Centre of Excellence for Science and Innovation Studies

CESIS Electronic Working Paper Series

Paper No. 322

Labor Decomposition
A Firm Level Analysis on Import Quality and Labor Demand

Peter Warda

June, 2013

The Royal Institute of technology
Centre of Excellence for Science and Innovation Studies (CESIS)
http://www.cesis.se

Labor Decomposition

A Firm Level Analysis on Import Quality and Labor Demand

Peter Warda[*, **]

(peter.warda@jibs.hj.se)

Abstract:

Structural changes due to global integration certainly affect the employment, productivity and profitability of firms. An interesting case reflects how firms use imports to replace certain stages in production of physical goods. The relevant question here is: if imports make up a substantial part of firms' sales value, then can the import quality affect firms' labor composition? The purpose of this paper is to analyze how high and low quality imports affect the labor composition in importing firms in Swedish manufacturing. Inter-firm variation shows that an increase in high (low) quality imports, on average, decreases the share of high-educated (low-educated) labor wages in total wages. Hence, a substitution effect. However, when intra-firm variation is considered the results are instead in favor of a complementary effect.

Keywords: Labor decomposition, labor composition, imports, quality of imports, manufacturing

JEL classification: F14, J21, J23, and O33

***** Jönköping International Business School (JIBS), Sweden

****** Center of Excellence for Science and Innovation Studies (CESIS) KTH, Sweden

1 Introduction

Does import quality matter for what type of labor is demanded by firms? In other words, do imports contain an additional source of knowledge that affects firms' labor composition?

According to Feenstra (2010), technological improvements in transport and communications in recent time have made costs in container shipping and other means of distribution lower compared to before.[1] In addition, developing countries grow at a fast pace and here firms can access services such as fiber optic cable and cellular telephone, as well as knowledge-based labor at lower costs than in advanced countries.

So what is this all about? Jones (2000) claims that firms' ability to utilize labor in foreign countries demonstrates that domestic resources no longer is the binding constraint on international trade. Hence, there are no forces that can hold back firms to scan the global economy in order to minimize costs. Costs have been pushed low enough so that it is worth for firms to break apart the production process into various fragments. Hence, the term "fragmentation" is used in Jones and Kierzkowski (2001: p1) to define a splitting up of a previously integrated production process into two or more components (or what is referred to as fragments) that are connected to the firm via advanced trade and service links.

After scanning the global economy for appropriate sources that fit the firms' cost function, one way for firms to achieve cost minimization and lower production costs is to bring competition on grounds of imports (Arndt 1998; Eaton and Kortum 2001). In this way, firms can replace labor-intensive and/or capital-intensive processes at home through importing ready to use inputs at lower costs. For example, Coe and Helpman (1995) find, for a bunch of OECD countries, that foreign R&D expenditure have a higher effect on domestic productivity, the higher the share of domestic imports in GDP. The result is also confirmed in subsequent research such as Eaton and Kortum (1999) and in Keller (2001).

More recent empirical research has related the effects of trade to an increased earnings gap. For example, Ekholm and Hakkala (2008) and Foster et al (2012) suggest that cheap imports, produced in foreign countries, reduce the earnings of domestic low-educated labor. In a theoretical point of view, this relationship is in line with the Heckscher-Ohlin-Samuelson (H-O-S) model, which predicts a widening earnings gap between low-educated and high-educated domestic labor when foreign trade increases.

[1] Korinek and Sourdin (2011) find that time-sensitive merchandise is typically transported via air cargo and often comprise imports of very high quality. In this sense, container shipping is slow and not suitable for sectors with rapid conversion of current goods produced.

However, how do imports become so important to a firm? The sales value of a firm can be defined as value added (i.e. labor cost plus gross profit) plus cost of inputs (of which some are imported). If imports correspond to a high share of the sales value, then imports contribute substantially to the firm's gross revenues from operating in the market. Hence, a firm that imports inputs (e.g. intermediate goods) of a certain quality might replace the type of labor that earlier processed such inputs in the firm. This setting brings about the fundamental research question raised in this paper: if firms' imports make up a substantial part of the sales value, can the quality of imports affect the labor composition in firms?

The purpose of this paper is to analyze how high and low quality imports affect the labor composition in importing firms in Swedish manufacturing. Furthermore, the paper contributes to existing research as it examines the relationship between import quality and labor composition at the firm level, and draws conclusions on the implications in regards to the firms' labor stock.

The paper is organized as follows: Section 2 gives a definition of imports in terms of both type and quality, and it includes a brief description of importing firms in Swedish manufacturing. Section 3 presents the theoretical framework that underpins the empirical model of choice in this paper. Section 4 covers an outline of the data (including descriptive statistics and a variables description). The regression results along with the empirical analysis are presented in Section 5. Finally, Section 6 concludes.

2 Import Type, Quality and Price

In reference to firm imports, some clarifications need to be stated before going into the import quality measurement. Imports can fall under the following three categories: A) current inputs, B) machinery and other capital goods, and C) consumer goods. Category C) comprises imports that usually are aimed directly towards retailers, and is not the focus in this paper. Hence, the focus here is on categories A) and B).

For an importing firm, categories A) and B) can be divided into imports that have: i) a higher quality, ii) an increased variety, and iii) lower costs. In the case of ii) and iii), the firm is allowed some flexibility. Such flexibility is explained in Jones (2000) as motivating firms to be less constrained from having binding domestic resources in relation to trade. Moreover, ii) and iii) are according to Dixit and Stiglitz (1977), Krugman (1980), Jones and Kierzkowski (2001), Helpman (2006) and Dicken (2007) main causes to that firms have a fragmented production system that is linked through trade and service networks.

Imports are reported at the eight-digit nomenclature according to the Standard International Trade Classification (SITC). In order to distinguish the quality of the import content one can consider the import unit price. Following Abd-el Rahman (1991) and Johansson (2008) an approximation of product quality using trade data is to compare average unit prices of imports in narrowly defined product groups.[2]

The unit import price of good g contained in product group G ($P^{M}_{g,g\in G}$) is obtained by dividing the import value of g contained in G ($M_{g\in G}$) with its weight ($Q_{g\in G}$) according to:

$$\frac{M_{g\in G}}{Q_{g\in G}} = P^{M}_{g,g\in G} \,. \tag{1}$$

Moreover, given that $P^{M}_{g,g\in G}$ is observed, then a high quality import can be defined as:

$$\frac{P^{M}_{g,g\in G}}{\bar{P}^{M}_{G}} > 1 \,, \tag{2}$$

where $\bar{P}^{M}_{G}$ is the average import price within the product group. A low quality import is given by:

$$\frac{P^{M}_{g,g\in G}}{\bar{P}^{M}_{G}} \leq 1 \,. \tag{3}$$

In this way, firm level imports can be distinguished in terms of low and high quality content.

