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# On Measurements of the Factor Content of Trade: - The Case of Sweden

By

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**Abstract**

In this paper we evaluate different measurement practices when calculating the human capital content of a country's net trade. The calculations are performed using a structural measure developed by Lundberg & Wiker (1997) that relates the average factor input requirements in exports relative to those in imports. We find the calculations highly dependent on measurement practice when performing those on a cross-section for a single year. However, when calculating the human capital content of trade over time instead, the inclusion of service sectors in the trade vector as well as variable factor input requirements seem to be very important. This paper then continues with an empirical evaluation of the human capital content of Swedish trade in 1986-2000. We find that during the period 1986-1992, the average human capital intensity in exports relative to imports was slightly increasing, mirroring an increased specialization in human capital-intensive production. After 1992, though, there is a rapid decrease in the human capital content of trade in exports relative to imports. In 1995 there is a recovery, but the recovery seems both to be leveling out and turning down in the late 1990's. In this paper we also draw the conclusion that a well functioning educational system is important for a country's comparative advantage.

**Keywords:** Factor content of trade, educational policy, high skilled labor
**JEL classification codes:** F11, I28, J24

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# 1. Introduction

The Heckscher-Ohlin (H-O) theorem has over the years been exposed to rigorous investigations, ever since the seminal empirical critique due to Leontief (1953), who used data on input requirements and U.S. exports and imports, to measure capital-labor ratios in U.S. exports and imports separately. The results, known as the Leontief paradox, have generated considerable debate since then.

More recent empirical work has focused on the Heckscher-Ohlin-Vanek (HOV) version of the theory, originating from Vanek (1968)[1], who recognized that we could think of trade as the international exchange of the services of factors of traded goods.[2] This allowed for an extension of the H-O theorem, from a two-factor model to a *n*-factor model and, hereby, made it possible to test. The HOV-theorem shows that, if trade is balanced, countries will have an embodied net export of factors in which they have an abundant relative endowment and a net import of factors in which they have a scarce relative endowment, where abundance and scarcity are defined in terms of a factor-price-weighted average of all resources.

The present study aims partly to estimate the factor content of Swedish trade. In doing so we will focus on one particular factor, viz. human capital, since labor - skilled or unskilled - has low mobility compared to commodities, many services and physical capital.[3] Because of this, countries' endowments of human capital will be increasingly important in the determination of a country's comparative advantage, and hereby of industrial location, international specialization and trade. As it turns out, the procedure to measure the factor content of Swedish trade opens up a number of questions about how to measure the different concepts involved in the calculations. In some cases, due to lack of data or for simplicity, in other because there are in practice several ways open and none is given *a priori* from theory. This constitutes the second aim of this study. To illustrate the importance of these choices, we actually calculate the human capital content of Swedish trade according to different alternatives and compare the results to see whether the choice matters or not.

Why is this important? As will be clear later in the study, conclusions drawn from cross-sectional factor content of trade calculations, i.e.

[1] To some extent even from Travis (1964) and Melvin (1968).
[2] It was Leamer (1980) who introduced the HOV-theorem into the Leontief paradox literature.
[3] Due to financial capital mobility.

calculations done for a single year do depend on how we measure the factor content of trade. A country that has been revealed to have a comparative advantage in a factor, and therefore is a net exporter of this factor, could actually be revealed by trade to have a comparative disadvantage in this factor instead, due to measurement practice. This could disturb implications for governments using the outcome from factor content of trade calculations when deciding, for example, which educational programs to support or not. This is important for the future, since current endowment of skilled labor is heavily influenced by past educational policy.

If we draw conclusions from the development of the factor content of trade over time instead, the choice of measurement takes on importance, it seems, when calculating the factor content of trade using the whole trade vector, i.e. inclusive of the service sectors, and when using variable factor input requirements in the calculations.[4]

The remainder of this paper is divided into six chapters, including this introduction. In the next chapter, we derive the HOV-equation. In the following chapter, we survey the HOV-literature. First, we survey literature calculating the human capital/skilled labor content of trade and secondly we survey literature conducting factor content of trade studies on Swedish data. In chapter four we address several measurement problems that arise from calculating the human capital content of trade. Next, in chapter five, we calculate and examine the Swedish factor content of trade in skilled labor over the period 1986-2000. These calculations are based on the conclusions drawn from chapter 4. Conclusions and final remarks are provided in the closing chapter.

# 2. Theory[5]

The standard multifactor, multicommodity, and multicountry setting model for predicting factor services trade is the Heckscher-Ohlin-Vanek (HOV)-model. The basic assumptions behind the HOV-model are identical technologies across countries; identical and homothetic preferences across countries; differing factor endowments; free trade in goods and services; and no factor intensity reversals. If all countries have their endowments

[4] The concept of variable factor input requirements is explained in chapter 4.
[5] This section is based on Feenstra (2004).

within their cone of diversification, this indicates that factor prices are equalized across countries.[6]

Let $c = 1,\ldots,C$ index countries; $i = 1,\ldots,I$ index industries; and $f = 1,\ldots,F$ index factors. Let $\mathbf{A} = \left[a_{if}\right]'$ be the amount of production factors used to produce one unit of output in each industry, where the rows of the matrix measure the different factors and the columns measures the different industries. This $\mathbf{A}$ matrix should measure the total factor demand, i.e. direct plus indirect use of input factors, since the total factor intensities are relevant for the explanation of trade flows in the case with more traded goods than factors.[7] This is easily done by post-multiplying the matrix $\mathbf{A}^{\mathbf{c}}_{\mathbf{direct}}$ with the Leontief-inverse,

$$\mathbf{A}^{\mathbf{c}}_{\mathbf{total}} = \mathbf{A}^{\mathbf{c}}_{\mathbf{direct}}\left(\mathbf{I} - \mathbf{B}^{\mathbf{c}}\right)^{-1} \tag{1}$$

where $\mathbf{A}^{\mathbf{c}}_{\mathbf{direct}}$ is the direct factor input requirements for country *c*, $\mathbf{I}$ is the identity matrix and $\mathbf{B}^{\mathbf{c}}$ is the technical coefficients matrix computed from the domestic input-output table for country *c*.

Let $Y^c$ be the $(\mathbf{I} \times \mathbf{1})$ vector of each industries output; $D^c$ be the $(\mathbf{I} \times \mathbf{1})$ vector of demand for each good; then the net-export vector can be written $\mathbf{T}^{\mathbf{c}} = \mathbf{Y}^{\mathbf{c}} - \mathbf{D}^{\mathbf{c}}$. The factor content of trade, i.e. the $(\mathbf{F} \times \mathbf{1})$ vector of net trade in factor services, can then be defined as $\mathbf{F}^{\mathbf{c}} \equiv \mathbf{A}^{\mathbf{c}}\mathbf{T}^{\mathbf{c}}$. With identical technologies across countries and factor price equalization we can write $\mathbf{A}^{\mathbf{c}} = \mathbf{A}$. The interpretation of $\mathbf{F}^{\mathbf{c}} \equiv \mathbf{A}\mathbf{T}^{\mathbf{c}}$ is straightforward: a positive value of an element in $F^c$ indicates that the factor is exported and a negative value indicates that the factor is imported.[8]

The goal of the HOV-model is to relate the factor content of trade to the underlying endowments of production factors in the country. If we calculate $\mathbf{A}\mathbf{Y}^{\mathbf{c}}$, the demand for factor *f* in country *c*, and if we use the assumption of full employment of all resources, we can write: $\mathbf{A}\mathbf{Y}^{\mathbf{c}} = \mathbf{V}^{\mathbf{c}}$, where $V^c$ is the endowment of factor *f* in country *c*. With factor price equalization, free trade and that the consumers in all countries have identical and homothetic taste, a country's consumption vector must be proportional to world consumption, i.e. $\mathbf{D}^{\mathbf{c}} = \mathbf{s}^{\mathbf{c}}\mathbf{D}^{\mathbf{w}}$. The term $s^c$ is country *c*'s

[6] The presence of non-tradables can be ignored as long as we have factor price equalization. See Davis & Weinstein (2001c).
[7] See Hamilton & Svensson (1983) or Deardorff (1984).
[8] This is the part of the HOV-model that we focus on in this study.

proportion of world consumption (adjusted for the trade balance) and $D^w$ is the world consumption. Since world production is equal to world consumption, due to the full employment assumption, we get:

$$\mathbf{AD^c = s^cAD^w = s^cAY^w = s^cV^w} \quad (2)$$

Together with the expressions for $AY^c$ and $AD^c$ we will get,

$$\mathbf{F^c \equiv AT^c = V^c - s^cV^w} \quad (3)$$

which is the HOV-equation. The left hand side of the equality sign is sometimes labeled the production side of the theorem or the *measured* factor content of trade, and the right hand side is sometimes labeled the absorption/consumption side of the theorem or the *predicted* factor content of trade. For an individual factor *f*, equation (3) will look like,

$$\mathbf{F_f^c = V_f^c - s^cV_f^w} \quad (4)$$

If country *c*'s endowment of factor *f* relative to world endowment of that factor exceeds country *c*'s share of world GDP, i.e.

$$\frac{\mathbf{V_f^c}}{\mathbf{V_f^w}} > \mathbf{s^c} \quad (5)$$

country *c* is abundant in factor *f*.

# 3. Literature survey

The seminal empirical critique of the Heckscher-Ohlin trade model is, as we mentioned in the introduction, the Leontief study from 1953 where he calculated labor-output ratios and capital-output ratios for a number of industries in the U.S. economy. Using these coefficients, he then calculated the amount of labor and capital embodied in U.S. imports and exports and found that the capital-labor ratio embodied in imports exceeded the ratio embodied in exports by approximately 30 %. This became a surprise at that time, and to some extent it still does, since the U.S. were considered the most capital rich country in the world, and this result has ever since been labeled the Leontief paradox.

This paradox has generated a big literature over the years.[9] In 1980, however, did Leamer show that Leontief actually had applied the wrong

[9] See the surveys by Deardorff (1984), Leamer (1984) and Feenstra (2004).

test of the Heckscher-Ohlin model. He showed that a comparison of capital-output ratios in exports and imports were theoretically inappropriate. Leamer used the HOV-model and Leontief data for the United States in 1947 to show that the U.S. actually was revealed by trade to be capital abundant.

In an influential article in 1981 Leamer & Bowen emphasized the importance of using separate measures of all three concepts of the HOV-model, viz. trade; factor input requirements, and factor endowments, when testing the HOV-model appropriately. One of the first studies following this method were performed by Bowen, Leamer & Sveikauskas (1987), BLS for short, who used the U.S. 1967 input-output table together with trade in 1967 and the 1966 supply of twelve resources (factors) for 27 countries to compute the factor content of net exports. The factors embodied in trade were then compared with actual endowments to determine the extent to which data conform to the HOV-calculations. They used both rank- and sign tests[10] to test the theory and the results from those tests showed that the HOV-calculations did no better than a coin-flip. This study introduced a new line of empirical tests that focused on relaxing the underlying assumptions of the HOV-model. In the BLS study they found support for a model that allows for technological differences and non-proportional consumption. Other studies following this new line are for example Trefler (1993) and Trefler (1995), which are described in a survey by Leamer & Levinsohn (1995).

Most of the literature mentioned above concerns, primarily, tests of the Heckscher-Ohlin trade model and other models derived from various relaxations of the underlying theories of the HOV-model. The remaining two parts of this literature survey will first cover studies that focus on calculations of the human capital/skilled labor content of trade. The second part will focus on studies that are performed completely or partly using Swedish data.

