

Product Quality and the Human Capital Content of Swedish Trade in the 1990s

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Abstract

In an earlier study, Widell (2005), we calculated the average human capital content of Swedish trade in exports relative to imports in manufacturing sectors and found that the human capital content were higher in imports over the period 1986-2000. However, one of the shortcomings when calculating the factor content of a country's net trade is the use of a common technology matrix for all countries, compared to using each country's own factor input requirements. This paper propose a method to circumvent this problem by combining a structural measure developed by Lundberg & Wiker (1997), which is based on the Heckscher-Ohlin-Vanek equation and used in Widell (2005), with the concept of vertical intra-industry trade. The proposed method makes a quality adjustment in the Lundberg & Wiker measure, reflecting the problem of collecting data on each of a country's trading partner's factor input requirements, when calculating the factor content in imports. The method is then used to (re)calculate the average human capital content of Swedish trade in exports relative to imports in 1997 and 2000 and the new results reveal that the average human capital content of Swedish exports were higher relative to imports for those years, contradicting the previous empirical results.

Keywords: Factor content of trade, intra-industry trade, product quality

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1. Introduction

Widell (2005) recently found that the average human capital content in Swedish imports was higher relative to exports in manufacturing sectors during the period 1986-2000. In the study he used a structural measure derived from the Heckscher-Ohlin-Vanek (HOV) equation and he – *inter alia* – calculated the human capital content of Swedish net trade and evaluated different measurement issues evolving from those calculations. The results showed that the calculations were dependent on measurement practice in the evaluation of a single year, but less dependent in the evaluations over time.

The result that the average human capital content in Swedish imports was higher relative to exports were not in accordance to our *a priori* expectations due to the fact that Sweden is highly endowed with skilled labor.¹ One explanation of the outcome may be that Swedish factor input requirements were used in calculating the skill content in both exports and imports.² The use of a common technology matrix follows both from the theory behind the Heckscher-Ohlin-Vanek model and from the conventional factor content of trade literature. However, there is some evidence that the adoption of a common technology matrix for all countries will lead to attenuation bias.³ One reason may be that a common technology matrix excludes the possibility of factor content in intra-industry trade. It would, however, be better to use the factor input requirements of each of Sweden's trading partners when calculating the skill content of imports, since if factor price equalization fails, factor contents should be measured by the production technology of the exporting country. However, data on factor input requirements for all, or even only the most important trading partners, are hard to obtain.

Other possible explanations for the results in Widell (2005) are i) that the service sectors are excluded from the calculations, due to lack of credible data and ii) the exclusion of the public sector from the calculation, which is very skill-intensive and relatively big in Sweden in comparison with other countries, the supply of skilled workers available to the manufacturing sectors become relatively smaller compared to other countries.

¹ Particularly since Widell (2005) measures skilled labor as labor with at least a post-secondary educational attainment level.

² See equation 3.7 below or equation 11 in Widell (2005).

³ See Treffer (1993 and 1995), chapter 3 in Wood (1994), Davis & Weinstein (2000) and Widell (2005).

Another possible way to advance in the calculations, taken in this paper, is to use the idea of vertical intra-industry trade (VIIT). With perfect information, a specific product variety sold at a higher price must be of higher quality than the variety sold at a lower price.⁴ According to Sutton (1986), given two varieties of the same good offered at the same price, the one good with the highest quality will be preferred by all consumers. Hence, if products that are both exported and imported are vertically differentiated, it is reasonable to think that the difference in product quality is associated with differences in skill content, i.e. high quality goods requires higher content of skilled labor than low quality goods.⁵

The remainder of this paper is structured as follows. Section 2 surveys some of the related literature, with special emphasis on Sweden and on the connection between human capital and product quality. Section 3, which are divided into three subsections, address theoretical, methodological and data questions. Subsection 3.1 outline the theoretical backgrounds on which the proposed model (method) is based, which is further described in subsection 3.2 and in subsection 3.3 a brief explanation of the data used in this study is provided. Section 4 is divided into three subsections, where in 4.1 the empirical results are shown, discussed and compared with those in Widell (2005); in 4.2 a sensitivity analysis of the results is performed and discussed and in 4.3 some policy implications are provided. Finally, concluding remarks are provided in the closing section 5.

