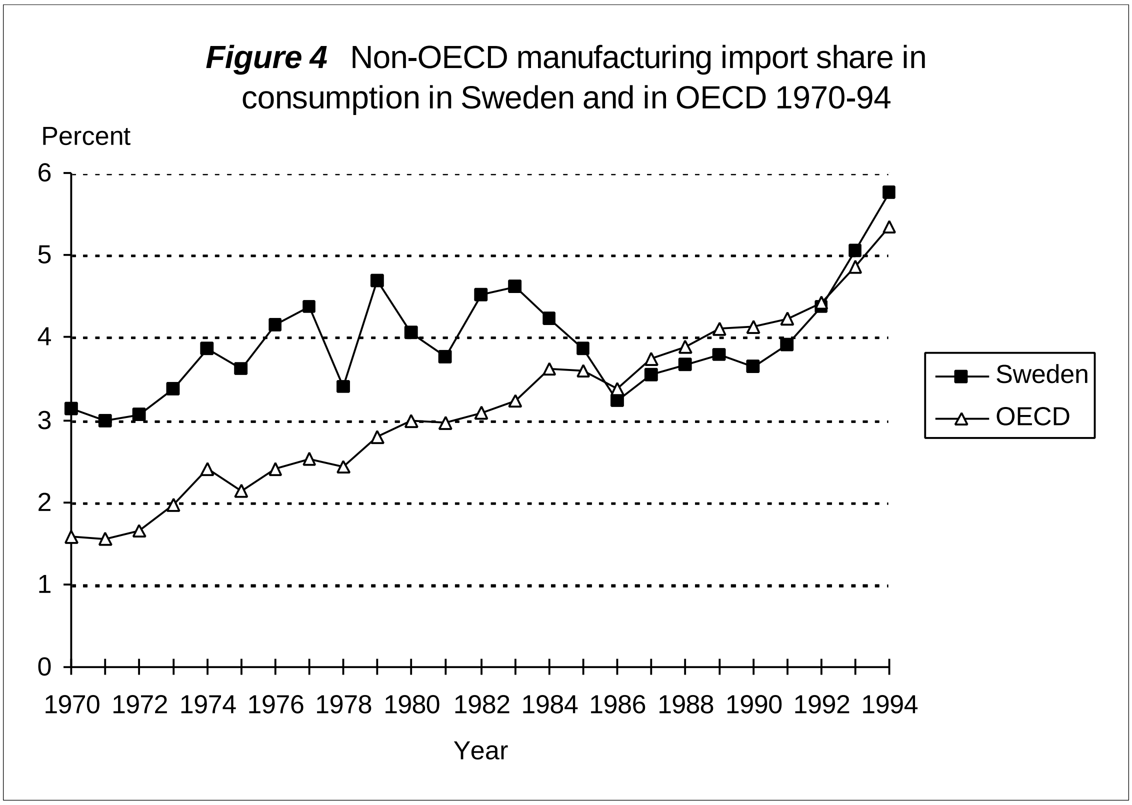


Figure 4 Non-OECD manufacturing import share in consumption in Sweden and in OECD 1970-94
Percent
6
5
4
3
2
1
0
1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994
Year
Sweden
OECD