## *3.1 Human capital/skilled labor*

Before we survey the human capital content of trade literature, we need to define what we mean by human capital. Since human capital (or skilled

[10] The rank test makes a comparison of all factors for each country in the study in pairs and ranks them, i.e. if country A is found to be relatively more abundant in factor *f* than factor *k* relative to country B, then net exports by country A relative to country B of factor *f* will be greater than net exports by country A relative to country B in factor *k*. The sign test compares the sign of the actual relative factor contents of trade between two countries with the sign of the predicted relative factor contents of trade.

labor) is not a homogeneous factor of production[11], it could be measured in several ways. A broad definition includes all characteristics of the labor force that gives in return a higher productivity of the workers. In this study, we will use educational attainment as our measure of human capital, because of-the-job and on-the-job training is hard to measure. When using educational attainment levels as the measure of human capital, we have to have in mind the following restrictions; i) there is no clear cut correspondence between educational proficiency and vocational aptitude; ii) that educational systems differ slightly between countries and; iii) the educational attainment level measure does only include formal education and not informal education and training. In the literature, we can find several different measures of human capital. For example, Kenen (1965) use earning differences, Lundberg & Wiker (1997) use educational attainment and BLS (1987), Webster (1993), Maskus, Sveikauskas & Webster (1994) and Engelbrecht (1996) use occupational status.[12]

Kenen (1965) uses wage differences between different occupational categories, such as professional-, clerical- and operative workers; and blue color workers (laborers) to reflect the gross return of capital invested in the labor force. His calculations, using U.S. and U.K. data, reversed the factor intensities compared to those from Leontief (1953).

Lundberg & Wiker (1997) calculate the factor content of services of skilled labor (classified by level of educational attainment) embodied in trade in manufactures for a sample of OECD countries for the period 1970-1985. They use the Swedish input-output table for 1985 for all countries and all years. Moreover, they use Swedish data for 1990 on employment by education and by four-digit SNI69[13] industry code for all countries and all years. The study investigates what role skill intensive production has on the trade pattern of the OECD countries. Human capital is treated as one single and separate factor of production in their study. The authors end up stressing the crucial role of the domestic education system, since it is an important determinant of a country's comparative advantage.

In the study by BLS (1987) they use data on seven occupational categories[14], among other factors, and they calculate the factor content of

[11] At least not in the short run.
[12] According to Brecher & Choudry (1988), when deciding upon which skill measure/s to use, it is important that any particular skill category is genuinely distinct from another.
[13] This is the Swedish ISIC rev.2 analogue.
[14] The categories are: professional/technical workers, managerial workers, clerical workers, sales workers, service workers, agricultural workers and production workers. They also include total labor as a production factor.

trade for several countries. The authors show, for example, that U.S. trade reveals the United States to be most abundant in professional and technical workers among the several labor categories. In the same study, they also calculate the factor content of trade for the same factors for 27 countries, including Sweden, and Sweden is here revealed to be abundant in all labor categories except agricultural workers.

Webster (1993) use data on 35 different occupational categories together with skill requirements of U.K. net exports in 1984. He finds that U.K. is revealed by trade to be abundant relative to unskilled labor in almost all categories of professional labor, i.e. accountants, lawyers and other professionals.

In Maskus, Sveikauskas & Webster (1994) they present evidence on the factor intensity of U.K. and U.S. trade with selected countries[15], using factor content of trade calculations. They use data on 74 occupational categories and finds that both U.K. and U.S. are revealed to be abundant in similar factors.
Finally, Engelbrecht (1996) calculates the human capital content of trade in West Germany in 1976, 1980 and 1984 using highly disaggregated skill variables (43 occupational categories). The main conclusion from the study is that West Germany is by trade revealed to be abundant in certain skilled manual workers (i.e. metalworkers, toolmakers, locksmiths, mechanics and chemical-workers).

## 3.2 Factor content of trade in Sweden

Studies concerned with calculating the factor content of net exports using the Leontief input-output technique and using Swedish data only, are very few. One is a study by Flam (1981) who calculated the direct factor content of Swedish exports and imports in 1959, 1966 and 1974 and total factor content in 1966. He found that Swedish exports were on average more capital intensive than Swedish imports for all years, when capital intensity were measured as flows of factor services. The results were less clear when capital intensity was measured from stock data.

One other study is by Norberg (2000) who analyzes the factor content of Swedish regions' net trade in 1995 and compare this to the predictions of the HOV-model. This study belongs to a strand of studies that have tested

[15] The countries are divided into developed countries, LDC's and EC. They also use bilateral trade data and compare the U.K. and the U.S.

the HOV-model in a setting that corresponds closer to the underlying assumptions.[16] Since she is using regions instead of countries, the assumptions of identical technologies, identical and homothetic preferences, free trade etc. are easier to accept compared to the multicountry case. Norberg uses data on two labor categories, viz. labor with secondary education and labor with higher than secondary education and she finds that the HOV-model is a poor predictor of Swedish region's trade.

Studies calculating the factor content of trade for several countries, including Sweden, are easier to find. The earliest study was performed by Keesing (1965), who calculated the factor content of trade of a subset of Swedish export and import. He found that Sweden had a comparative advantage in skilled workers compared to unskilled ones in 1957. His results are based on the assumption that each country in the study has the same labor skill combinations to produce each product as the U.S. Other studies that fall into the multicountry category are BLS (1987), Torstensson (1992, 1998), Lundberg & Wiker (1997) etc., who find that Sweden is revealed by trade to be abundant in skilled labor.

To summarize chapter 3, many studies, although primarily testing the HOV-model, actually reveal by trade that various types of skilled labor/human capital[17] are important sources for a country's comparative advantage. Most of the factor content of trade studies that are using Swedish data only and those that are only partially using it reveal by trade that Sweden is abundantly endowed in skilled labor.

# 4. On net factor content of trade

Does it matter how we measure the factor content of net trade? To be able to answer this question, we first need to derive the equation that we will use to highlight the different measurement problems to come. If we use equation (3), we may write net trade in embodied services of production factors *f* for country *c*, i.e. an element in $AT^c$, and summing over industries *i*, as

$$F_f^c = \sum_{i=1}^{I} X_i^c a_{ifc} - \sum_{i=1}^{I} M_i^c a_{ifc} = \sum_{i=1}^{I} X_i^c \sum_{i=1}^{I} x_i^c a_{ifc} - \sum_{i=1}^{I} M_i^c \sum_{i=1}^{I} m_i^c a_{ifc} \tag{6}$$

[16] Another study using the same idea is Davis et al (1997). The other strand of research was discussed in chapter 3 above and they have focused on relaxing the underlying assumptions.
[17] Measured by earning differences, educational attainment, or occupational status.

where $X_i^c$ and $M_c^i$ are exports (imports) from (to) industry *i* in country *c*, $x_i^c$ and $m_c^i$ the share of the *i*th industry in the total exports (imports) from (to) country *c*, and $a_{if}$ the total use of factor *f* per unit of production from the *i*th industry.[18]

The comparison of the factor content of trade can be written in difference form, as in equation (6) above, or as a ratio,

$$z_{fct} = \frac{\sum_{i=1}^{I} x_{it}^c a_{ifct}}{\sum_{i=1}^{I} m_{it}^c a_{ifct}}. \tag{7}$$

The *z*-measure has a simple interpretation, i.e. the average[19] requirements of a factor *f* per unit of exchange[20] of exports, compared to the average requirements of the imports. This will give us information about the difference in export- and import structure with respect to a particular factor's intensity in products and services, regardless of the trade balance.[21] We have included an extra subscript *t* in equation (7), indicating that we are interested in the development of *z* over time.

In the literature, the $F_f^c$ measure is predominant when measuring the factor content of trade since the greater part of the literature is concerned with testing the performance of the Heckscher-Ohlin-(Vanek) trade model. This $F_f^c$ measure is often changed to cover modifications due to relaxations of the underlying assumptions of the HOV-model. In a study by Lundberg & Wiker (1997) though, they construct other measures, such as the *z*-measure used in this study, and a measure that relates $F_f^c$ to endowments of factor *f*, i.e. $V_f^c$. This latter measure will give us information about the relative relation between measured factor content of trade and the country's own relative endowment.

The $a_{ifct}$ variable in equation (7) are the elements of matrix A and they have been calculated from the definition of factor content of trade, i.e.

$$\mathbf{F_f} \equiv \mathbf{AT} \tag{8}$$

[18] We can also write this as: $F_f^c = \sum_{i=1}^{I} X_i^c a_{ifc} - \sum_{i=1}^{I} M_i^c a_{ifc} = \sum_{i=1}^{I} T_i^c a_{ifc}$, where $T_i^c$ is net-exports for industry *i* in country *c*.

[19] Weighted by trade shares.

[20] In thousands of Swedish kronor.

[21] See Lundberg & Wiker (1997) for further details.

Since we are focusing on human capital as the only factor of production, the **AT** vector refers only to trade in services of skilled labor. Skilled labor is here measured as labor with at least a post secondary educational attainment level. An individual entry in the direct factor input requirements matrix is computed by the following,

$$a_{ifct} = \frac{w_{ifct}}{q_{ict}},$$

which is actually measured as,

$$a_{ifct} = \frac{w_{ifct}}{\sum_{f=1}^{F} w_{ifct}} \frac{\sum_{f=1}^{F} w_{ifct}}{q_{ict}}, \qquad \forall t, \tag{9}$$

since $w_{ifc}$ and $q_{ic}$ are only available from two different data sources. The first ratio on the right hand side of the equality sign of equation (9) is taken from the database RAMS where $w_{ifc}$ is the sum of factor *f*'s wage in industry *i* in country *c*. The second ratio is taken from the database IS/FS, where $q_{ic}$ is gross production in industry *i*.[22]

Both employment- and wage data are collected for the part of the labor force with at least post secondary education and for the total of the labor force. The educational group is measured at the five-digit level of Swedish industrial statistics (SNI69 and SNI92)[23] when using direct factor input requirements, and at the same subdivision as in the Swedish input-output table for 1995 when using total factor input requirements. Data on Swedish imports and exports are collected from various databases maintained by Statistics Sweden. Some compilations have been done to merge the different datasets. Calculations using the SNI69 classification are done for the period 1986-1993 and calculations using the SNI92 classifications are done for the period 1990-2000. Figures for the different variables are left in nominal form; since the calculations carried out in equation (7) eliminate the need to convert them to real values.