2. Related literature

In a survey article by Leamer (1992) he noted that there are only two empirical findings that have altered the way economists think of the causes of international trade. The first is the Leontief paradox, which gave birth to the extensive factor content of trade literature; the second is the great degree of intra-industry trade catalogued by Grubel & Lloyd (1975). Since 1975 there have been several other studies confirming the big share of intra-industry trade, e.g. Abd-el-Rahman (1991) on French data, Crespo & Fontoura (2001) on Portuguese data, Greenaway *et al.* (1994) on UK data and Lundberg (1982) and Greenaway & Torstensson (1997) on Swedish data.

⁴ Stiglitz (1987) gives several examples also in cases with imperfect competition.

⁵ Celi (1999) also uses the assumption that VIIT is driven by differences in skill content. Greenaway *et al.* (1994) and (1995) implicitly assumes the same, since they use the ratio of manual workers to total employment of each industry as a proxy variable for quality differentiation.

Until the beginning of the 1990s, most of the literature on intra-industry trade has thought of product differentiation as a horizontal phenomenon, meaning that different varieties of a specific product are of a similar quality. Recently, there has been a distinction between horizontal intra-industry trade (HIIT) and VIIT that has grown in importance, where VIIT arises when different varieties of the same product are of different qualities.⁶ Since international specialization does not only emerge in countries specializing in producing products in different industries, but of different varieties of products within the same industry both vertically and horizontally, we have to separate the different types of international trade. One reason for doing this is that the results from a trade expansion have different implications on factor markets, since the determinants behind VIIT and HIIT differ (see e.g. Aturupane *et al.* (1999) and Torstensson (1992, 1996a)). Empirically Greenaway *et al.* (1995) and Greenaway *et al.* (1999) show that VIIT is markedly more important than HIIT for the UK. Fontagné & Freudenberg (1997) find a similar result for the EU. Hansson (1994) finds that VIIT in Swedish manufacturing in 1983 is an important determinant of intra-industry trade and that it is most common in trade with other developed countries.

One problem that arises here is how to disentangle HIIT and VIIT from the trade data. Two of the more prominent studies in the field are Greenaway *et al.* (1994) and Fontagné & Freudenberg (1997). Both studies use unit value ratios together with a dispersion factor to find the two forms of intra-industry trade, but they do it in slightly different ways. They both calculate unit value ratios for a product and Greenaway *et al.* (1994), on the one hand, checks if the calculated value lies within an interval $[(1-\alpha), (1+\alpha)]$, which indicates HIIT, or not, which indicates VIIT. Fontagné & Freudenberg (1997), on the other hand, use the interval $[1/(1-\alpha), (1+\alpha)]$, with a similar interpretation. In a recent study, Azhar & Elliot (2004) use a different method based on the share of HIIT or VIIT in total intra-industry trade. They use an index that has symmetrical limits and is equally distributed between both lower and upper bounds. In this study we will, however, use a logarithmized version of the Greenaway *et al.* (1994) dispersion factor.⁷

⁶ The distinction between HIIT and VIIT draws here on Greenaway *et al.* (1994). Lloyd & Grubel (2003), however, note that there was a different distinction earlier in the literature, dated back to the mid 1970s, where HIIT meant the exchange of competing or substitute products and where VIIT meant the exchange of products at different stages in the production process of the products.

⁷ This is further discussed in section 3.2.

There is not, to our knowledge, a straightforward theoretical link between product quality, price and human capital.⁸ Greenaway & Milner (1986) has suggested, though, that it is human capital and not physical capital that is, to a great extent, positively related to quality. Torstensson (1996b) draws on this suggestion and investigates whether physical or human capital is most important in influencing the quality of vertically differentiated products. He finds from a study of Swedish imports of vertically differentiated products at SITC 3-digit level in the 1980s, that human capital is the main determinant behind the quality of production. Redding (1996) argues that a country's scarcity in education and other types of training is highly related to firms' product quality investments. Hansson (1994), however, studies manufacturing sectors in 1983 and finds that the relationship between quality (measured by price per tonne) and capital intensity (physical and/or human) has a weak empirical support. Greenaway & Torstensson (1997) finds that abundant human capital endowment increases the quality of the OECD countries manufacturing exports, using Swedish data from 1969, 1981 and 1994. They also find that human capital becomes a more important determinant of quality over time.