2.1 Imports in Swedish Manufacturing

Imports of Swedish manufacturing firms have been increasing at a high pace over the time period analyzed. In 2000, the total imports in Swedish manufacturing were SEK 22,361 billion, which can be compared to SEK 34,186 billion in 2008. The average number of importing firms across the 22 sectors in Swedish manufacturing was 7,311, per year. Figure 1 displays the share of high and low quality imports in sales value for importing firms in Swedish manufacturing during the period 2000-2008. The share of high quality imports in sales value has been about two to three percent and increasing over the time period. The share of low quality imports in sales value has increased from about 16 percent in 2000, to approximately 18 percent in recent years.

[2] In the procedure to derive the import price, the product groups have been narrowed down to the fourth-digit nomenclature of the Standard International Trade Classification.

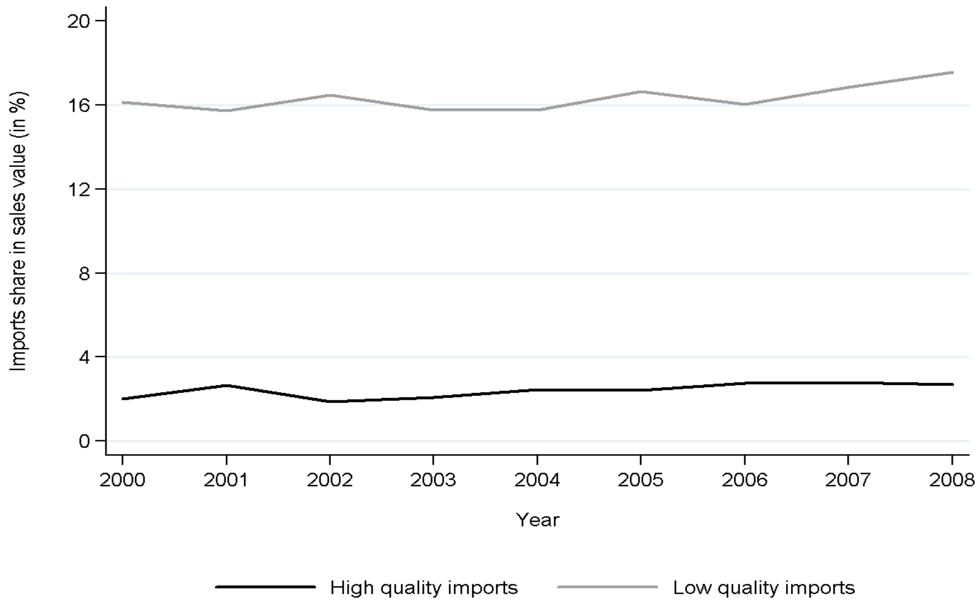

Figure 1 Imports share in sales value, importing firms in Swedish manufacturing (SNI 15-36) 2000-2008
Source: SCB (2013)

Figure 2 breaks down the setting depicted in Figure 1 into shares of high and low quality imports in sales value within various sectors in Swedish manufacturing. The share of high quality imports in sales value is large in sectors such as "petroleum and related", "chemicals and related", "apparel and fur dyeing", "basic metals", "medical/optical instruments", and "office machinery and PCs". However, in a majority of sectors in Swedish manufacturing, the share of high quality imports in sales value is low and fluctuates around values between one and two percent. The largest shares of low quality imports in sales value are found in "textile manufactures", "apparel and fur dyeing", "leather tanning/dressing", "rubber and plastic", and "motor vehicles".[3] Sectors that show smaller shares of low quality imports in sales value are "tobacco products", "wood and related", "pulp and paper" and "media production".

[3] Warda (2013) finds that West European (including Swedish) automotive firms typically locate low-skilled processes, such as simple assembly, in low-cost countries and later import these in form of inputs in domestic production. Gråbacke and Jörnmark (2008) find a similar trend in Swedish textile manufacturing.

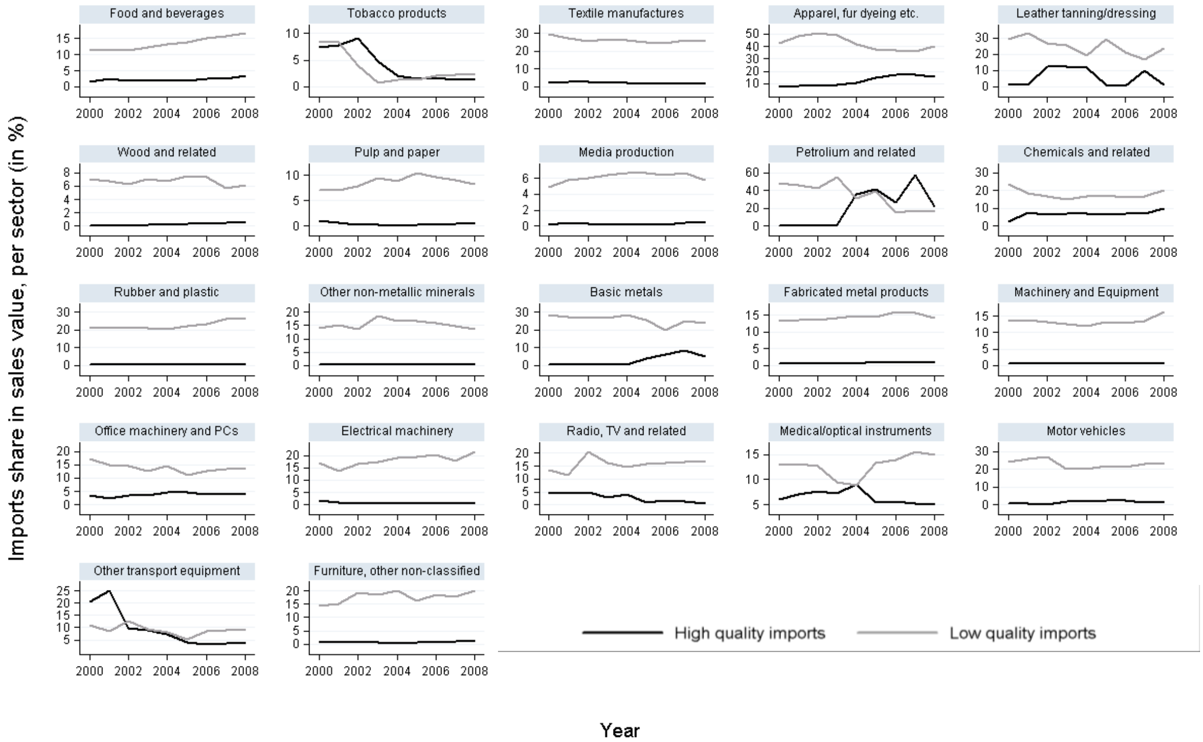

Figure 2 Imports share in sales value, importing firms in Swedish manufacturing (SNI 15-36) per sector 2000-2008
Source: SCB (2013)

Imports make up a substantial amount (about 20 percent) of the sales value genereated by importing firms in Swedish manufacturing. It is thereof motivated to ask whether the quality content of imports contain an additional source of knowledge that might affect the firms' labor composition.