Before entering the measurement problem part of this study, we will reproduce equation (7) here, together with some extra indexes. These

[22] The main source for the data is Statistics Sweden. The abbreviations RAMS = Register based labor force statistics, and IS/FS = Industrial statistics/Financial statistics. Wage taken from RAMS is annual earnings and wage taken from IS/FS is labor costs inclusive of social security costs.
[23] SNI92 is the Swedish ISIC rev. 3 analogue.

indexes will correspond to the different sub-sections to come. Equation (7) can be written,

$$z_{ft} = \frac{\sum_{i=1}^{I} x_{it} a_{ifct}^{\alpha}}{\sum_{i=1}^{I} m_{it} a_{ifct}^{\alpha}}, \tag{10}$$

where the index α represents direct or total factor input requirements, *i* industries, *f* factors, *c* countries and *t* time. We will present the different measurement problems graphically by comparing various calculations with a base case model in order to highlight our arguments. This base case model is computed using direct factor input requirements, which varies annually, on five digit SNI69 and SNI92 level, using manufacturing industries only and labor with post secondary educational level attained as the only production factor.[24]

### *4.1 Measurement errors in the A-matrix*

The first problem we will focus on is the factor input requirements matrix **A**, which is a potential source for measurement errors. The elements in the **A** matrix consist of average values and not marginal values, which could cause problems in the calculations. If industry *i* is heterogeneous, it could be the case that the $a_{if}$ in export heavy firms could be greater than industry average, i.e. $\widehat{a}_{if} > \overline{a}_{if}$. Although not all firms in an industry are exporters, they are still part of the wage-shares for that industry, which could bias the calculations of *z* one way or another. According to Bernard & Jensen (1997), exporting plants are quite different when it comes to factor requirements than plants within the same industry that do not export.[25]

In table 4.1 we present a variance decomposition of the average skill intensity, both on an annual basis and for the whole period, for exporting- and non-exporting firms, based on data at firm level.

[24] The different concepts of the base case model will be explained in the following sub-sections.
[25] This is probably true for plants facing substantial import competition.

Table 4.1: Variance decomposition of average skill intensity. Exporters vs. non-exporters

| | Exporters | | | Non-exporters | | |
|---|---|---|---|---|---|---|
| | Between | Within | Total | Between | Within | Total |
| All manufacturing by industry* | | | | | | |
| 1990 | 0.0244 | 0.0359 | 0.0397 | 0.0459 | 0.0247 | 0.0435 |
| 1991 | 0.0253 | 0.0365 | 0.0448 | 0.1056 | 0.0273 | 0.0603 |
| 1992 | 0.0256 | 0.0378 | 0.0477 | 0.1404 | 0.0109 | 0.0804 |
| 1993 | 0.0285 | 0.0369 | 0.0472 | 0.0699 | 0.0258 | 0.0512 |
| 1994 | 0.0288 | 0.0388 | 0.0470 | 0.0566 | 0.0125 | 0.0388 |
| 1995 | 0.0294 | 0.0357 | 0.0453 | 0.0774 | 0.0272 | 0.0419 |
| 1996 | 0.0349 | 0.0371 | 0.0489 | 0.0981 | 0.0425 | 0.0643 |
| 1997 | 0.0321 | 0.0383 | 0.0512 | 0.0540 | 0.0265 | 0.0482 |
| 1998 | 0.0298 | 0.0379 | 0.0519 | 0.0529 | 0.0235 | 0.0451 |
| 1999 | 0.0311 | 0.0401 | 0.0546 | 0.0514 | 0.0366 | 0.0498 |
| 2000 | 0.0359 | 0.0429 | 0.0550 | 0.0621 | 0.0317 | 0.0590 |
| 1990-2000 | 0.0270 | 0.0396 | 0.0485 | 0.0545 | 0.0541 | 0.0513 |

*Notes*: Manufacturing companies with a labor force of 50 employees and above. Between numbers represent shifts across industries; within numbers represent changes within industries.

*Industries are calculated according to SNI-92 at 5-digit level.

There seem to be a small but, for most years, a significant difference in skill intensity between non-exporting firms and exporting firms. The average skill intensity is higher for non-exporting firms compared to exporting firms both for the whole period and for each single year. This gives in hand that on this Swedish data, the input coefficients isn't the best averages for the different industries, but the best we can use at this time. One other interesting result in the table, is that the within variation is higher than the between variation for exporting firms, and the opposite result holds for non-exporters. Does this mean that the group of exporters is more heterogeneous than non-exporters?

Another source that could cause problems in calculating *z* is if the import coefficients are not equal to the export coefficients. If we don't have factor price equalization, the $a_{if}$ can/will be different between exports and imports. Davis & Weinstein (2001a) pay attention to this problem and use a model, developed by Deardorff (1982) and Helpman (1984), which measure the factor content of trade with no factor price equalization. The core of this model is that with no factor price equalization, the factor content of trade should be measured with the producers' technology, i.e.

$$F_{fc} = A_{fc}X_c - \sum_{c'} A_{fc'}M_{cc'}, \qquad (11)$$

where $c$= country $c$, $c'$= all other countries, $A_{fc}$= row $f$ in the total factor input matrix, $X_c$ = exports from country $c$ and $M_{cc'}$= imports from $c'$ to $c$. In order for us to follow this procedure, we need to have bilateral trade data and each country's factor input requirements matrices. It is though possible to get hold of bilateral trade data for Sweden but, unfortunately, data on each of Sweden's trading partners factor input requirements are hard, or practically impossible, to get hold on. Trefler (1993) deals with this problem in a completely different way, in his cross-sectional multicountry study, by allowing all factors in every country to differ in their productivities, and he uses the U.S. as a benchmark country with factor productivities normalized to unity. One result of this exercise is that the HOV-equation no longer becomes testable, since it holds as an identity by the choice of productivity parameters.[26]

In sum, although there seem to be a difference in skill intensity between exporting firms and non-exporting firms, and since we cannot calculate equation (11) because of data shortage, we have to assume that the input coefficients in our data are good averages for the different industries, and that the import coefficients are similar to the export coefficients.

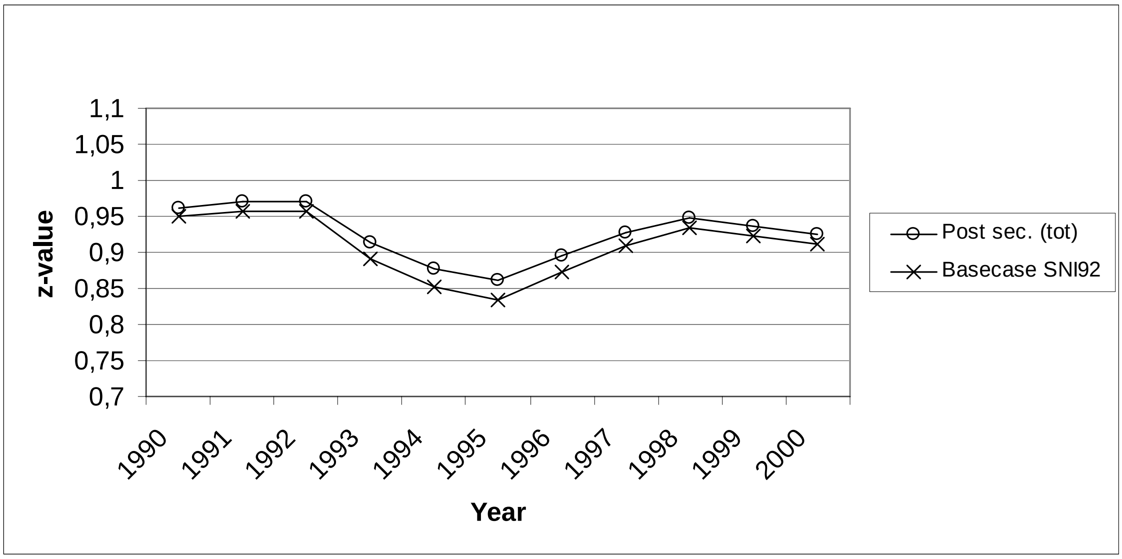
## 4.2 Direct vs. total input coefficients

The next measurement issue deals with the question whether we should use direct or total factor input coefficients. This relates to superscript $\alpha$ in equation (10). In theory, we should use total factor input requirements when calculating the factor content of trade[27], but in practice, not all studies do it. One reason for this behavior is that there are very few input-output tables available. Another reason is that those who are available are highly aggregated. This is especially true when committing a study involving several countries. In this subsection, we use the Swedish 1995 input-output table together with annual direct factor input requirements to compute annual total factor input requirements for the period 1990-2000. The annual total factor input requirements are then used together with annual trade data. All data used are in concordance with the input-output industries, making it possible to perform the required vector multiplications acquired to calculate the $z$ measure.

[26] Trefler recommends two methods to validate the results from this exercise; i) checking whether the productivity parameters are positive or not and; ii) a comparison of these parameters with other economic data to evaluate how *reasonable* those parameters are. This study and Trefler (1995) has however been criticized by Gabaix (1997), who shows that Trefler's calculation of cross-country differences in productivity of inputs is insensitive to the factor content of net exports. He does this by comparing Trefler's calculations with a calculation setting the factor content of trade equal to zero. In both cases, virtually identical numbers are obtained.

[27] See Hamilton & Svensson (1983) or Deardorff (1984).

*Fig. 4.1 Direct vs. total input coefficients (SNI-92)*




As we can see from figure 4.1, the two curves representing *z*, computed by total- and direct factor input requirements respectively, follow each other quite close over the period, with a level shift of around 2 percentage points. The correlation between the two curves is 0.999, which indicates that using total factor input requirements instead of direct, will not change the trend of the *z*-curve. This will give in hand that the choice between total or direct factor input requirements is only important if we are looking at *z* for a single year. Since we are interested in the development of *z* over time, this choice does not matter that much. Therefore, the conclusion here will then be that total factor input requirements are theoretically correct and should be used in those cases where point estimates matter. However, if we are interested in the development of the *z* measure over time, the choice of method, i.e. using total- or direct factor input requirements, does not greatly affect the results. This last conclusion is drawn from the fact that we only have one input-output table representing the whole period. A better comparison between total and direct factor input requirements would be to use annual input-output tables for the whole period, but unfortunately, the 1995 input-output table for Sweden is the only one that has been compiled by Statistics Sweden during the period.[28]

[28] Statistics Sweden has however recently published an input-output table for 2000. We have recalculated the total factor input requirements using the 2000 input-output table instead, and this resulted only in a level shift of the *post.sec(tot)*-curve. The conclusions drawn in this chapter is not affected by this exercise. Any results from this exercise will not be presented here but are available upon request from the author.

## 4.3 Aggregation

When comparing results from different factor content of trade studies, one often runs into the problem with the level of aggregation of the measured data.[29] In most studies, the level of aggregation is quite high which could cause an aggregation bias in the calculations. In a recent paper by Feenstra & Hanson (2000), they show both theoretically and empirically that the aggregation bias could be substantial when aggregating different industries together. They show that this aggregation bias is due to the domestic full employment condition.[30] In order to preserve this condition when aggregating factor input requirements, one needs to use domestic outputs as weights. However, they show that this particular weighting scheme does not preserve the value of the factor content of trade. The authors also show that the aggregation bias will only be zero in two cases; i) if the disaggregated industries within each aggregated group have identical input requirements for each factor, or, ii) if the input requirements vary but are completely uncorrelated with the ratio between net exports and output within each group.[31] In the empirical part of their study, they use the U.S. input-output table for 1982, which are divided into 371 manufacturing industries, together with trade and direct factor input requirements in concordance with the same 371 industries. The years for the study are 1982, 1985, 1988, 1991 and 1994, and the authors show that when using 4-digit SIC level compared to 2-digit SIC level, it results in an increase in both the production- and non-production labor embodied in net exports in 1982. The same direction of the aggregation bias is shown for the other years of the study.

In what follows we calculate *z* using our base case model under different levels of aggregation for both the SNI69 and SNI92 industrial classifications.