3. Theory, methodology and data

3.1 Theoretical bases of the proposed model

The standard multifactor, multicommodity, and multicountry setting model for predicting factor services trade is the HOV model.⁹ The model show that countries, if trade is balanced, who have an abundant relative endowment of a factor will have an embodied net export of that factor and a net import of the factor in which they have a scarce relative endowment.¹⁰

Intra-industry trade, i.e. simultaneous exports and imports of the same statistical product group, sometimes denoted two-way trade, is an area of research where publications began in the 1960s. The term intra-industry was first used by Balassa (1966) and has now become one of the tools in each trade economist's toolbox. In 1971 Grubel & Lloyd presented a measure of intra-industry trade, later known as the Grubel-Lloyd index, which have been highly used ever since. The evolution since the 1970s ha

⁸ Stokey (1990), however, develops a growth model with heterogeneous labor, differentiated by human capital, as the only factor of production and where she assumes that higher-skilled labor produces higher-quality products.

⁹ See Vanek (1968) and Leamer (1980).

¹⁰ The HOV-model is further described in Widell (2005).

been characterized by Greenaway & Milner (1986, p. 2) as; “a phenomenon in search of a theory”.

One commonly used link between the Heckscher-Ohlin trade model and intra-industry trade was presented by Falvey (1981) and further developed by Falvey & Kierzkowski (1987).¹¹ Their model, commonly named the “neo-Heckscher-Ohlin model of intra-industry trade”, consists of two countries and two factors, where one factor is industry specific. This factor can freely move between firms within a given sector but not between different sectors. They also assume that at least one sector produces vertically differentiated goods using labor and the industry specific factor as inputs.¹² Falvey (1981) defines a sector by the range of products the industry specific capital equipments can produce. The technology exhibits constant returns to scale and markets are perfectly competitive.¹³ The outcome of the model shows that relatively capital-abundant countries specialize in and export high quality products and the relatively labor-abundant countries specialize in and export low-quality products.¹⁴ Balboni (2004), however, builds a model that explains trade in products of different quality that have identical factor intensity at any relative price. This is consistent with the empirical findings that VIIT is observed even at a much disaggregate level of statistical classification.

Two other ways to measure quality has been proposed in the literature by Cooper *et al.* (1993) (hedonic pricing) and Brenton & Winters (1992) (price elasticities). A problem with both those methods are that they are too data intensive and more appropriate to use in analyses of individual product markets compared to the multiproduct analysis carried out here.

3.2 The Method

The most popular way to separate different quality levels in product datasets is to calculate a unit value by dividing the monetary value of trade

¹¹ Further studies have used their model e.g. Celi (1999), Ferragina & Pastore (2004) & Torstensson (1996b).

¹² The authors assume that it is capital that is industry specific in the model. Further descriptions of the neo-Heckscher-Ohlin model can be found in chapter 2 in Greenaway and Milner (1986).

¹³ Some competing models, e.g. Brander (1981), Krugman (1981) and Helpman & Krugman (1985), rely on imperfect competition together with horizontal product differentiation and economies of scale when explaining intra-industry trade. Davis (1995), however, provides a model based on comparative advantage that does not involve increasing returns and Flam & Helpman (1987) provides a model that focus on trade between North and South with a focus on Ricardian supply effects.

¹⁴ The model assumes that the production of higher-quality products requires a higher quantity of capital per unit of labor.

by the quantity, which gives a price per tonne.¹⁵ The rationale for using such unit values is that a product of a higher quality should demand a higher price, which means that it can be considered as an, although not perfect, indicator of quality.¹⁶ When measuring the human capital content of net trade in Sweden, it is reasonable to suppose that differences in product quality are associated with differences in skill content. This implies that a high quality product should incorporate a high content of skilled labor.

The method proposed in this study builds on two assumptions that are not tested here. The first assumption is that the price, measured by unit-value ratios, of a product p in a given sector i is proportional to the input requirements of skilled labor in that sector, i.e. $a_{i,p,f} = b \times UVR_{i,p}$, where b is a constant and subindex f indicate a factor or factors; second, that the constant b is identical among all sectors.