The section that follows outlines the theoretical underpinnings that help explain the behavior of the firm in its choice of production, and how such choices can be empirically applied in research.

3 Theoretical Framework

A relevant point that needs clarification before going into the theoretical framework is the time perspective of the production function. The literature lists two types of production functions at the firm level. These are the traditional neoclassical theory of production (putty-putty) explained in Johansen (1959), and the putty-clay production theory that originates in Salter (1960). On the one hand, traditional neoclassical theory builds upon assumptions to substitute freely between factor inputs and is mostly adapted for analyzing long-term developments in the firm structure. A limitation of the traditional neoclassical production theory is that it is less suitable for analyzing short and medium term problems in the firm structure (Førsund and Hjalmarsson 1987). On the other hand, production theory of putty-clay puts emphasis on a shorter time perspective by combining technological choice, capacity and structural change. Ex ante, the putty-clay production theory assumes that there are full substitution possibilities, whereas ex post both capacity and factor proportions are fixed. The short term micro level production function is commonly optimized by maximizing output for given levels of current input (Johansen 1959; Salter 1960), and hence, is also the relevant production function in this paper.

There are two main approaches to analyze the behavior of the firm at the micro level. The first approach involves firms that maximize profits. Typical profit maximization for firm i follows from a maximization of its sales value (or revenues) less its costs. In line with Chambers (1988), an adapted profit maximization problem for an importing firm could take the following form:

$$\pi_i = max_{x,y\geq 0}\, R(\bar{K}_H, \bar{K}_L, \bar{L}_H, \bar{L}_L, M_H, M_L, I, p)_i - C(r_H K_H, r_L K_L, w_H L_H, w_L L_L)_i\ ,$$
$$\text{subject to} \quad f(K, L, M, I, p)_i \geq y_i \qquad (4)$$

where π is profit, R is the revenue function, and C is the cost function for firm i, respectively. Moreover, $\bar{K}$ and $\bar{L}$ are fixed amounts of capital and labor, M is imports, I refers to investment, and p is the price. r and w denote the cost of capital and the price of labor input, respectively. f is a production function of variable and fixed inputs, x is an input vector and y is output. Subscripts H and L indicate if input factors are assigned to high or low-skilled operations.

The second approach to analyze firms' behavior is to cost minimize. The short-run cost function of firm i given a putty-clay production function $f(x, \bar{x})$ is:

$$SC(w, \bar{w}, y; \bar{x})_i = \min_x w_i x_i + \bar{w}_i \bar{x}_i\ , \qquad \text{subject to} \qquad f(x, \bar{x})_i \geq y_i \qquad (5)$$

where x is a vector of variable inputs and $\bar{x}$ is a vector of fixed inputs. w and $\bar{w}$ are input prices of variable and fixed inputs, respectively. y denotes output. Equation (5) states that firm i minimizes its variable (wx) and fixed ($\bar{w}\bar{x}$) costs, subject to a given constraint. If input vector $x(w, \bar{w}, y; \bar{x})$ solves the minimization problem, then:

$$SC(w, \bar{w}, y; \bar{x})_i = w_i x(w, \bar{w}, y; \bar{x})_i + \bar{w}_i \bar{x}_i\ . \qquad (6)$$

The approach in where the behavior of the firm is to follow a cost minimization problem will be the starting point of the empirical application in this paper. The origins of this second approach in how to analyze firms' behavior can be traced back to Coase (1937), who suggested that firms exist in order to reduce the transaction costs that arise when economic agents trade in markets.[4] Vernon (1966) further dwelled on the cost perspective in an international setting by developing a framework where multi-plant firms created new products and processes in home and foreign markets. Dunning (1980) followed up on Vernon by arguing for the importance of location-specific factors as drivers of international firms seeking to exploit benefits in foreign countries.

Subsequent research has produced a whole stream of framework conditions that examine the implications of production fragmentation and/or technological change on the domestic labor composition. For example, Hamermesh (1993) presents an extensive review of methodologies to estimate various labor demand functions using different production functions such as Cobb-Douglas, Generalized Leontief, translog and CES translog cost functions. The following sub-section will briefly review the literature on shifts in labor composition.

3.1 A Review on Shifts in Labor Composition

In recent years the interest in skill-biased technological change, building upon framework conditions in Nelson and Phelps (1966) and Welch (1970), has developed substantially in empirical research on shifts in labor composition. The hypothesis in this stream of literature is that educational attainment increases with technological change, and more knowledge-intensive firms tend to implement new technology more efficient. Bartel and Lichtenberg (1987) extend this theory to also incorporate comparative advantages of high-educated workers into the framework condition, and thus clearly indicate that technological change is biased for different classes of labor.

A common methodology to model shifts in labor composition is to adapt a translog cost function presented in Berman et al (1994). The assumptions underlying this model are that firms minimize costs in choice of inputs and that there are constant returns to scale in production. The share equation in first differences that measures the change in non-production wages relative to total wages ($\mathrm{d}S_{nj}$) is:

$$\mathrm{d}S_{nj} = \beta_0 + \beta_1 \mathrm{d}\ln\left(\frac{w_{nj}}{w_{pj}}\right) + \beta_2 \mathrm{d}\ln\left(\frac{K_j}{Y_j}\right) + \epsilon_j \,, \qquad (7)$$

[4] Allen (1991) provides two common definitions of when transaction costs take place: first, transaction costs occur only when a market transaction takes place, and second, transaction costs occur as a property right is established or requires protection. In addition, transaction costs are explained in Arrow (1971) as: exclusion costs, interaction costs (e.g. information exchange, negotiation, contract formation, contract monitoring and contract enforcement costs), search and disequilibrium costs.

where w_n and w_p are wages of non-production and production labor, respectively. j is the industry index, K is capital and Y is value added. Whether β_1 is positive, or not, depends on if the elasticity of substitution between production and non-production labor is below or above unity. If β_2 is greater than zero, then there is capital skill-complementary. The intercept β_0 measures the average cross-industry bias in technical change, and adding the stochastic error (ϵ_j) to the intercept gives the industry-specific bias in technical change. Equation (7) has commonly been adapted to examine the relationship between trade and demand for labor skills, for example in terms of increased earnings gap.