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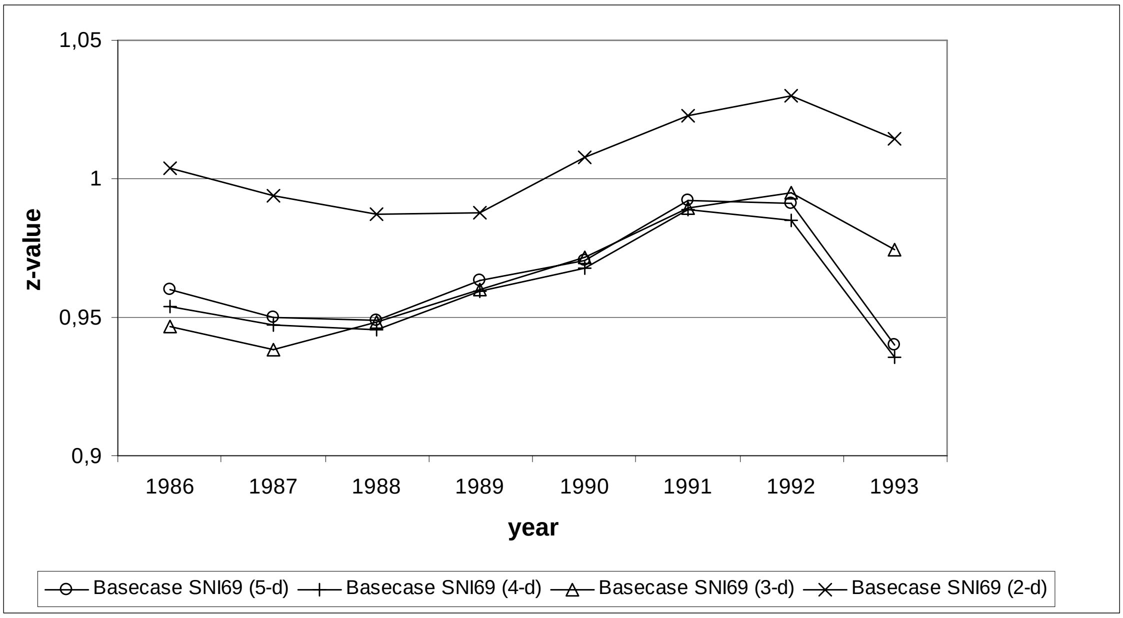
[29] This relates to subscript *i* in equation (10).

[30] See chapter 2.

[31] The case that there should be no correlation at all is not true for at least two reasons The first reason is due to the abundant evidence from different studies, for example Davis & Weinstein (2001a) and Bernard & Jensen (1997), and the second is due to the spirit of the Heckscher-Ohlin theorem.

### *Fig. 4.2 Aggregation (SNI-69)*




### *Table 4.2 Correlations*

Correlations:

| | 2-digit | 3-digit | 4-digit | 5-digit |
|---|---|---|---|---|
| 2-digit | 1 | | | |
| 3-digit | 0,868082 | 1 | | |
| 4-digit | 0,625868 | 0,721068 | 1 | |
| 5-digit | 0,649979 | 0,649979 | 0,997227 | 1 |

The curves in figure 4.2 show that the *z*-measure, following SNI69, calculated on 5-digit, 4-digit and 3-digit level are highly correlated, see table 4.2 above, and that the curves are quite close together. The calculations on the 2-digit level shows however a level shift upwards compared to the others. This shift is around 6 percentage points but the curve is still highly correlated with the others. The level shift due to the aggregation could be caused by the industry classification. When aggregating industries from 5-digit level to 4-digit, 3-digit and finally to 2-digit level, we will of course enforce more and more heterogeneity into the differently aggregated groups. The higher the levels of aggregation, the more heterogeneous are the industries.

Next we perform the same calculations following the SNI92 classification instead.

*Fig. 4.3 Aggregation (SNI-92)*

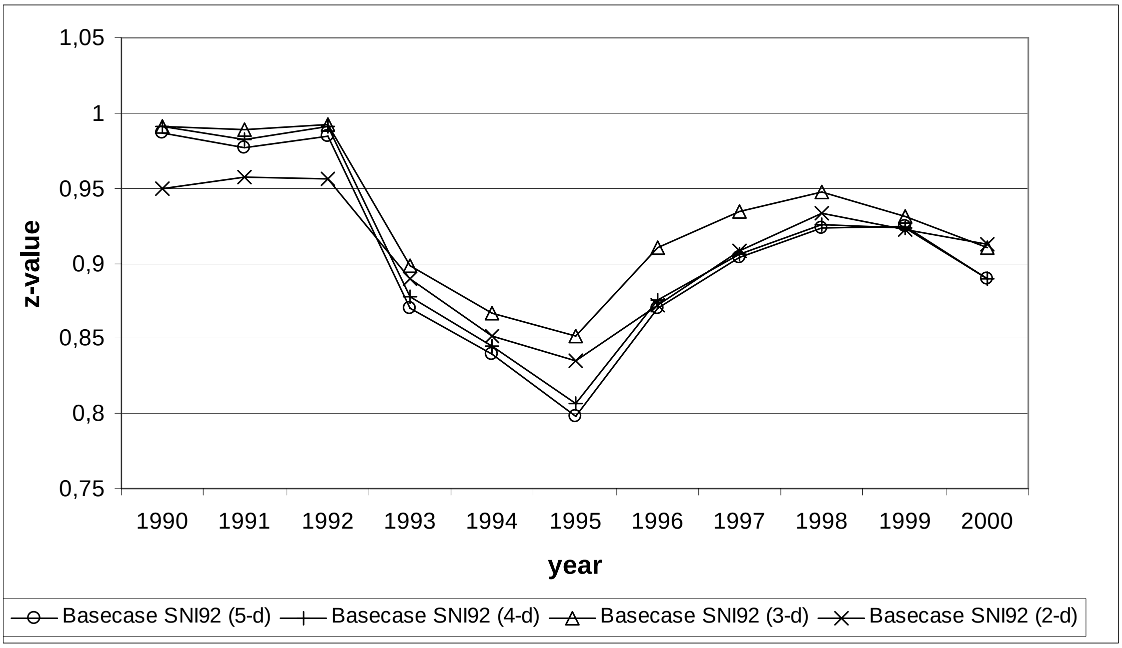



***Table 4.3 Correlations***

Correlations:

| | 2-digit | 3-digit | 4-digit | 5-digit |
|---|---|---|---|---|
| 2-digit | 1 | | | |
| 3-digit | 0,9595 | 1 | | |
| 4-digit | 0,966542 | 0,990465 | 1 | |
| 5-digit | 0,972516 | 0,988942 | 0,998997 | 1 |

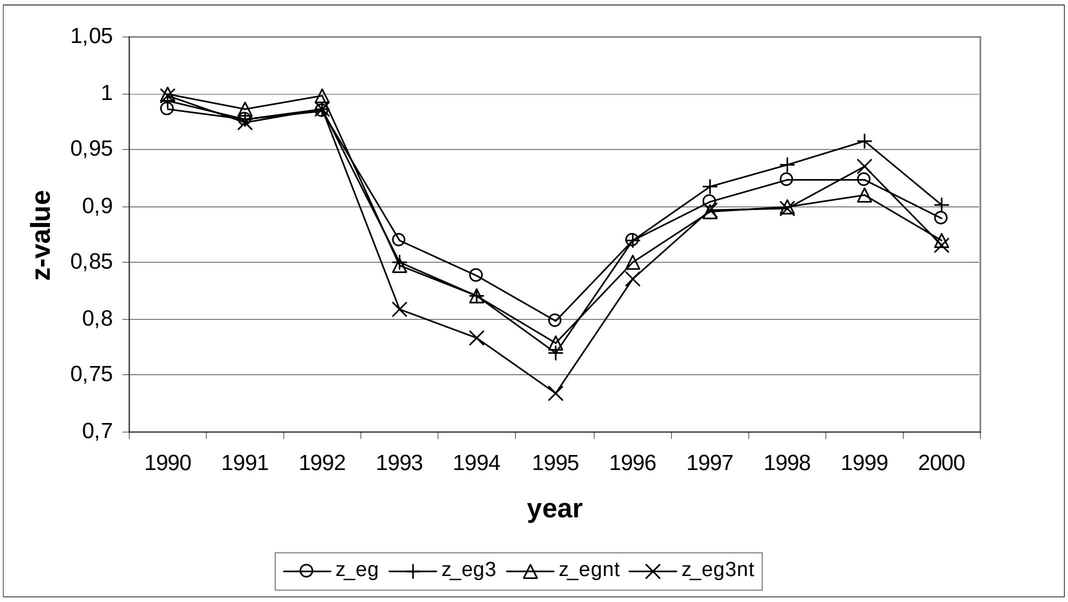
The four curves in figure 4.3 seem to be more close together than the curves in figure 4.2. The reason for this could be due to the change in classification from SNI69 to SNI92. If this change in classification has reduced the heterogeneity within each industry class, maybe the *z*-calculations will be less affected by aggregation. One interesting result from a comparison between figures 4.2 and 4.3 is the gap between the two *z*-measures calculated on 2-digit level. When changing classification from SNI69 to SNI92 we have a downward shift of the *z*-curve of around 7 percentage points during the years 1990-1993. This phenomenon does not occur at such a big magnitude for the other aggregated levels. The correlations between the four different aggregated levels in figure 4.3, see table 4.3 above, are very high, even higher than in table 4.2.

A conclusion that can be drawn from this subsection is that the level of aggregation doesn't matter much if we are interested in the development of *z* over time. However, it takes on importance if we want to evaluate a single year instead.

## 4.4 How to measure human capital/skilled labor

Do the calculations of *z* depend on how we define skilled labor? If we start from the fact that we have chosen educational attainment as our measure of human capital, see section 3.2 above, we can then chose between different levels of attainment.[32] In the database to our disposal, RAMS, we can chose between three different educational attainment levels for all workers, viz. secondary-, post secondary- and longer (3 years) post secondary education. The post secondary- and longer post secondary educational levels can also be divided into a subgroup of workers with scientific- or technical alignment. In figure 4.4 we have chosen four educational measures. The first is labor with at least a post secondary educational attainment level; the second is labor with longer post secondary educational attainment level; the third is the post secondary subgroup with scientific and technical alignment; and the fourth is the longer post secondary subgroup with scientific and technical alignment.[33]

***Fig. 4.4 Different skill levels***




[32] This will correspond to subscript *f* in equation (10).
[33] One problem that can arise when comparing these four educational measures is the fact that the two groups with scientific and technical alignment are subgroups of the two others.

*Table 4.4 Correlations*

| Correlations: | z_eg | z_eg3 | z_egnt | z_egnt3 |
|---|---|---|---|---|
| z_eg | 1 | | | |
| z_eg3 | 0,979797 | 1 | | |
| z_egnt | 0,99353 | 0,959142 | 1 | |
| z_egnt3 | 0,98744 | 0,991948 | 0,980968 | 1 |

The four different curves in figure 4.4 are highly correlated; see table 4.4, and the curves follow each other very close. Due to the high correlation and the small level differences between the curves, we can conclude that, in this case, the choice of educational attainment level doesn't matter much when evaluating $z$ over time. This only takes on importance, as we have seen before, in the evaluation of a single year.

## 4.5 International comparison using national factor input requirements

In many early studies of the factor content of trade, one country's factor input requirements matrix, direct or indirect, is often used to represent all countries in the study. The use of a common factor input requirements matrix for all countries is theoretically correct due to the HOV-models underlying assumptions, viz. identical technology across countries and factor price equalization, but empirically it has been rejected by for example Davis & Weinstein (2001b) and Trefler (1993).