The calculation of VIIT adjusted average human-capital content of trade in Swedish exports relative to imports follows a step-by-step procedure according to the following. First, we calculate the unit-value ratio between Swedish exports and imports for each single bilateral trade flow, using data from COMTRADE at SITC rev. 3 (4/5-digit).¹⁷ Following Greenaway *et al.* (1995) we distinguish between horizontal- and vertical IIT, using,

$$UVR_{i,p,c} \Rightarrow (1-\alpha) \leq \frac{UV_{i,p,c}^x}{UV_{i,p,c}^m} \leq (1+\alpha), \quad (3.1)$$

where i denote industry, p product, c country and α dispersion factor. This dispersion factor is in various studies set to 0.15 or 0.25; and we will use both values in this study as a comparison.¹⁸ If the $UVR_{i,p,c}$ is less then $(1-\alpha)$, the lower bound, it is thought of as low quality VIIT and if the $UVR_{i,p,c}$ is greater than $(1+\alpha)$, the upper bound, it is thought of as high quality VIIT. All other ratios between $(1-\alpha)$ and $(1+\alpha)$ are defined as HIIT. The $UVR_{i,p,c}$ will also be logarithmized in order to ensure symmetry between the lower and upper bounds in terms of their relative distance from unity when

¹⁵ Torstensson (1991), on the contrary, uses unit values per item as an alternative to unit values per tonne.

¹⁶ See Stiglitz (1987). However, Lüthje & Nielsen (2002) discuss that unit-value ratios are poor indicators of quality, but we haven't found a better alternative measure of quality, so we will stick to using unit values.

¹⁷ Here we also follow Aturupane *et al.* (1999), Crespo & Fontoura (2001) and Gullstrand (2002) and let small trade volumes be removed from the sample together with trade flows without any information on quantity. The limit value we use is 20,000 USD.

¹⁸ We will also use $\alpha=0$ to see how sensitive the results are from the use of different dispersion factors.

distinguishing between VIIT and HIIT.¹⁹ This exercise gives us the following equation,

$$\log UVR_{i,p,c} \Rightarrow \log(1 - \alpha) \leq \log\left(\frac{UV_{i,p,c}^x}{UV_{i,p,c}^m}\right) \leq \log(1 + \alpha), \quad (3.2)$$

which is the equation used for distinguishing between VIIT and HIIT.

The unit value ratios that are revealed to be of the horizontal category will be set to 1 while those that are revealed to be vertical will keep the calculated values from equation (3.1).²⁰

Secondly, we aggregate the unit value ratios for each product separately using trade weights, i.e. by SITC rev. 3 products, according to,

$$\text{ProdUVR}_{i,p} = \sum_c \left(\text{UVR}_{i,p,c} * \frac{(X_{i,p,c} + M_{i,p,c})}{\sum_{UVR \in \Omega_p} (X_{i,p,c} + M_{i,p,c})} \right) \forall_p, \quad (3.3)$$

where Ω_p is the set of unit value ratios ($UVR_{i,p,c}$) that belong to a specific product p .

Thirdly, we aggregate the products that belong to each industry group according to the 4-digit level of ISIC rev.3. The allocation of products to industries was based on a concordance table between SITC rev. 3 (4/5 digit) and ISIC rev. 3 (4-digit) attained from the Eurostat classification server Ramon.²¹ This gives us the following equation,

$$\text{IndUVR}_i = \sum_p \left(\text{ProdUVR}_{i,p} * \frac{(X_{i,p} + M_{i,p})}{\sum_{p \in \Omega_i} (X_{i,p} + M_{i,p})} \right) \forall_i, \quad (3.4)$$

where Ω_i is the set of products that belongs to a specific industry i . This gives a set of industry weights that will, in the next step, either scale up or scale down the skill intensity in the separate industries respectively. These

¹⁹ See Fontagné & Freudenberg (1997) and the discussion about the “proportionality” effect in Azhar & Elliot (2004) for a more thorough treatment of this issue.

²⁰ The separation between HIIT and VIIT is made by equation (3.2), but equation (3.1) is used (after setting the horizontal category to 1) hereafter, since unit value ratios less than one will have a negative value in its logged form.