Increased differences in earnings have been analyzed in framework conditions for both trade and international outsourcing. The framework condition for trade relies heavily upon the H-O model, published in Ohlin (1933) and later extended in Stolper and Samuelson (1941) into the H-O-S model. Here, cheap imports produced by foreign low-educated labor act to reduce the domestic wages of low-educated labor, which tend to increase the earnings gap between domestic labor classes. Moreover, Eaton and Kortum (2001) present a unified framework for technology, trade and growth that illustrates a rising aggregate productivity as countries open their borders to imports. The trade gains from imports are not only dependent on technology and geographic barriers, but on endogenously determined wages as well. In the international outsourcing framework (see e.g. Feenstra and Hanson (1996, 1997); Arndt (1997, 1998); Jones and Kierzkowski (2001)), the changes in labor composition are further exacerbated in favor of high-educated workers as firms exploit differences in costs of production factors, for example between developed and developing countries.

The approach to quantitatively analyze shifts in labor composition in empirical research builds mostly upon the methodology presented in Berman et al (1994) and Head and Ries (2002). For example, Morrison-Paul and Siegel (2001) use a dynamic cost function framework to simultaneously asses the impacts of trade, technology, and outsourcing on shifts in labor demand. The results show that technological change has the largest impact on changes in labor composition in favor of high-educated workers. Moreover, the impact of trade on demand for low-educated workers is negative.

The link between production transfer within Swedish MNEs in manufacturing and skill-upgrading in parent companies is examined in Hansson (2005). By using a non-homothetic translog cost function, Hansson finds that an increased employment share in affiliates in non-OECD countries has a positive effect on the share of skilled labor in Swedish parent firms.

However, the parent firms' skill upgrading is unrelated to employment changes in their affiliates in OECD countries.

Ekholm and Hakkala (2008) analyze the effects of offshoring of intermediate goods on relative demand for Swedish labor with different education levels. The methodological approach in this paper makes use of a translog cost function similar to that proposed in Berman et al (1994). The results show that offshoring to low-income countries tends to shift labor demand away from labor with an intermediate level of education and towards labor with a high level of education. Offshoring to high-income countries has the opposite effect.

Foster et al (2012) examine the link between international outsourcing and the skill-structure of labor demand in 18 countries. The approach to analyze the relative demand for labor involves estimating a translog cost function. The results show that international outsourcing has affected all skill-levels negatively. Yet, the largest impact is observed for medium-skilled (and to a lesser extent high-skilled) labor.

The results from previous research indicate that trade (in general) and fragmentation measures (such as outsourcing and/or offshoring) have a mixed relationship to technical change and shifts in labor composition. This ambiguity tends to make conjectures on how imports affect firms' labor composition more complex in this paper. The next sub-section intends to empirically apply a model that captures shifts in firms' labor composition as they proceed with importing various inputs of different quality (as defined in Section 2).

3.2 Empirical application

Inspired by Arndt (1997, 1998) and Jones (2000), I suggest that firm level imports of physical goods contain hidden sources of knowledge that become adapted into various segments in production of final goods. One can refer this as to firms' importing knowledge in "ready-to-adapt goods". To see this, assume that firm i produces good y by using two variable inputs: x_1 and x_2 (for simplicity assume zero fixed inputs). x_1 is a capital-intensive input processed by high-educated labor, whereas x_2 is labor-intensive and is processed by low-educated labor. Firm i initially produces y by using both inputs x_1 and x_2 at home and thus minimizes the variable cost function:

$$VC(w_1, w_2, y; x_1, x_2)_i \;=\; \min_{x_{zi}} w_{1i}x_{1i} + w_{2i}x_{2i} \quad ; \quad \forall\, i \;,\; z = 1, 2\,, \tag{8}$$

where w denotes the price of variable inputs. Suppose that firm i now decides that it might be possible to lower further its costs by instead importing the labor-intensive input x_2, simultaneously as it continues the process of x_1 at home, where it also assembles the final good y. In this case, firm i will minimize a new variable cost function according to:

$$VC(w_1, w_2^M, y; x_1, x_2^M)_i \; = \; \min_{x_{zi}} w_{1i}x_{1i} + \; w_{2i}^M x_{2i}^M \quad ; \quad \forall\, i \;,\; z = 1, 2\,, \tag{9}$$

where superscript M refers to firm i's imports of x_2. Hence, there are two distinct outcomes in the relationship between Equation (8) and Equation (9). Either the minimized costs from processing both inputs x_1 and x_2 at home are higher, or they are lower than the minimized costs of processing x_1 at home and importing x_2. This follows from the inequality:

$$VC(w_1, w_2, y; x_1, x_2)_i \; \gtreqless \; VC(w_1, w_2^M, y; x_1, x_2^M)_i \,. \tag{10}$$

In the case where Equation (9) is the superior cost alternative, firm i imports the labor-intensive input x_2 and processes the capital-intensive input x_1 at home. Note that the scenario can also be reversed. For example, firm i could import the capital-intensive input x_1, and process the labor-intensive input x_2 at home, or it could import both inputs given that the associated cost functions are lower than Equation (8).

Since imports comprise a larger or smaller fraction (the size depends solely on the firm's import propensity) of the total inputs used in production of y, the labor demand function, or the variable cost function of firm i can also be explained by imports, and more interestingly in terms of import quality. The point made here is that the choice of firm level inputs depend on how firms' cost minimize. In line with Feenstra and Hanson (1996, 1997), Bernard et al (2007), Ekholm and Hakkala (2008), van Winden et al (2011) and Foster et al (2012), one way for firms to cost minimize is to import cheap inputs from low-cost countries. Depending on the input content (i.e. whether inputs are labor-intensive or capital-intensive) it might affect firms' labor composition in production of final goods.