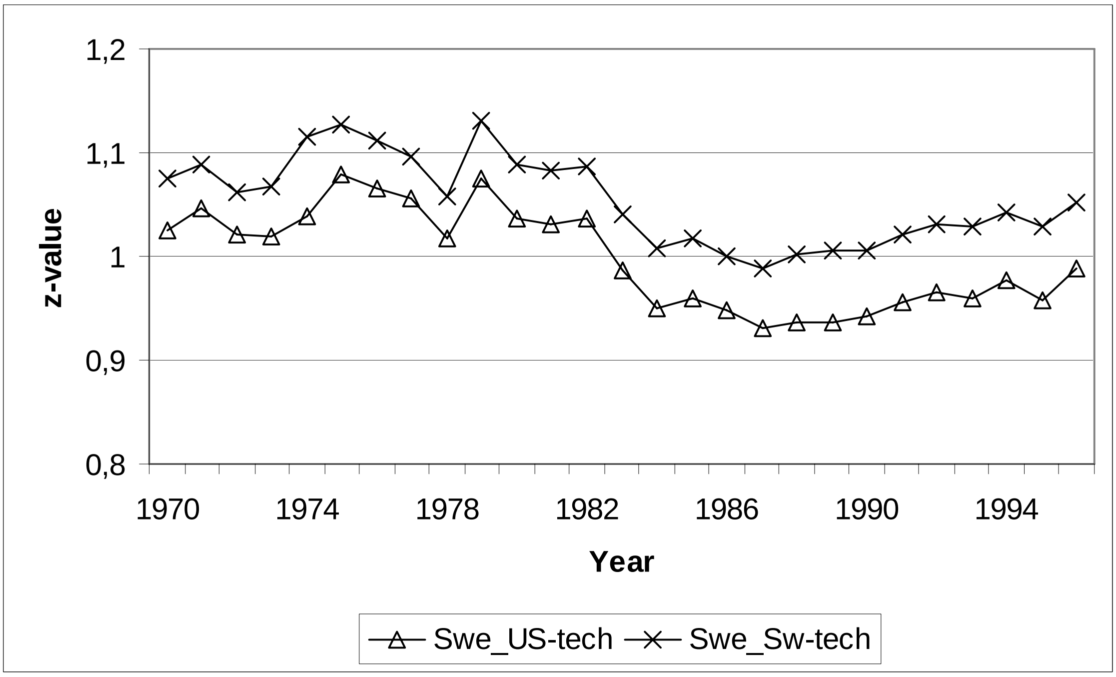
In this subsection we have calculated $z$ using data from the OECD database STAN and the OECD input-output database, together with data from the Swedish input-output table of 1985 and RAMS (Statistics Sweden), arranged according to the SNI69 classification. The $a_{ift}$ in equation (9) has been slightly changed according to the following,

$$a_{ift} = \frac{skilled_{ift}}{\sum_{f=1}^{F} skilled_{ift}} \frac{\sum_{f=1}^{F} skilled_{ift}}{q_{it}}. \tag{12}$$

The first ratio on the right hand side of the equality sign is taken from the database RAMS where $skilled_{if}$ is the sum of factor $f$'s employment in industry $i$. This ratio is the same for both calculations showed in figure 4.5. The second ratio is taken from the database STAN, where $q_i$ is gross production in industry *i*. The subscript *t* refers to the year 1986, since *z* have been calculated using total factor input requirements. All trade data has been collected from STAN for the period 1970-1997.

When calculating *z* for Sweden with Swedish technology, the curve *Swe_Sw-tech*, we have used the Swedish 1985 input-output table together with Swedish direct factor input requirements from RAMS. Then, when calculating *z* for Sweden with U.S. technology, the curve *Swe_US-tech*, we have used the U.S. 1984 input-output table from the OECD input-output database.[34] All data have been arranged in concordance with the U.S. input-output table.

***Fig. 4.5 U.S. technology assumption***




In figure 4.5 we see a close correspondence between the *z*-curve calculated with U.S. technology and the *z*-curve calculated with Swedish technology. The correlation between the two curves is 0.98, which give in hand that we, in this particular case, can conclude that it doesn't matter if we use Swedish or the U.S. total factor input requirements when evaluating *z* over time. Even here it only takes on importance when evaluating a single year. One interesting result though, is the upward shift of the *z*-curve when changing from U.S. technology to Swedish technology.

[34] The Swedish input-output table has been arranged in concordance with the U.S. input-output table. The source for the Swedish input-output table is Statistics Sweden.

## 4.6 The T-vector

Most papers calculating the factor content of trade are limited to a trade-vector containing only trade in goods, or even manufactures, but the HOV-model is derived for all trade, so it does not necessarily hold for a subset of trade.[35] One interesting exercise would be to compare the factor content of trade in the services of skilled labor using manufacturing industries only with that of using goods industries.[36] The next obvious step would then be to expand the trade-vector further to include service industries as well. This exercise is, due to shortage of data, only possible for the period 1993-2000 on a 2-digit SNI92 level.

***Fig. 4.6 The T-vector (SNI-92)***

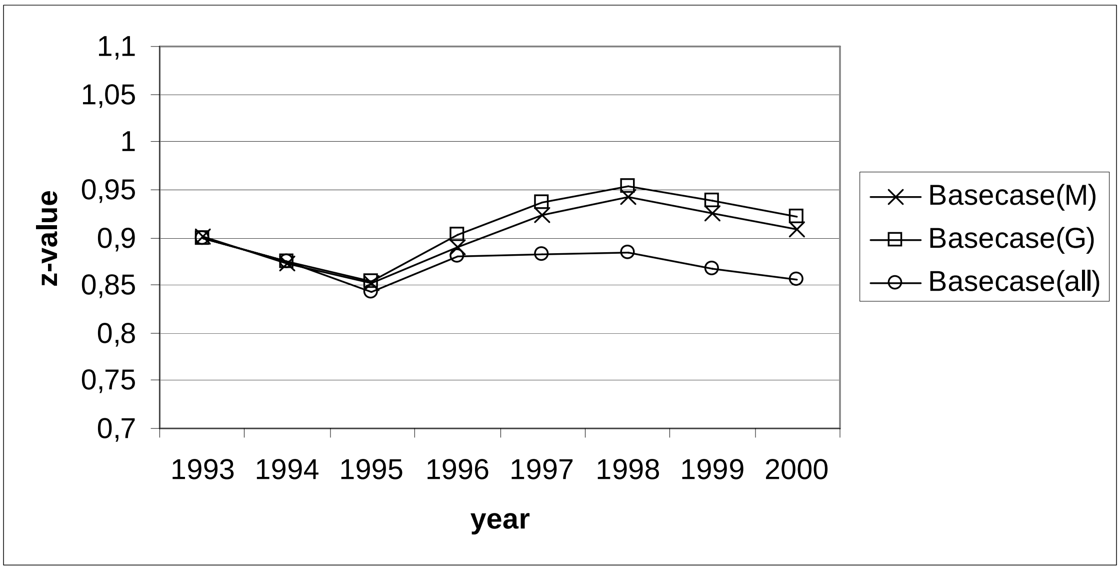



***Table 4.5 Correlations***

| Correlations: | Manufacturing | Goods | All trade |
|---|---|---|---|
| Manufacturing | 1 | | |
| Goods | 0,989819 | 1 | |
| All | 0,460584 | 0,383334 | 1 |

The different *z*-curves in figure 4.6 are subject to level shifts, but the "basecase(all)"-curve seems to be widening the gap to the two other *z*-

[35] This exercise corresponds to subscript *i* in equation (10).

[36] Goods industries refer here to industries involving agriculture, forestry, fishing, extraction industries and manufactures. Sometimes one also includes energy- and construction industries in the goods expression, but in this study, those industries are included in the service sectors instead. Manufacturing industries refer to sectors 15-37 in SNI92.

curves over time.[37] The correlations between the three curves are shown in table 4.5. The correlations between the "basecase(all)" and the two other curves are much lower than any other correlation shown so far in this study. If this is an indication on the importance of including service industries in the factor content of trade calculations, is hard to say due to the highly aggregated data. In order to investigate this further, we have analyzed firm level data, on 5-digit SNI92 level, and calculated direct factor input requirements of skilled labor for manufacturing firms, i.e. SNI92 industries 15111-372000, and service firms, i.e. SNI92 industries 40000-95000, respectively. The coefficient of variation has then been calculated for the two groups respectively and they are shown in tables 4.6 and 4.7.

Table 4.6: Manufacturing SNI92 15111-37200

| year | # of obs. | mean | sd | iqr | CV |
|---|---|---|---|---|---|
| 1990 | 234 | 0.0362910 | 0.0275134 | 0.0254619 | 75.80681 |
| 1991 | 235 | 0.0416237 | 0.0373771 | 0.0293805 | 89.79764 |
| 1992 | 237 | 0.0415060 | 0.0297966 | 0.0268847 | 71.78866 |
| 1993 | 240 | 0.0393064 | 0.0275824 | 0.0259532 | 70.17280 |
| 1994 | 238 | 0.0392291 | 0.0290094 | 0.0253549 | 73.94868 |
| 1995 | 243 | 0.0391307 | 0.0279929 | 0.0244669 | 71.53693 |
| 1996 | 251 | 0.0413909 | 0.0282171 | 0.0249530 | 68.17223 |
| 1997 | 249 | 0.0436645 | 0.0284571 | 0.0235507 | 65.17216 |
| 1998 | 249 | 0.0459536 | 0.0306726 | 0.0252348 | 66.74689 |
| 1999 | 250 | 0.0480057 | 0.0341433 | 0.0301280 | 71.12343 |
| 2000 | 253 | 0.0507041 | 0.0443642 | 0.0285370 | 87.49628 |
| Pooled | 2679 | 0.0425247 | 0.0320368 | 0.0268897 | 75.33692 |

Note: iqr = inner quartile range; CV = coefficient of variation; and pooled = all years pooled into one dataset.

[37] When measuring "basecase(G)" and "basecase(all)" we have excluded SNI92 industry 11 (Oil- and gas extraction) since it is an extreme outlier which biases the results heavily downwards.

Table 4.7: Service sectors SNI92 40000-95000

| year | # of obs. | mean | sd | iqr | CV |
|---|---|---|---|---|---|
| 1990 | 290 | 0.0697354 | 0.0966629 | 0.0597526 | 138.61382 |
| 1991 | 298 | 0.0752022 | 0.1020514 | 0.0689386 | 135.70268 |
| 1992 | 287 | 0.0827017 | 0.1157354 | 0.0723570 | 139.94319 |
| 1993 | 286 | 0.0765299 | 0.1004090 | 0.0810208 | 131.20231 |
| 1994 | 297 | 0.0745314 | 0.1052606 | 0.0665850 | 141.22987 |
| 1995 | 300 | 0.0760625 | 0.1037792 | 0.0639659 | 136.43938 |
| 1996 | 332 | 0.0731961 | 0.0927666 | 0.0619945 | 126.73708 |
| 1997 | 339 | 0.0833888 | 0.1098264 | 0.0743571 | 131.70402 |
| 1998 | 338 | 0.0836420 | 0.1067932 | 0.0727796 | 127.67892 |
| 1999 | 338 | 0.0877632 | 0.1112114 | 0.0726894 | 126.71758 |
| 2000 | 338 | 0.0905575 | 0.1095946 | 0.0770081 | 121.02211 |
| Pooled | 3443 | 0.0796760 | 0.1052376 | 0.0698725 | 132.08193 |

Note: iqr = inner quartile range; CV = coefficient of variation; and pooled = all years pooled into one dataset.