²¹ See <http://europa.eu.int/comm/eurostat/ramon>.

industry weights are used as a weighting scheme in calculating the human capital content of trade in Sweden in 1997 and 2000.²²

The equation we will use to measure the human capital content of trade is derived from the Heckscher-Ohlin-Vanek equation,

$$F^c \equiv AT^c = V^c - s^c V^w, \quad (3.5)$$

where F^c is factor content of trade in country c , A is a vector or matrix of factor input requirements, T^c is a vector of net trade in country c , V^c is the endowment vector of a specific factor/factors in country c , s^c is a vector of country c 's share of world consumption, and V^w is the world endowment vector of a specific factor/factors.

We can write the 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

$$F_f^c = \sum_{i=1}^I T_i^c a_{ifc} = \sum_{i=1}^I X_i^c a_{ifc} - \sum_{i=1}^I M_i^c a_{ifc} = \sum_{i=1}^I X_i^c \sum_{i=1}^I x_i^c a_{ifc} - \sum_{i=1}^I M_i^c \sum_{i=1}^I m_i^c a_{ifc}, \quad (3.6)$$

where T_i^c is net exports for industry i in country c , X_i^c and M_i^c are exports (imports) from (to) industry i in country c , x_i^c and m_i^c the share of the i :th industry in the total exports (imports) from (to) country c , and a_{if} the use of factor f per unit of production from the i :th industry.

The comparison of the factor content of trade can be made in difference form, as in equation (3.6) above, or as a ratio,²³

$$z_{fct} = \frac{\sum_{i=1}^I x_{it}^c a_{ifct}}{\sum_{i=1}^I m_{it}^c a_{ifct}}. \quad (3.7)$$

If a superior (high quality) VIIT is revealed within an industry in equation (3.4), the skilled factor input requirements in imports, i.e. the denominator in equation (3.7), will be weighted down by the IndUVR_{*i*}-number and the opposite for inferior (low quality) VIIT.²⁴ These *adjustments* give us the following equation,

²² The choice of years is further discussed in section 3.3.

²³ This is a structural measure developed by Lundberg & Wiker (1997).

²⁴ The IndUVR's are not used to actually indicate the skill-intensity of a particular product or industry. Instead they are used to scale relative factor intensity among partner countries given a particular factor intensity that is industry specific.

$$z_{fct} = \frac{\sum_{i=1}^I x_{it}^c a_{ifct}}{\sum_{i=1}^I (m_{it}^c a_{ifct} / IndUVR_i)}. \quad (3.8)$$

Thes z -measure has a simple interpretation as the average requirements of a factor f , weighted by trade shares, per unit of exchange of exports, in thousands of Swedish kronor, compared to the average requirements of the imports, adjusted for quality differences. This gives 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.²⁵ This is the final equation in the step-by-step procedure.

Finally, a note on the factor input requirements, i.e. variable a_{ift} in equation (3.8). Theoretically we should use total factor input requirements in the calculations of the factor content of trade (see e.g. Hamilton & Svensson (1983) or Deardorff (1984)). However, since Statistics Sweden only has published symmetrical input-output tables on a highly aggregated level²⁶, we will use the direct factor input requirements when calculating the z -value in equation (3.8). Widell (2005) have shown that, using equation (3.7), both the choice of total- over direct factor input requirements on a 2-digit level (ISIC rev. 3) and the choice of aggregation level of the data do matter in a cross-sectional approach (as is done here). Feenstra & Hanson (2000) also show that aggregating different industries together gives a substantial aggregation bias.

3.3 Data

The data used in this study are taken both from the COMTRADE database maintained by the United Nations Statistics Division and from various databases maintained by Statistics Sweden. The COMTRADE-data consists of Swedish commodity trade, both imports and exports, with all its partner countries, i.e. on a multilateral basis, according to SITC rev.3 at 4/5-digit level for the years 1997 and 2001. The data are reported both in values (in USD) and in quantity units.²⁷ The data from Statistics Sweden were collected from the databases register based labor market statistics (RAMS), industrial statistics/financial statistics (IS/FS) and the foreign trade statistics. From RAMS we have collected both total wages and wages by educational groups at 4-digit ISIC rev.3; and from IS/FS we have

²⁵ See Lundberg & Wiker (1997) for further details.

²⁶ Statistics Sweden has published IO-tables for 1995 and 2000 on a 2-digit level ISIC rev.3.