An approach to estimate shifts in labor composition as a part of a system of equations in empirical research is based on approximations using translog forms. The model specification considered here is based upon a translog cost function similar to that in Berman et al (1994). Moreover, the assumptions underlying the cost function in this paper are that firms are cost minimizers, the time perspective is short to medium term, the production exhibits constant returns to scale, and that the market is perfectly competitive. The quality of imports is presumed to affect the firms' labor composition (or variable costs). This is due to that some of the imported inputs might replace the type of labor that earlier processed such inputs in firms, and thus can be referred to as a substitution effect (see e.g. Eaton and Kortum (2001)). Hence, an increased amount of high quality imports would imply that firms replace inputs that require high-educated labor to process in production for low-educated labor. In a similar way, an increasing amount of low quality imports would imply that firms replace inputs that require low-educated labor to process in production for high-educated labor. The hypotheses can then be stated according to:

Hypothesis 1: High (low) quality imports affect high-educated labor in firm i negatively (positively), i.e. import quality has a substitution effect
Hypothesis 1A: High (low) quality imports have no effect on high-educated labor in firm i, or affect high-educated labor in firm i positively (negatively), i.e. import quality has a complementary effect

Hypothesis 2: Low (high) quality imports affect low-educated labor in firm i negatively (positively), i.e. import quality has a substitution effect
Hypothesis 2A: Low (high) quality imports have no effect on low-educated labor in firm i, or affect low-educated labor in firm i positively (negatively), i.e. import quality has a complementary effect

Also, by following Moretti (2004), the translog cost function considered here controls for the mean of firms' years of schooling among labor. This control would allow for more flexibility in interpreting the empirical results in the absence (i.e. $\partial f_i/\partial E = 0$), or presence (i.e. $\partial f/\partial E > 0$) of human capital spillovers from education (E).

Equation (11) shows the log of firm i's variable costs (VC) that can be approximated by function f, that exhibits a translog form:

$$\ln VC_i = f\left(\ln w_{ji}, \ln \frac{K_i}{Y_i}, \ln M_{\tau i}, \ln R_i, \bar{E}_i, t\right), \qquad i = 1, 2, \dots, k \text{ firms} \tag{11}$$

where w is wage, K/Y is physical capital relative to value added, and M is imports for firm i, respectively. j denotes the type of labor under analysis,[5] and τ the quality of imports in terms of high or low as defined in Section 2. Moreover, the variable cost function considers firm size in terms of sales value (R) and the years of schooling mean ($\bar{E}$) in order to account for the firm's human capital stock. t indicates that variable costs also are a function of time.

Invoking the assumption that firms' variable inputs are cost minimized and applying Sheppard's lemma to Equation (11) with respect to wages of type j educated labor (w_{jit}) yields:

$$\frac{\partial \ln VC_{it}}{\partial \ln w_{jit}} = \ln(S_{jit}), \tag{12}$$

[5] Two types of labor will be analyzed in terms of low-educated labor (high school diploma or lower), and high-educated labor (bachelor's degree or higher).

where S_{jit} is the share of type j educated labor wages in total wages of firm i at time t. By assuming that wages are homogenous of degree one and that the production exhibits constant returns to scale such that:

$$\ln(S_{jit}) = \beta_0 + \beta_1 \ln\left(\frac{w_{jit}}{w_{\bar{j}it}}\right) + \beta_2 \ln\left(\frac{K_{it}}{Y_{it}}\right) + \beta_3 \ln(M_{\tau it}) + \beta_4 \ln(R_{it}) + \beta_5 \bar{E}_{it} + u_{it} \,, \tag{13}$$

where $w_{jit}/w_{\bar{j}it}$ is wages of type j educated labor relative to complementary types of educated labor in firm i at time t. In line with Berman et al (1994), assuming that price changes are confounded with quality changes would imply that the relative wage ($w_{jit}/w_{\bar{j}it}$) across firms will be a constant, and ignoring it will only affect the intercept (β_0) and nothing else. In this case, Equation (13) becomes:

$$\ln(S_{jit}) = \alpha_0 + \beta_1 \ln\left(\frac{K_{it}}{Y_{it}}\right) + \beta_2 \ln(M_{\tau it}) + \beta_3 \ln(R_{it}) + \beta_4 \bar{E}_{it} + u_{it} \,. \tag{14}$$

Equation (14) is the model to be estimated in Section 5. The labor composition comprises two types of labor, high-educated and low-educated, and thereof two regression models will be estimated. The following section outlines the data and variables of choice. It also presents descriptive statistics for the dependent and explanatory variables.

4 Data, Variables and Descriptive Statistics

The data in this paper has been collected by Statistics Sweden and comprise publicly audited micro level data. It includes detailed information on employees (e.g. wage and education level data), firms (e.g. physical capital and trade data) and establishments (i.e. information on how many establishments each unique firm has).

Since the interest is to analyze how the utilization of high and low quality imports affects the labor composition, the focus in this paper is only on importing manufacturing firms in Sweden. Manufacturing firms are more suited for examining effects of imports due to that the majority of imports in this industry come in form of physical goods, i.e. either as inputs, or as machines. The manufacturing firms in this context are all importing firms in Sweden that belong in sectors classified after SITC 15-36 (see Table A1 in the Appendix for details). Moreover, the time period examined is 2000-2008.

With this setup I have constructed a panel that comprise 65513 observations across firms and across time. The following sub-section describes the variables that enter the model presented in Equation (14).

4.1 Variables

The dependent variable (S_{jit}) measures the share of type j labor in total labor wages for firm i at time t. The dependent variable is constructed in terms of shares of: i) high-educated labor wages, and ii) low-educated labor wages, in total wages, respectively. High-educated labor comprises persons that hold a bachelor of science degree, or higher such as a master of science degree or a PhD. Low-educated labor is persons with a high school diploma (or less) as the highest attainment degree.

Turning to the explanatory variables in Equation (14), the capital variable of firm i (K_{it}) is reported in SEK and corresponds to buildings, machines and land holdings at time t. The value added of firm i (Y_{it}) is measured in SEK and is defined as revenues less costs of inputs. These controls are included to capture possible variation that might be due to changes in firms' capital stock relative to value added generated from improved goods production (e.g. due to skill-complementary technical change in the labor composition).