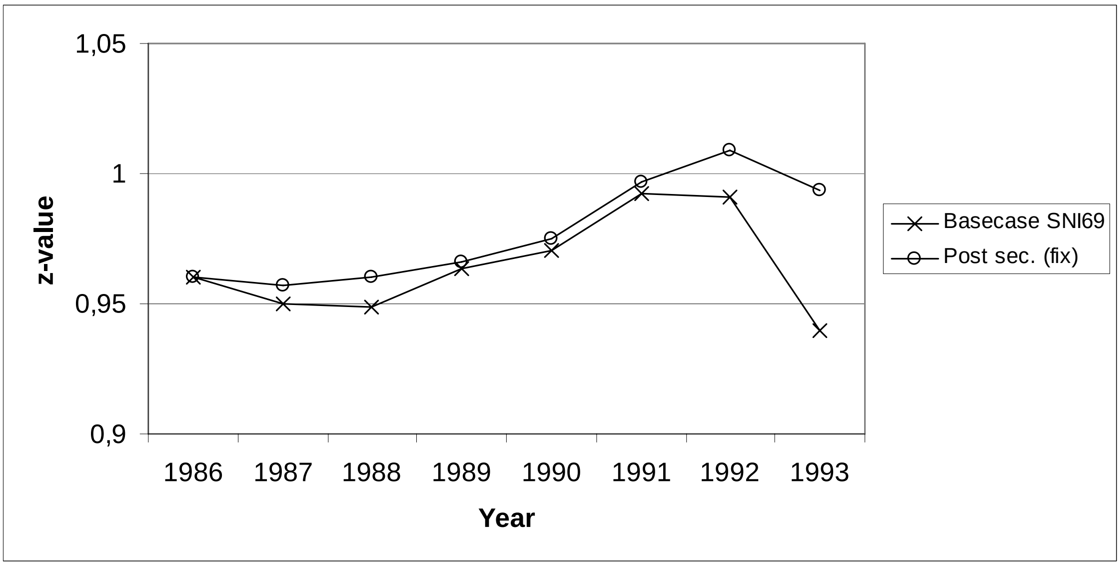
As we can see in the two tables, the coefficient of variation in the factor input requirements of skilled labor for the service firms are higher than for the manufacturing firms. This result indicates, together with figure 4.6, that an exclusion of service industries in the factor content of trade calculations could bias the results in an undesirable way. Therefore, we conclude that an inclusion of the service sectors in the calculation of factor content of trade seems to matter, both for the trend of *z*, and for the single year evaluation.

## 4.7 Fixed vs. variable factor input requirements

One measurement issue, arising from the literature of evaluating *z* over time, is whether to use current values of factor input requirements or, as is most often done, use fixed coefficients, for one year, so all variables except trade is due to *t*. Lundberg & Wiker (1997) uses fixed total factor input requirements, calculated with the Swedish input-output table for 1985 and direct factor input requirements for 1990. This amounts to assuming that the factor input requirements are constant over time.

Below we compare between using fixed- or variable factor input requirements, calculated according to the SNI69 classification at 5-digit level. The "Post sec. (fix)-curve" is calculated using factor input requirements for 1986 only and annual trade data for the period 1986-1993, and the "Basecase SNI69-curve" is calculated using variable factor input requirements and annual trade data.

*Fig. 4.7 Fixed vs. variable input coefficients (SNI69)*

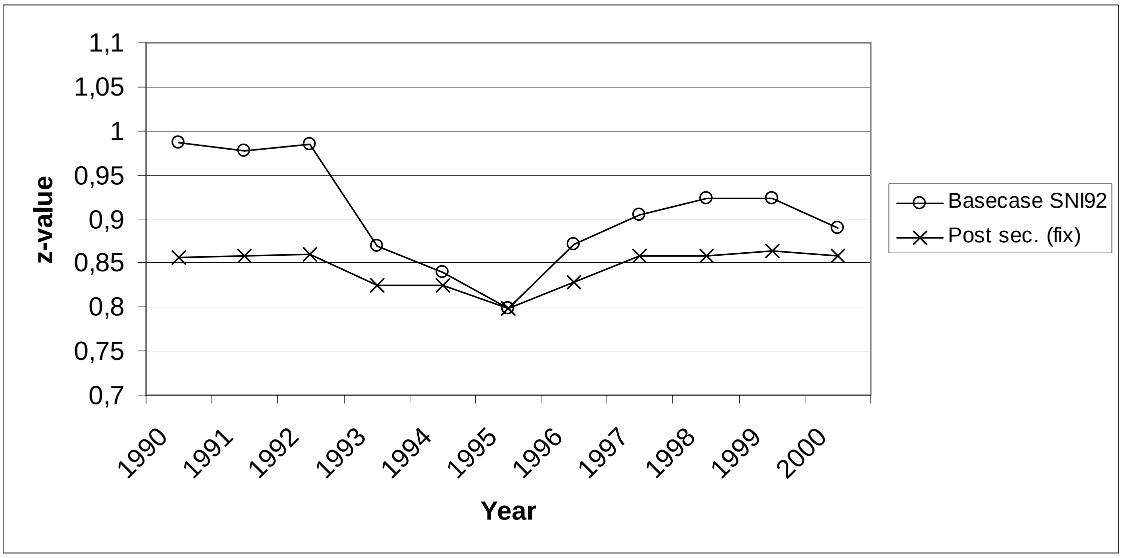



The two curves in figure 4.7 follow each other quite close from 1986 to 1991, after that we can see a dramatic downward change in the curve calculated with variable factor input requirements. The correlation between the two curves is 0.601 over the period 1986-1993 and if we look at the sub period 1986-1991 the correlation is 0.958. Why there is such a dramatic change in the last two years are hard to explain, but maybe there is problems with the data collection. However, taken all this into consideration, we conclude that there is no big difference between the two ways of measuring *z*. We also did the same exercise as above, but we used 1990 as our base year for the fixed curve instead. The *new* fixed-curve looked similar to the above one, so it seems that the choice of base year doesn't matter so much for this period either.[38]

The *z*-values illustrated in figure 4.8 is calculated in a similar way to those in figure 4.7, except using SNI92 classified data at 5-digit level, a period ranging between 1990 and 2000, and the fixed values calculated for the year 1995 instead.

[38] Calculations and graphs for this exercise are not presented here, but they are available upon request from the author.

***Fig. 4.8 Fixed vs. variable input coefficients (SNI-92)***




There is a big gap between the two curves during this period, but the correlation between them is 0.836, which is quite high. We did also change the base year for the *fixed* curve here as we did for the 1986-1993 period. The new base year was set to 1990 and the shape of the new *fixed* curve was close to the 1995 one, but there were a big upward shift, ending around the *z*-value of one. So, in this case the *z*-value seems to be very dependent on the choice of base year.[39]

The comparison between using fixed input requirements and using annual values in the calculations of the *z*-value, gives us a somewhat interesting picture. Why is there a different development between the variable and fixed estimates? When using fixed factor input requirements we only capture the changing trade pattern of the factor services over time, but in the variable case we capture both the changing trade pattern and the change in factor input requirements over time.[40] We find that the choice between calculating *z* with fixed- or variable factor input requirements do matter when evaluating *z* over time, since there is a quite different trend between the two curves. Why the two curves behave so differently is hard to explain. The difference between the two curves is affected, according to the differentiation in appendix A, by the correlation between net exports and the change in factor input requirements in the different industries. There seem to be some kind of a business cycle effect but we are not sure, since the level of also affects the difference between the two curves.

[39] Those calculations and graphs are also available upon request from the author.
[40] See appendix A for a differentiation of equation (7).

If we conclude the various measurement issues in chapter 4, we can see that the choice of how to measure the factor content of trade, do depend on the purpose of our study and what data that is available. In table 4.8 we have summarized the various measurement problems discussed in chapter 4.

***Table 4.8 Summary table***

| **Measurement issues:** | **Single year evaluation** | **Development over time** |
|---|---|---|
| *Direct vs. variable* | ***X*** | |
| *Aggregation* | ***X*** | |
| *Measure of human cap.* | ***X*** | |
| *National a's or not* | ***X*** | |
| *The T-vector* | ***X*** | ***X*** |
| *Fixed vs. variable* | - | ***X*** |

*Notes:* The symbol *X* denotes if the particular measurement issue takes on importance or not, depending on a single year evaluation or the trend of *z*. The symbol "-" indicates that the issue is not relevant in this case.

The ideal case for a single year evaluation of the factor content of trade, seem to be using total factor input requirements[41], using all trade (goods and services) on 5-digit SNI69 or SNI92 level of aggregation and Swedish technology for the export part of equation (7). When calculating the import part of equation (7) one needs the producer's technology and bilateral imports. Since we are not interested in the evaluation of a single year in this study, we leave it to the reader to decide upon how to measure the concepts involved in his/hers own specific case.

The choice of measurement of the development of the human capital content of trade over time, seem to be affected by the inclusion of service sectors or not and the use of variable factor input requirements. As we saw in table 4.5, the correlations between *z* measured with all trade and *z* measured with manufactures only or with goods trade are very low. This will end up in a choice between calculating *z* using our base case model described in the first part of chapter 4 for the period 1986-2000 or calculating *z* using all trade (goods and services) for the period 1993-2000 on a 2-digit SNI92 level. The obvious choice would be to use the latter way to measure *z*, but there is one major restriction in using this way to measure the concepts involved, viz. the short time-period (1993-2000). We think that the information prior to 1993 is important in describing the

[41] Probably calculated with annual input-output tables and annual direct factor input requirements.

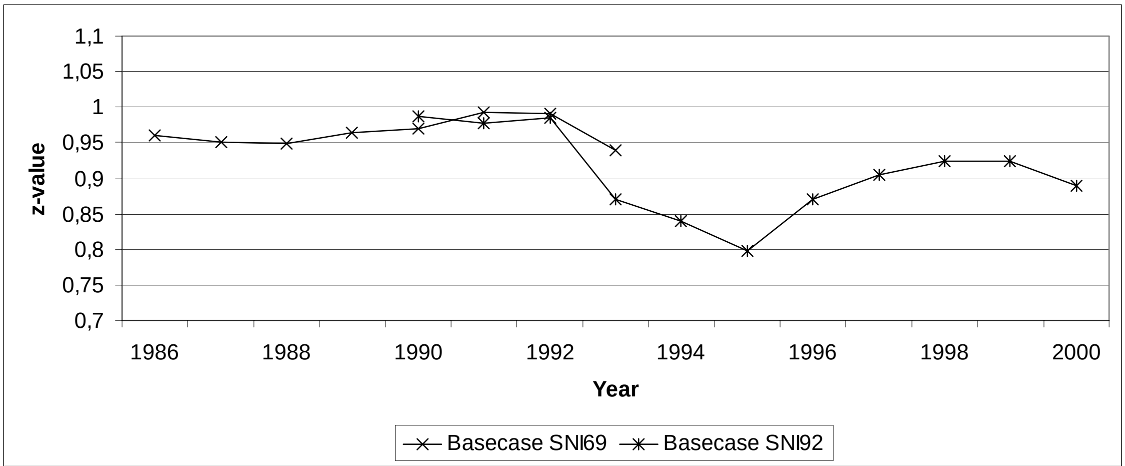
development of the Swedish factor content of trade in skilled labor, so our choice for the remaining part of the study will be the base case models.