²⁷ The COMTRADE data will only be used in calculating the IndUVR's.

collected total wages and gross production at the same 4-digit ISIC rev. 3 level. Wage taken from RAMS is annual earnings and wage taken from IS/FS is labor costs inclusive of social security costs. Exports and imports at the same ISIC level were collected from the foreign trade statistics. The years available are 1990-2000. Further explanation of the data from Statistics Sweden can be found in Widell (2005). The conversion key between SITC rev.3 and ISIC rev.3 were available from the Eurostat server RAMON. Here we limit ourselves to investigate manufacturing industries only, i.e. sectors 1511-3720 (ISIC rev.3), due to data availability.

The choice of years in the study is restricted by the available data. In this study we calculate the human capital content of net trade in 1997, with all data originating from 1997, and in 2000, with product trade data from 2001 and all other data from 2000. In 1997 the COMTRADE data contains around 54 000 observations on import values and around 80 000 observations on export values. In the calculations of unit value ratios, equation (3.1), we use approximately 27 000 bilateral observations. After calculating equation (3.3) we end up with around 2 100 observations (products) and when calculating equation (3.4) we end up with around 110 (industry sectors). In the dataset from Statistics Sweden we have observations representing around 200 industry sectors. When matching those datasets we get a perfect match for around 25 per cent of the industry sectors representing around 50 per cent of total trade value for all observations within the manufacturing sectors.

4. Results and analysis

When presenting the empirical results in this section we calculate equation (3.8) using one dataset including all of Sweden's trade partners, the column named "z-value (all countries)", and one dataset using only Sweden's trade with the OECD countries, the column named "z-value (OECD)".²⁸ We also include calculations using different values of the dispersion factor α , column "Dispersion factor", evaluating the importance of this factor in this type of studies.

²⁸ The OECD dataset is a subset of the "all countries" dataset.

4.1 Empirical results

The results from calculating the average human capital²⁹ content of exports relative to imports in Swedish manufacturing industries in 1997, using equation (3.8), are reported in table 4.1 below.

[Table 4.1 about here]

The first row show the result from the calculation performed in Widell (2005) for 1997,³⁰ the second to fourth rows show the calculations of equation (3.8) using different dispersion factors respectively. Both the calculations using data from all countries and those using data from only OECD countries, give an upward adjustment of the z-value compared to the results in Widell (2005). The z-value of the former is slightly higher than that of the latter, which is in accordance to our expectations. Due to the fact that the dataset containing OECD countries only consists of highly developed countries (North), we would expect the skill content in products produced in those countries to be of a similar quality to those products produced in Sweden, which in turn will give a small adjustment of the z-value in either direction, depending on the skill content in the traded products. Here we notice that the z-value in the OECD-calculations is adjusted upwards mirroring that the skill content in Swedish exports is higher than the OECD average.

In the dataset containing all countries, both developed/high skilled countries (North) and less developed/low skilled countries (South) are lumped together. Since “South” has a relatively large supply of unskilled labor compared to “North” that has a relatively large supply of skilled labor, we would expect the quality of a product produced in “South” to be lower than the same statistical product produced in “North”, resulting in a bigger effect on the z-value compared to that of the OECD countries.³¹ We would also expect this z-value to be higher than both that of the OECD countries and that in Widell (2005).

When comparing the different dispersion factors, it doesn't seem to be important which factor to use in the calculations of the z-value. In the case of using data from the whole dataset we find that the dispersion factor has

²⁹ A broad definition of human capital includes all characteristics of the labor force that gives in return a higher productivity of the worker, e.g. education, on-the-job and of-the-job training. We use educational attainment as our measure of human capital, since the other two are hard to measure.

³⁰ See figure 4.3 in Widell (2005), which is based on the 4-digit level of ISIC rev.3.

³¹ See Wood (1994) for a similar argument about quality differences between North and South.

an insignificant effect on the resulting z-value, and in the case of using data from only the OECD countries, we find that the dispersion factor have a very small effect on the z-value. This low, or no, impact of the dispersion factor on the calculations may be a consequence of the weighted aggregations performed in equations 3.3 and 3.4.

Table 4.2 below reports the same calculations as table 4.1 using trade data from 2001 and factor input requirements data from 2000.

[Table 4.2 about here]

The results from the calculations are similar to those in 1997, both when using the dataset covering all countries and in the use of the dataset covering the OECD countries. We see an upward adjustment of the z-values that are slightly higher in magnitude in 2001 than in 1997. The choice of dispersion factor seems to be unimportant even in this year.