Imports of firm i ($M_{\tau it}$) constitute physical goods that are reported at the eight-digit nomenclature of the SITC. τ indicates the type of quality that imports consist of, i.e. whether imports are of high quality (H), or of low quality (L). The distinction in import quality is defined in Section 2 above. A strength of this import dataset is that it follows the same reporting type in the nomenclature of goods throughout the period 2000-2008. This reporting procedure minimizes any loss of information that is due to changes in type and quality of goods.[6]

Two additional controls are the sales value in SEK (R_{it}) and the years of schooling mean ($\bar{E}_{it}$), for firm i at time t, respectively. Previous empirical studies on shifts in labor composition commonly avoid using the total labor stock on the right-hand side due to collinearity problems with other explanatory variables. Thereof the choice of an alternative size variable in terms of the firm sales value. Finally, the years of schooling mean is included in the variable cost function to control for firms' years of schooling mean, when holding all else equal.

[6] A possible limitation that I am aware of is that some consumer goods might still be reported in the import data, yet impossible to correct for (see e.g. Feenstra and Jensen (2012)) However, this error margin is small enough to not have an impact on the overall result.

Table 1 presents a variables description and the expected signs of the explanatory variables based upon the framework conditions reviewed in Section 3.

Table 1 Variables description and expected signs

Dependent variable	Description	Regression model		
S_{hi}	Share of high-educated labor wages in total wages of firm i	**1**		
S_{li}	Share of low-educated labor wages in total wages of firm i	**2**		
Explanatory variable	**Description**	**Expected sign**		**Framework**
		S_{hi}	S_{li}	
K_i/Y_i	Capital in SEK relative to value added in SEK of firm i	+	–	Berman et al (1994)
M_{Hi}	High quality imports of firm i in SEK	–	+	Arndt (1997, 1998); Jones (2000)
M_{Li}	Low quality imports of firm i in SEK	+	–	Arndt (1997, 1998), Jones (2000)
R_i	Sales value of firm i in SEK	+	+	Chambers (1988)
$\bar{E}_i$	Years of schooling mean of firm i	+	–	Moretti (2004)

4.2 Descriptive Statistics

Table 2 presents the descriptive statistics for the dependent and explanatory variables in Equation (14).[7] Total number of firm observations for all variables is 65513. The two dependent variables in non-logged form are S_h and S_l. The average share of high-educated labor wages in total wages of a firm (S_h) is 0.226, whereas the average share of low-educated labor wages in total wages (S_l) is 0.774. It is obvious that low-educated workers dominate the labor composition of importing firms in Swedish manufacturing. More than three fourths of the labor hold a high-school diploma, or less.

The explanatory variables in non-logged form have a large variance. This is however, adjusted for by log-transformation (see Tables A2 and A3 in the Appendix). The mean of physical capital relative to value added is 0.797, which indicates that importing firms in Swedish manufacturing are highly driven by refined production. The average firm has high quality imports of SEK 4.7 million, whereas low quality imports are about SEK 32 million. This difference is somewhat

[7] Descriptive statistics are presented in non-logged form for an easier interpretation.

expected, since final goods production is typically of high quality across sectors in Swedish manufacturing (see e.g. Oh et al (2012)). Moreover, the average sales value of firms is approximately SEm K 194 million. The high average sales value suggests that importing firms are more or less larger manufacturing firms. Finally, the years of schooling mean, $\bar{E}$, indicates that the firm average is 11.617. A high school diploma in Sweden is awarded after 12 years of schooling, which is close to the mean of $\bar{E}$. Moreover, the minimum value of $\bar{E}$ is nine, whereas the maximum value of $\bar{E}$ is 22.

Table 2 Descriptive statistics

Variable	Obs.	Mean	Median	Std. dev.	Minimum	Maximum
S_h	65513	0.226	0.163	0.240	0	1
S_l	65513	0.774	0.837	0.239	0	1
K/Y	65513	0.797	0.335	16.695	0.001	3917
M_H	65513	4 745 452	1 314	117 386 372	0	11 014 716 567
M_L	65513	31 859 994	734 961	355 804 581	0	28 374 278 594
R	65513	194 482 922	21 953 659	1 842 219 533	1 277	108 735 000 000
$\bar{E}$	65513	11.617	11.415	1.081	9	22

The section that follows presents the empirical results and analysis. I estimate two models by Equation (14) in order to analyze how high and low quality imports affect firms' labor composition. Model 1 explains the share of high-educated labor wages in total wages, whereas Model 2 explains the share of low-educated labor wages in total wages.

5 Empirical Results and Analysis

An estimation of Equation (14) implies that we obtain beta coefficients in a multiplicative form, i.e. the beta coefficients can be analyzed as elasticities (note that this does not apply to the years of schooling mean, $\bar{E}$). Models 1 and 2 are estimated by OLS in order to analyze the empirical results for the pooled variation across firms. For comparison reasons, Models 1 and 2 are also estimated with fixed effects to observe possible variation within firms.

When estimating Model 1 (i.e. the share of high-educated labor wages in total wages) by OLS, the elasticities (or beta coefficients) for physical capital relative to value added (K/Y), and sales value (R), on average, positively affect the share of high-educated labor wages in total wages. The years of schooling mean ($\bar{E}$), also shows a positive relation to the dependent variable. Moreover, the elasticities of interest are those for high (M_H) and low (M_L) quality imports. All else equal: an increase in high quality imports, on average, lowers the share of high-educated labor wages in total wages. In addition, an increase in low quality imports, on average, increases the share of high-educated labor wages in total wages. The results of Model 1 are in line with Hypothesis 1, i.e. there is a substitution effect between high quality imports and high-educated labor.

For Model 2 (i.e. the share of low-educated labor wages in total wages) the OLS estimation produces a similar relationship, yet at a lower magnitude, for sales value as did Model 1. Different from Model 1, the physical capital relative to value added and the years of schooling mean affect the share of low-educated labor wages in total wages negatively. Turning to the import quality, one can observe that all else equal: an increase in high quality imports, on average, increases the share of low-educated labor wages in total wages, whereas an increase in low quality imports has the opposite effect. Model 2's results confirm the substitution effect in Hypothesis 2.

The results from the OLS estimations are much in line with the theoretical frameworks. The estimated coefficient for the years of schooling mean suggests that human capital spillovers typically benefit high-educated labor (see e.g. Moretti (2004)). Moreover, the elasticity for physical capital relative to value added takes on a positive sign for high-educated labor. This result is also observed in previous research (e.g. Berman et al (1994) and Feenstra and Hanson (1996)), and indicates that there is skill-complementary technical change for high-educated labor, whereas the opposite is true for low-educated labor (cf. Çivril (2011) who also finds this relationship). The elasticities of the import quality do affect importing firms' labor composition in Swedish manufacturing. An increased amount of high (low) quality imports induces firms to replace inputs that require high-educated (low-educated) labor to process in production for low-educated (high-educated) labor. Thus, there is a substitution effect between import quality and the type of labor under analysis.