# 5. Factor content of Swedish trade: 1986-2000

When measuring the trend of the human capital content of Swedish trade, we have shown in chapter 4 that exports and imports of service sectors are important to include in the calculations as well as using variable factor input requirements. However, due to the short period when trade data for service sectors are available, we have decided to use the base case model instead, comprising direct factor input requirements, which varies annually, on five digit SNI69 and SNI92 level, using manufacturing industries only and labor with post secondary educational level attained as the only production factor, to examine the human capital content of Swedish trade over the period 1986-2000.

In figure 5.1 we can see that the specialization pattern for Sweden has over the measured period moved away from industries intensively using high skilled labor in exports compared to imports, i.e. a negative long-term trend in *z*. This result would probably be reinforced if trade in services could be included.

***Fig. 5.1 Factor content of Swedish trade: 1986-2000***

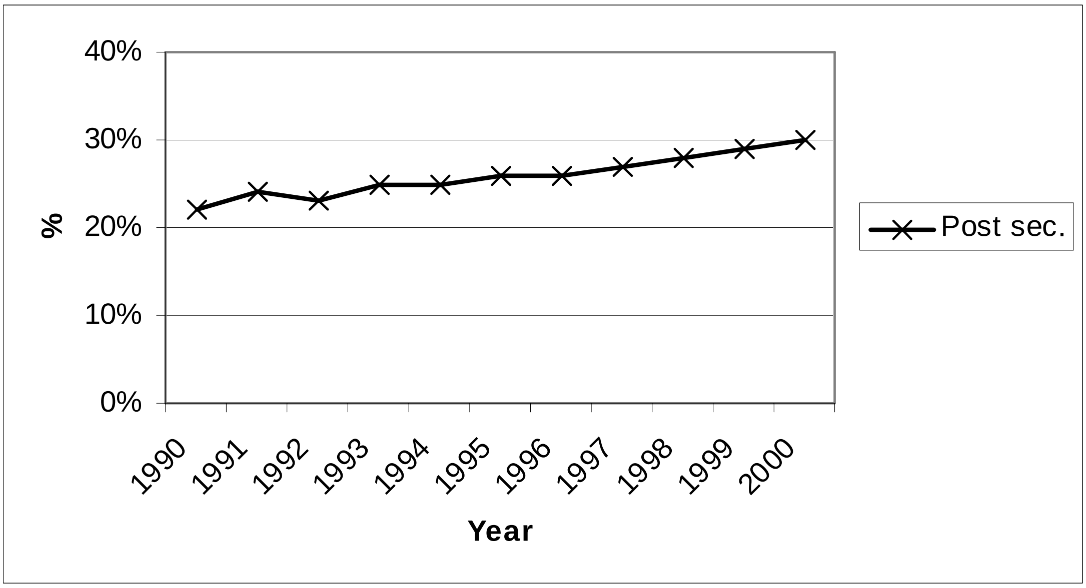



The average human capital intensity in exports relative to imports was actually slightly increasing during the period 1986-1992. This course of events mirrors an increasing specialization in human capital-intensive production, which is a development that a priori can be expected from a mature economy like Sweden. After 1992 though there is a rapid decrease in the average human capital intensity in exports compared to imports, which continues until 1995. Why there is such a big drop is puzzling, but when looking in detail, there are at least two causes that drive this result; i) there is a big increase in the import value of “Office machinery & computers”, sector 30020 according to SNI92, compared to the export value; and ii) Sweden went from a fixed- to a variable exchange rate regime in November 1992, with a big fall in the value of the Swedish krona as a result.[42] The big increase in import value of “Office machinery & computers” is probably caused by both an increasing import of especially computers and the exchange rate effect, causing the Swedish import to become more expensive. This scenario had a big impact on the decrease in *z* during this period. One other reason that might have influenced the results is the use of Swedish factor input requirement when calculating both the numerator and the denominator of equation (7). On one hand, if the factor input requirements of the Office machinery & computer manufacturing sector is lower in the country, or countries, which Sweden are importing the goods from, compared to Swedish factor input requirements, then there will be a bias downwards of the *z*-measure when using the Swedish factor input requirements instead. On the other hand, there will be an opposite effect if the Swedish factor input requirements is lower instead. There has since 1995 been a recovery of the *z*-measure, but this recovery seems both to be leveling out and turning down in the beginning of 2000. In figure 5.1 we have also included the "Basecase(all)" curve from figure 4.6 indicating that if one includes service sector trade in the calculations of *z*, the increase in *z* between 1995 and 1998 would have been considerably smaller.

The depreciation of the Swedish krona could in the short run have structural effects within the Swedish economy, but in the long run it is probably the endowment of high skilled labor that is determining relative human capital intensity in the Swedish manufacturing industries. The endowment of high skilled labor in Sweden, measured as the proportion of total population in the age group 25-64 with at least a post secondary education, has increased slowly but steadily throughout the 90's, which are shown in figure 5.2.

[42] The value dropped around 20% towards the Ecu, 30% towards the German mark and 40% towards the US$.

***Fig. 5.2 Endowments of skilled people as percentage of total population in the age group 25-64 years***




*Source: Statistics Sweden*

An increase in the endowment of skilled labor is on it self not an evidence of increased skill intensity in the Swedish manufacturing industries compared to the rest of the world for several reasons. Firstly, the endowment of skilled labor in figure 5.2 is calculated as the proportion of the total labor force with at least a post secondary educational attainment level in the age group 25-64. If we compare those values with the *z*-values, which are calculated for manufacturing industries only, we may run into problems since requirements of university graduates in other sectors than manufacturing are very high. Secondly, the size of the public sector also plays an important role, since the proportion of university-trained employees is much higher than in the private sector in general, and in manufacturing sectors in particular. Thirdly, the annual increase in the endowment of skilled labor in Sweden could be higher, equal to or lower compared to the rest of the world, or, more specifically, compared to its biggest trading partners. In countries where the proportion of skilled labor in the total labor force has been growing at a high rate compared to its competitors, one would expect a restructuring of production towards skill intensive industries, and that exports should become increasingly skill intensive compared to imports. One interesting exercise would then be to check if the accumulation of skilled labor in Sweden is different compared to the other OECD countries over the measured period.

The different trends in educational attainment at tertiary level for the OECD countries over the period 1991-2000, have been computed using a multiple dummy variable regression model of the following form,

$$y_{it} = \beta_1 + \beta_2 t + \sum_{i=2}^{29} \varphi_i D_i + \sum_{i=2}^{29} \delta_i D_i t + u_{it} \tag{13}$$

where $y_{it}$ is the proportion of the labor force that has attained tertiary education in country $i$ at time $c$, $D_i$ is a country dummy, $\varphi_i$ and $\delta_i$ are regression coefficients, $u_{it}$ is the error term and Sweden has been set to be the reference country. The regression results are shown in table 5.1.[43]

[43] Historical data on educational attainment for the whole period were difficult to get. The period 1991-2000, though, were available from OECD, but only for three major levels of education; i.e. i) less than upper secondary education -- 0/1/2 (ISCED 97 equivalent levels), ii) upper secondary and some postsecondary education -- 3/4 (ISCED 97 equivalent levels), and iii) tertiary non-university and university -- 5/6 (5A/5B/6 ISCED 97 equivalent levels). Before 1997, educational attainment levels were coded according to international mapping ISCED 76. OECD has translated the ISCED-76 levels into ISCED-97 levels. (See table B1 in appendix B).

**Table 5.1:** Trends in tertiary educational attainment levels for the OECD countries in 1991-2000. Dependent variable: Share of tertiary attainment to total labor force.

| Country | Differential intercept coefficient[1] | | Differential slope coefficient[2] | |
|---|---|---|---|---|
| Sweden (base country) | 23.880 | (25.42)*** | 0.577 | (3.43)*** |
| Austrialia | -2.048 | (-1.50) | 0.002 | (0.01) |
| Austria | -17.863 | (-13.45)*** | 0.240 | (1.01) |
| Belgium | 0.634 | (0.47) | 0.409 | (1.55) |
| Canada | 6.734 | (5.07)*** | 0.489 | (2.06)** |
| Czech Republic | -13.977 | (-10.46)*** | -0.475 | (-2.02)** |
| Denmark | -6.575 | (-4.49)*** | -0.031 | (-0.08) |
| Finland | 2.047 | (1.54) | 0.077 | (0.33) |
| France | -6.825 | (-5.36)*** | 0.243 | (1.04) |
| Germany | -3.121 | (-2.35)** | -0.262 | (-1.10) |
| Greece | 2.880 | (1.45) | -1.465 | (-4.53)*** |
| Hungary | -12.895 | (-3.76)*** | 0.068 | (0.14) |
| Iceland | -8.773 | (-2.56)** | -0.099 | (-0.20) |
| Ireland | -2.636 | (-1.98)** | -0.044 | (-0.19) |
| Italy | -17.538 | (-13.19)*** | 0.495 | (2.07)** |
| Japan | 1.791 | (0.36) | 0.462 | (0.69) |
| Korea | -7.933 | (-6.23)*** | 0.495 | (2.13)** |
| Mexico | -17.210 | (-6.81)*** | -0.490 | (-1.26) |
| Netherlands | -3.095 | (-2.31)** | 0.025 | (0.09) |
| Norway | 1.473 | (1.11) | -0.146 | (-0.62) |
| New Zealand | -1.753 | (-1.31) | -0.174 | (-0.73) |
| Poland | -17.093 | (-6.05)*** | 0.504 | (1.21) |
| Portugal | -13.903 | (-9.49)*** | -0.529 | (-2.08)** |
| Slovak Republic | -11.612 | (-5.86)*** | -0.788 | (-2.44)** |
| Spain | -9.988 | (-7.52)*** | 0.942 | (3.96)*** |
| Switzerland | -3.391 | (-2.55)** | -0.290 | (-1.22) |
| Turkey | -17.915 | (-13.40)*** | -0.182 | (-0.77) |
| United Kingdom | -6.395 | (-4.81)*** | 0.425 | (1.79)* |
| United States | 6.153 | (4.63)*** | -0.022 | (-0.09) |

Adj. $R^2$ = 0.9751

F-test = 4.88*** $H_0: \delta_1 = \delta_2 = \ldots = \delta_{28} = 0$

No. of obs. = 222

Notes: Luxembourg has been dropped in the regression due to missing values. T-values in brackets. *** indicates significance at 1% level; ** at 5% level; and * at 10% level.

[1] All intercept coefficients, except for Sweden, are measured as deviations from Sweden.

[2] All slope coefficients, except for Sweden, are measured as deviations from Sweden.

There are big differences in the levels of educational attainment among the OECD countries. Twenty-one of the countries have a significant difference in the differential intercept coefficients, $\varphi_i$, compared to Sweden. The interpretation of this is ambiguous, since the educational systems differ across countries with respect to the stages into which education is broken. A program classified as a tertiary program in one country could be classified as something else in another country, causing the differences in intercept levels. The differential slope coefficients, $\delta_i$, are only significant for Greece and Spain at 1% level, Canada, Czech Republic, Italy, Korea, Portugal and the Slovak Republic at 5% level and the United Kingdom at 10% level. The F-test, indicating that all the differential slope coefficients are zero, was rejected at 1% level (F = 4.88). Among those countries that have a significant difference in the slope coefficient, only Italy and U.K. ranks among Sweden's top ten trading partners.[44] We also checked if the differential slope coefficients were equal to zero for the top ten foreign destinations for Swedish exports and the top ten countries of origin for Swedish imports respectively. The F-test on export markets is equal to 2.01 which is significant on 5% level and the F-test on import origins is equal to 1.49 which is insignificant. Our conclusion of this has to be that the growth in endowment of skilled labor in Sweden is not different compared to Sweden's most influential trading partners (competitors), since there is a low or no significant difference in the accumulation of skilled labor between Sweden and its biggest trading partners.