Comparing the results from tables 4.1 and 4.2 with those in Widell (2005) we find that the z-values in 1997 and 2000 are lower than those reported here. Since the z-values in 1997 and 2000 in Widell (2005) also are below 1 and that the z-values calculated in this study for those years are above 1, the interpretation of the z-value in this study is the opposite. In this study we find that the average human capital content in Swedish exports is higher compared to the imports both in 1997 and in 2000. Those results follow our *a priori* expectations stated in the introduction. The results drawn from tables 4.1 and 4.2 above also corroborates with those of Torstensson (1991), who found that the quality of Swedish imports were generally lower than that of Swedish exports in the mid 1980s.

4.2 Sensitivity analysis

A possible link between product quality and human capital content of trade on one hand and the traditional factor content of trade literature on the other hand is technological differences. In the traditional factor content of trade literature, the poor fit of the Heckscher-Ohlin trade model have by many authors been ascribed the assumption of equal technologies across countries.³² Treffer (1993) and (1995) develops extended versions of the HOV-model allowing for technological differences between countries. In the 1993 study he allows all factors in every country to differ in their

³² See Widell (2005) and references therein.

productivities, while in the study from 1995 he allows the factor input requirements matrix to differ across countries. The difference between the two ways of allowing for technological differences is that in the first case, Trebler assumes that a factor in a country is, for example, 5 percent more productive than in another country, while in the second case, he assumes that a country needs 5 percent more of a production factor to produce the same amount of a product than another country. It is the latter case that form the basis of the model used in the sensitivity analysis.

In order to test how sensitive the results are from using unit value ratios as a measure of product quality, we have recalculated equation (3.8), without using quality weights, but instead using a Trebler (1995) inspired adjustment of the factor input requirements. This is calculated as follows,

$$z_{fct} = \frac{\sum_{i=1}^I x_{it}^c a_{ifct} \left(\frac{\bar{a}_{ifct}^{VH}}{\bar{a}_{ifct}^{tot}} \right)}{\sum_{i=1}^I m_{it}^c a_{ifct} \left(\frac{\bar{a}_{ifct}^{VL}}{\bar{a}_{ifct}^{tot}} \right)}, \quad (4.1)$$

where \bar{a}_{ifct}^{VH} is the average factor input requirements of those sectors that are revealed to produce high quality products (VIIT high), \bar{a}_{ifct}^{VL} is the average factor input requirements of those sectors that are revealed to produce low quality products (VIIT low); and \bar{a}_{ifct}^{tot} is the average factor input requirements for all sectors. The motivation for using average values is that a high quality good are assumed to be produced with higher skill content and *vice versa* with a low quality good.

[Table 4.3 about here]

As is seen in table 4.3 above, there is a large difference in the results when using average factor input requirements as indicator of product quality compared to unit value ratios. The results are also sensitive to which year the separation between high and low quality trade takes place. When using product trade data from 1997 we end up with a value below both the z_{eg} value and the z_{eg} (VIIT-corr) value, but when using product trade data from 2001 we end up above the two.

4.3 Policy implication

This study has thus far followed a positive approach. However, in this subsection we use the attained results and make some policy implications.

If we think of vertical product differentiation as an intra-industry product cycle, a country with an abundant relative endowment in high skilled labor will produce and export products that intensively use this factor. As the quality of the product decreases, i.e. the more standardized the product gets; the country will abandon the production of this particular product quality and introduce higher qualities or new products. The abandoned qualities will instead be produced in countries with an abundant relative endowment of low skilled labor.³³ This change in production factors has an effect on the comparative advantages of a country.

The calculation of adjusted z-values is, in the light of this, an important indicator of what type of products (quality) that are produced in a country relative to its trading partners. This, in turn, indicates that educational policy is needed to strengthen a country's comparative advantage. Thus, this is important since countries' endowments of human capital will be increasingly important in the determination of industrial location, international specialization and trade. The results presented in this study show that the average quality of Swedish imports is generally of a lower quality than the quality of Swedish exports suggesting that an educational policy aiming at increasing the skill intensity of the Swedish labor force is preferable.

The results from this study can also be interpreted as suggesting that the government should encourage those employees losing their jobs in low skilled sectors (or companies) either to search for work in high skilled sectors or to enhance their human capital through education.