The OLS estimation accounts for possible variation across firms (i.e. inter-firm variation). To consider the possible variation within firms (i.e. intra-firm variation), I also estimate Models 1 and 2 by fixed effects within regression (FE).[8]

[8] Unobserved firm-specific effects are found to be correlated with explanatory variables in the panel. A Hausman Test has confirmed the choice of an FE-model approach.

The regression results for the intra-firm variation can be summarized as follows: the elasticities for physical capital relative to value added and sales value have the same signs, but different magnitudes, as those obtained with OLS. The same is true for the years of schooling mean coefficient (note that $\ln(K/Y)$ is insignificant for Model 2). In terms of import elasticities, all else equal: an increase in high quality imports, on average, increases the share of high-educated labor wages in total wages (the elasticity of low quality imports is insignificant in Model 1). In addition, an increase in low quality imports, on average, increases the share of low-educated labor wages in total wages (the elasticity of high quality imports is insignificant in Model 2).

Different from the OLS estimation, the FE regression results are in line with Hypotheses 1A and 2A, and thus partly confirm a complementary effect between import quality and the type of labor under analysis. The explanatory power of Models 1 and 2 is about 40 percent and 20 percent, for OLS and FE, respectively.

Table 3 Regression results

	Model 1 Dependent: $\ln(S_h)$		**Model 2 Dependent:** $\ln(S_l)$	
	OLS	**FE**	**OLS**	**FE**
Explanatory variable	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**
$\ln(K/Y)$	0.046*** (0.0103)	0.402** (0.0174)	-0.033*** (0.0060)	0.009 (0.0096)
$\ln(M_H)$	-0.004* (0.0023)	0.007*** (0.0023)	0.004*** (0.0011)	0.001 (0.0011)
$\ln(M_L)$	0.010*** (0.0039)	0.003 (0.0045)	-0.011*** (0.0019)	0.005* (0.0024)
$\ln(R)$	1.047*** (0.0105)	0.584*** (0.0377)	0.223*** (0.0059)	0.180*** (0.0215)
$\bar{E}$	1.917*** (0.0164)	2.024*** (0.0569)	-1.120*** (0.0136)	-1.099*** (0.0439)
Year dummies	Yes	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes	Yes
Observations	65513	65513	65513	65513
Prob. > F	0.000	0.000	0.000	0.000
r^2: Overall	0.43	0.39	0.41	0.40
Within		0.19		0.21
Between		0.43		0.47

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parenthesis. OLS estimated by linear regression, FE estimated by fixed effects within regression.

6 Conclusions

The purpose of this paper has been to analyze how high and low quality imports affect the labor composition in importing firms in Swedish manufacturing. Framework conditions, as well as previous research have highlighted the importance of trade and firms' ability to utilize labor in foreign countries. From a theoretical perspective the behavior of the firm is motivated by cost minimization, where one way of doing so occurs when firms import cheap inputs. This development has eventuated in a somewhat decomposed labor composition in firms.

Previous research, that for example examine offshoring's effect on labor demand, find mixed results when analyzing how offshoring affects production and non-production workers across industries.

In this paper I highlight the quality of imports as an important input in firms' variable cost function. Import quality is found to affect firms' labor composition differently depending on the type of variation considered. Across firms, the import quality affects firms' labor composition in terms of substitution effects. However, within firms the import quality has partly complementary effects on firms' labor composition.

References

Abd-el Rahman, K. (1991). "Firms Competitive and National Comparative Advantages as Joint Determinants of Trade Composition." Weltwirtschaftliches Archiv **127**(1): 83-97.

Allen, D. W. (1991). "What are Transaction Costs?" Research in Law and Economics **14**: 1-18.

Arndt, S. W. (1997). Globalization and the Gains from Trade. Trade, Growth and Economic Policy in Open Economies. in K. Jaeger and K. J. Koch (eds). New York, Springer-Verlag.

Arndt, S. W. (1998). "Super-Specialization and the Gains from Trade." Contemporary Economic Policy **16**(4): 480-485.

Arrow, K. J. (1971). Political and Economic Evaluation of Social Effects and Externalities. Frontiers of Quantitative Economics. in M. D. Intrilligator (ed.). Amsterdam, North-Holland.

Bartel, A. P. and F. R. Lichtenberg (1987). "The Comparative Advantage of Educated Workers in Implementing New Technology." Review of Economics and Statistics **69**(1): 1-11.

Berman, E., Bound, J., and Z. Griliches (1994). "Changes in the Demand for Skilled Labor within US Manufacturing: Evidence from the Annual Survey of Manufacturers." The Quarterly Journal of Economics **109**(2): 367-397.

Bernard, A. B., Redding, S. J., and P. K. Schott (2007). "Comparative Advantage and Heterogeneous Firms." Review of Economic Studies **74**(1): 31-66.

Chambers, R. G. (1988). Applied Production Analysis: A Dual Approach. Cambridge, Cambridge University Press.

Çivril, D. (2011). The Impacts of Technology and Offshoring on Labor Demand: An Analysis Using Microlevel Data, International Business School, Brandeis University.

Coase, R. H. (1937). "The Nature of the Firm." Economica **4**(16): 386-405.

Coe, D. T. and E. Helpman (1995). "International R&D Spillovers." European Economic Review **39**(5): 859-887.

Dicken, P. (2007). Global Shift: Mapping the Changing Contours of the World Economy. London, United Kingdom, Sage Publications.

Dixit, A. K. and J. E. Stiglitz (1977). "Monopolistic Competition and Optimum Product Diversity." American Economic Review **67**(3): 297-308.

Dunning, J. H. (1980). "Towards an Eclectic Theory of International Production: Some Empirical Tests." Journal of International Business Studies **11**(1): 9-31.

Eaton, J. and S. Kortum (1999). "International Technology Diffusion: Theory and Measurement." International Economic Review **40**(3): 537-570.

Eaton, J. and S. Kortum (2001). "Technology, Trade, and Growth: A Unified Framework." European Economic Review **45**(4-6): 742-755.

Ekholm, K. and K. N. Hakkala (2008). The Effect of Offshoring on Labor Demand: Evidence from Sweden, No. 5648. CEPR Discussion Paper.

Feenstra, R. C. (2010). Offshoring in the Global Economy. Cambridge, MIT Press.