# 6. Conclusions and final remarks

This paper has presented several measurement problems related to the calculation of the Swedish human capital content of trade. Our analysis in chapter 4 reveals to some extent the importance of including the service sectors in the calculations and using annual factor input requirements, since the choice of measurement of the development of the human capital content of trade over time, seem only to be affected by those two measurement issues. If we are interested in calculating the factor content of trade for a single year instead, the calculations seem very dependent on how we measure the different concepts involved in the calculations.[45]

[44] The top ten foreign destinations for Swedish exports amounts for 2/3 of total exports, and the top ten countries of origin for Swedish imports amounts for 3/4 of total imports. (See table B2 in appendix B).
[45] See table 4.8.

In chapter 5 we showed that the specialization pattern for Sweden has moved away from industries intensively using high skilled labor. The *z*-value has been gradually declining during the first half of the 1990's, indicating that the average requirements of high skilled labor in exports have been falling relative to average requirements in imports. In the second part of the 1990's we have an increase in *z*, but this increase was leveling out and started to turn back down at the end of the period.

A general conclusion that can be deduced from the analysis is that the factor content of trade in a single year is dependent on how we measure the different concepts involved in the calculations. If our structural measure is reliable, we can conclude that the skill intensity in Swedish net trade of manufacturing goods has been decreasing during the measured period. This result is important for future educational policy, since current endowment of skilled labor is heavily influenced by past educational policy. In order to increase the skill intensity in Swedish net exports, big efforts are needed to increase the educational attainment level of the labor force in manufacturing industries.

This work can be extended by using annual input-output tables to check whether one shall use direct or total factor input requirements in the *z*-calculations over time. Another extension can be to include more countries in the study. This latter extension will give us an opportunity to generalize our results from chapter 4 or not, since we don't know if the conclusions in this study are country specific or not.

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# Appendix

## A. Fixed or variable factor input requirements (differentiation)

In this note we decompose the $z$-equation, equation (7), in order to understand the forces behind the puzzling result whether to use fixed or variable factor input requirements when calculating the factor content of trade. If we use equation (7), i.e. $z = \sum x_i a_i \big/ \sum m_i a_i$, where $x_i = X_i \big/ \sum_i X_i$, $m_i = M_i \big/ \sum_i M_i$ and $a_i = \frac{wL_i}{p_i Q_i}$, where $L_i$ is the number of skilled workers, $w$ wage for skilled workers, $p_i$ output price, $Q_i$ output volume in industry $i$ respectively. If we differentiate equation (7) totally with respect to $x_i$, $m_i$ and $a_i$ we get,

$$dz = \sum_i \frac{a_i \sum_k a_k m_k}{\left(\sum_k a_k m_k\right)^2} dx_i - \sum_i \frac{a_i \sum_k a_k x_k}{\left(\sum_k a_k m_k\right)^2} dm_i + \sum_i \frac{x_i \sum_k a_k m_k - m_i \sum_k a_k x_k}{\left(\sum_k a_k m_k\right)^2} da_i, \quad \text{(A1)}$$

where $i = k$ . If we rearrange and simplify equation (A1) we get,

$$dz = \frac{1}{\sum_k a_k m_k}\left(\sum_i a_i dx_i + \sum_i x_i da_i\right) - \frac{\sum_k a_k x_k}{\left(\sum_k a_k m_k\right)^2}\left(\sum_i a_i dm_i + \sum_i m_i da_i\right) .$$

Since $z = \sum x_i a_i \big/ \sum m_i a_i$ and $i = k$ we can simplify the equation even further,

$$dz = \frac{1}{\sum_k a_k m_k}\left[\left(\sum_i a_i dx_i + \sum_i x_i da_i\right) - z\left(\sum_i a_i dm_i + \sum_i m_i da_i\right)\right].$$

Let the $z$-equation for fixed input requirements be denoted as $z^F = \sum x_t a_0^F \big/ \sum m_t a_0^F$ and the equation for variable input requirements be denoted as $z^V = \sum x_t a_t^V \big/ \sum m_t a_t^V$ . The difference $\Delta z = z^V - z^F$ will then depend on,

$$\Delta z = \frac{1}{\sum_k a_k m_k}\left(\sum_i x_i da_i - z \sum_i m_i da_i\right) ,$$

which is also equal to,

$$\Delta z = \frac{1}{\sum_k a_k m_k}\left( \sum_i \left( x_i - zm_i \right) \;\; da_i \right) \;,$$

since $a_i$ is treated as a constant in the fixed case. The difference between fixed and variable factor input requirements do depend on a scale parameter, $1/\left(\sum_k a_k m_k\right)$, and $\left(\sum_i \left(x_i - zm_i\right) \;\; da_i\right)$. In the case where $z$ = 1 the difference is simply the sum of each sectors net trade times its change in skill intensity.[46] Then, a value of $\Delta z > 0$ will mean that there has been a positive general increase in skill intensity in net exporting industries or a negative general decrease in skill intensity in net importing industries.[47] In those cases where the level of $z$ is not equal to one, the interpretation will become more difficult, since the level of $z$ affects the outcome. It seems, though, that if $z > 1$, it places a higher weight on the skill intensity in imports which increases the negative effect on $\Delta z$ downwards and the other way around if $z < 1$, if there is a positive increase in the factor input requirements.

[46] This result shall of course also be multiplied by the scale parameter.
[47] There is a special case, though, since when we have an equal change in all sectors skill intensity, positive or negative, the effect on $\Delta z$ will be zero.

# B. Tables

Table B1 **Trends in educational attainment at tertiary level (1991-2001)** *Percentage of the labor force of 16 to 64-year-olds that has attained tertiary education.*

| | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
| **OECD countries** | | | | | | | | | | |
| Australia | 22.4 | m | 22.7 | 23.4 | 24.6 | 25.1 | 23.0 | 26.1 | 27.1 | 27.6 |
| Austria | 7.1 | 7.3 | m | 8.1 | 8.3 | 8.5 | 11.0 | 12.0 | 12.0 | 15.0 |
| Belgium | 24.5 | 24.8 | m | 27.4 | 29.9 | 29.2 | m | m | m | 33.0 |
| Canada | 30.0 | 31.2 | m | 34.5 | 35.3 | 35.9 | 37.7 | 38.3 | 39.0 | 39.4 |
| Czech Republic | 9.6 | 10.3 | 10.3 | m | m | m | 10.4 | 10.3 | 10.7 | 11.0 |
| Denmark | 17.2 | 18.1 | m | 18.6 | 19.5 | 20.2 | m | m | m | m |
| Finland | 25.9 | 26.5 | m | 27.7 | 28.6 | 29.2 | 30.4 | 30.9 | 30.3 | 31.9 |
| France | 16.8 | 17.6 | 19.0 | 19.7 | 20.6 | 21.2 | 22.1 | 22.7 | 23.5 | 24.3 |
| Germany | 20.9 | 20.5 | m | 21.0 | 23.0 | 22.8 | 22.8 | 23.2 | 23.0 | 23.2 |
| Greece | m | m | m | 21.4 | 21.3 | 23.0 | 23.3 | 25.4 | 27.2 | 8.4 |
| Hungary | m | m | m | m | m | 15.2 | 14.0 | 15.1 | 15.5 | 17.7 |
| Iceland | m | m | m | m | m | 17.8 | 18.1 | 17.8 | 18.7 | 19.9 |
| Ireland | 19.3 | 20.6 | m | 22.9 | 24.5 | 27.3 | 27.4 | 25.2 | 24.0 | 23.0 |
| Italy | 7.2 | 7.5 | m | 9.1 | 9.6 | 10.0 | m | 16.1 | 16.8 | 14.0 |
| Japan | m | m | m | m | m | m | 32.5 | 32.3 | 33.6 | 35.5 |
| Korea | 15.6 | 17.3 | 18.7 | 19.1 | 20.0 | 21.0 | 21.3 | 24.3 | 24.7 | 25.5 |
| Luxembourg | m | m | m | m | m | m | m | m | m | m |
| Mexico | m | m | m | m | 6.9 | 7.1 | 7.4 | 7.1 | 7.7 | 7.2 |
| Netherlands | 20.4 | 21.6 | m | 22.6 | 23.5 | 23.8 | m | m | m | 26.0 |
| New Zealand | 22.0 | 23.1 | m | 22.5 | 24.3 | m | 24.1 | 25.0 | 25.1 | 26.2 |
| Norway | 25.0 | 25.6 | m | 27.8 | 29.1 | 26.7 | 26.0 | 25.9 | 29.9 | 30.6 |
| Poland | m | m | m | m | 10.3 | m | 14.1 | 15.1 | 15.7 | 15.6 |
| Portugal | 7.6 | m | m | 11.5 | 12.1 | 11.9 | m | 9.1 | 9.6 | 9.8 |
| Slovak Republic | m | m | m | 11.7 | 11.2 | 11.6 | 10.8 | 10.8 | 10.3 | 10.6 |
| Spain | 11.9 | 16.7 | m | 19.0 | 20.3 | 21.9 | 23.4 | 24.6 | 25.5 | 27.0 |
| Sweden | 23.8 | 24.4 | m | 25.7 | 26.7 | 26.9 | 26.7 | 27.5 | 28.3 | 29.6 |
| Switzerland | 20.0 | 21.1 | m | 21.7 | 21.6 | 22.3 | 21.6 | 22.2 | 22.9 | 23.3 |
| Turkey | 6.5 | 5.8 | m | 7.3 | 7.4 | m | 8.4 | 8.5 | 8.8 | 10.0 |
| United Kingdom | 16.1 | 18.6 | m | 21.7 | 22.3 | 22.8 | 23.3 | 24.3 | 25.2 | 26.1 |
| United States | 29.9 | 30.0 | m | 32.0 | 32.9 | 33.2 | 33.1 | 33.8 | 34.3 | 34.9 |

*Notes: The letter "m" indicates missing value. Source:* OECD. See Annex 3 for country notes in Education at a Glance 2003. (www.oecd.org/edu/eag2003).

**Table B2:** Top ten export- and import shares by trading partner in 2000.

| **Country** | **Export share** | **Country** | **Import share** |
|---|---|---|---|
| Germany | 0.1089 | Germany | 0.1739 |
| USA | 0.0962 | United Kingdom | 0.0941 |
| United Kingdom | 0.0935 | Norway | 0.0851 |
| Norway | 0.0768 | Netherlands | 0.0751 |
| Denmark | 0.0552 | Denmark | 0.0717 |
| France | 0.0523 | USA | 0.0698 |
| Finland | 0.0522 | France | 0.0585 |
| Netherlands | 0.0497 | Finland | 0.0555 |
| Belgium | 0.0430 | Belgium | 0.0367 |
| Italy | 0.0386 | Japan | 0.0307 |
| Sum: | 0.67 | Sum: | 0.75 |

***Note:*** The export (import) shares have been calculated as the sum of Swedish exports (imports) to (from) country i divided by the sum of Swedish exports (imports) to (from) all countries in year 2000. Source is Statistics Sweden's statistical databases at www.scb.se.