5. Concluding remarks

In this paper we remodeled/adjusted a structural measure developed by Lundberg & Wiker (1997), which builds on the Heckscher-Ohlin-Vanek equation, by using the concept of VIIT. Due to the fact that a great part of a country's exports and imports takes place within the same statistical product groups, and that those products are often vertically differentiated,

³³ This scenario can also be explained by the Flam & Helpman (1987) North-South model with quality upgrading.

the structural measure, equation 3.7 above, needs to be adjusted in order to take this fact into account. This is done by adding an extra term in the denominator (see equation 3.8) measuring the unit value ratio between exports and imports for each industry.

If the adjusted z-equation (equation 3.8) reveals the true average human capital content of Sweden's export relative to imports, there is higher skill content in Swedish exports compared to imports in both 1997 and 2000. This result alters that of our earlier study (Widell 2005) using the standard z-equation (equation 3.7), which revealed that Swedish imports had a higher skill content, compared to exports for the whole time period 1986-2000. However, we want to stress that these calculations hinges on the idea that a specific product variety sold at a higher price must be of higher quality than the variety sold at a lower price.

The empirical results in this study also highlight the importance of an educational policy aimed at strengthen a country's comparative advantage. Since Sweden is a high skilled country with a positive net export, an increase in the skill level of the Swedish labor force through human capital formation (education etc.) is important for future welfare.

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Appendix

Variable definitions and construction + data availability

Table A.1 Variable definitions and data description

Variable definition	Data source
<ul style="list-style-type: none"> - Export (product) - Import (product) 	Trade data (exports and imports in values and quantities) from the UN statistics database COMTRADE, classified according to SITC rev.3 and recorded at the 4/5-digit level. Values are recorded in US dollars.
<ul style="list-style-type: none"> - Export (industry) - Import (industry) 	Trade data (exports and imports in values) from the foreign trade statistics at Statistics Sweden, classified according to ISIC rev. 3 (SNI-92) and recorded at the 4-digit level. Values are recorded in Swedish kronor.
Factor input requirements (a_{ifct} in equation 3.6, 3.7 and 3.8) Variables: <ul style="list-style-type: none"> - Total wages by industry - Total wages by educational group and industry 	Data collected from Statistics Sweden's database RAMS (register based labor market statistics). All data is classified according to ISIC rev.3 and recorded at the 4-digit level.
Factor input requirements (a_{ifct} in equation 3.6, 3.7 and 3.8) Variables: <ul style="list-style-type: none"> - Total wages by industry - Gross production by industry 	Data collected from Statistics Sweden's database IS/FS (industrial statistics/ financial statistics). All data is classified according to ISIC rev.3 and recorded at the 4-digit level.

Note! The COMTRADE database can be found at: <http://unstats.un.org/unsd/comtrade/default.aspx>; and the various databases from Statistics Sweden can be found at: <http://www.scb.se>.

Tables

Table 4.1 *The average human capital content of Swedish exports compared to imports in 1997.*

Model	Dispersion factor	z-value (all countries)	z-value (OECD)
Widell (2005)	-	0.906	-
Eq. 3.8	0.25	1.104	1.061
Eq. 3.8	0.15	1.104	1.063
Eq. 3.8	0	1.104	1.062

Note! The “all countries” z-value is based on a dataset including all of Sweden’s trade partners; and the “OECD” z-value is based on a dataset including Sweden’s trade with the OECD countries only. All calculations are based on equation 3.8, except the Widell (2005), which is the calculated z-value for 1997 in that study.

Table 4.2 *The average human capital content of Swedish exports compared to imports in 2000.*

Model	Dispersion factor	z-value (all countries)	z-value (OECD)
Widell (2005)	-	0.890	-
Eq. 3.8	0.25	1.170	1.133
Eq. 3.8	0.15	1.169	1.132
Eq. 3.8	0.00	1.169	1.132

Note! The “all countries” z-value is based on a dataset including all of Sweden’s trade partners; and the “OECD” z-value is based on a dataset including Sweden’s trade with the OECD countries only. All calculations are based on equation 3.8, except the Widell (2005), which is the calculated z-value for 2000 in that study.

Table 4.3 *Calculation of equation 4.1*

Year	z-value
1997	0.712
2000	1.220

Note! All calculations are performed on 4-digit ISIC rev.3 level.