Feenstra, R. C. and G. H. Hanson (1996). "Globalisation, Outsourcing and Wage Inequality." American Economic Review **86**(2): 240-245.

Feenstra, R. C. and G. H. Hanson (1997). "Foreign Direct Investment and Relative Wages: Evidence from Mexico's Maquiladoras." Journal of International Economics **42**(3-4): 371-393.

Feenstra, R. C. and J. B. Jensen (2012). "Evaluating Estimates of Materials Offshoring from U.S. Manufacturing." Economics Letters **117**(1): 170-173.

Foster, N., Stehrer, R., Timmer, M. and G. de Vries (2012). Offshoring and the Skill Structure of Labour Demand. Vienna, Austria, Vienna Institute for International Economic Studies.

Førsund, F. R. and L. Hjalmarsson (1987). Analyses of Industrial Structure: A Putty-Clay Approach. Stockholm, Almqvist & Wiksell International.

Gråbacke, C. and J. Jörnmark (2008). Den textila modeindustrin i Göteborgsregionen: En kartläggning. Göteborg, Business Region Göteborg.

Hamermesh, D. S. (1993). Labor Demand. New Jersey, Princeton University Press.

Hansson, P. (2005). "Skill Upgrading and Production Transfer within Swedish Multinationals." Scandinavian Journal of Economics **107**(4): 673-692.

Head, K. and J. Ries (2002). "Offshore Production and Skill Upgrading by Japanese Manufacturing Firms." Journal of International Economics **58**(1): 81-105.

Helpman, E. (2006). Trade, FDI, and the Organization of Firms. NBER Working Paper No. 12091. Cambridge.

Johansen, L. (1959). "Substitution versus Fixed Production Coefficients in the Theory of Economic Growth: A Synthesis." Econometrica **27**(2): 157-176.

Johansson, S. (2008). "R&D Accessibility and Comparative Advantages in Quality Differentiated Goods." Ifcai Journal of Knowledge Management **6**(1): 29-51.

Jones, R. W. (2000). Globalization and the Theory of Input Trade. Cambridge, MIT Press.

Jones, R. W. and H. Kierzkowski (2001). A Framework for Fragmentation. Fragmentation: New Production Patterns in the World Economy. In S. W. Arndt and H. Kierzkowski (eds). New York, Oxford University Press.

Keller, W. (2001). International Technology Diffusion. NBER Working Paper No. 8573. Cambridge.

Korinek, J. and P. Sourdin (2011). To What Extent are High-Quality Logistics Services Trade Facilitating? OECD Trade Policy Working Papers No. 108. Paris.

Krugman, P. (1980). "Scale Economies, Product Differentiation and the Pattern of Trade." The American Economic Review **70**(5): 950-959.

Moretti, E. (2004). "Workers' Education, Spillovers, and Productivity: Evidence from Plant-Level Production Functions." American Economic Review **94**(3): 656-690.

Morrison-Paul, C. J. and D. S. Siegel (2001). "The Impacts of Technology, Trade and Outsourcing on Employment and Labor Composition." Scandinavian Journal of Economics **103**(2): 241-264.

Nelson, R. R. and E. S. Phelps (1966). "Investments in Humans, Technological Diffusion, and Economic Growth." American Economic Review **56**(1): 69-75.

Oh, D., Heshmati A., and H. Lööf (2012). "Technical Change and Total Factor Productivity Growth for Swedish Manufacturing and Service industries." Applied Economics **44**(18): 2373-2391.

Ohlin, B. G. (1933). Interregional and International Trade. Cambridge Massachusetts, USA, Harvard University Press.

Salter, W. E. G. (1960). Productivity and Technical Change. Cambridge, Cambridge University Press.

Stolper, W. F. and P. A. Samuelson (1941). "Protection and Real Wages." Review of Economic Studies **9**(1): 58-73.

van Winden, W., van den Berg, L., Carvalho, L. and E. van Tuijl (2011). Manufacturing in the New Urban Economy: Regions and Cities, Routledge, Abingdon, UK.

Warda, P. (2013). Trends and Patterns in Offshoring in the European Automotive Industry, in Johansson, B., Karlsson, C., and R. Stough (eds.). Entrepreneurial Knowledge, Technology and the Transformation of Regions. Abingdon, Routledge.

Welch, F. (1970). "Education in Production." Journal of Political Economy **78**(1): 35-59.

Vernon, R. (1966). "International Investment and International Trade in the Product Cycle." The Quarterly Journal of Economics **80**(2): 190-207.

Appendix

Table A1 presents the sectors within the Swedish manufacturing industry. The classification is according to Standard International Trade Classification (SITC). The description of each sector is based upon SNI2002, published by Statistics Sweden.

Table A1 The Swedish manufacturing industry: SITC description

SITC	Description
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	Manufacture of pulp, paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment not elsewhere classified
30	Manufacture of office machinery and computers
31	Manufacture of electrical machinery and apparatus not elsewhere classified
32	Manufacture of radio, television and communication equipment and apparatus
33	Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semi-trailers
35	Manufacture of other transport equipment
36	Manufacture of furniture; manufacturing not elsewhere classified

Table A2 outlines the descriptive statistics for the dependent and explanatory variables in logged form (note that the years of schooling mean is not presented here due to that its functional form is not logarithmic).

Table A2 Descriptive statistics of variables in logged form

Variable	Obs.	Mean	Median	Std. dev.	Minimum	Maximum
$\ln(S_h)$	65513	-3.731	-1.815	4.182	-11.510	0
$\ln(S_l)$	65513	-0.609	-0.178	1.933	-11.510	0
$\ln(K/Y)$	65513	-1.314	-1.093	1.408	-14.670	8.270
$\ln(M_H)$	65513	5.961	7.181	6.125	0	23.120
$\ln(M_L)$	65513	12.606	13.508	4.498	0	24.070
$\ln(R)$	65513	17.013	16.904	1.782	7.150	25.410

A correlation matrix for the explanatory variables is presented in Table A3. The correlation is fairly low among a majority of explanatory variables, however, is moderately high between imports and sales value.

Table A3 Correlation matrix for explanatory variables

	$\ln(K/Y)$	$\ln(M_H)$	$\ln(M_L)$	$\ln(R)$	$\bar{E}$
$\ln(K/Y)$	1				
$\ln(M_H)$	0.0237	1			
$\ln(M_L)$	0.1114	0.2467	1		
$\ln(R)$	0.1613	0.4219	0.6003	1	
$\bar{E}$	-0.1775	0.1041	-0.0129	-0.0229	1