LUND UNIVERSITY
School of Economics and Management

Variety Growth and the Gains from Trade

- is globalization forever?

Author: Marcus Wik

Supervisor: Fredrik Sjöholm

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Abstract

In this thesis I estimate the gains from trade produced by an increase in imported product varieties in the Swedish economy. This is done by generating a variety adjusted import price index, following the methodology developed by Feenstra (1994) and Broda and Weinstein (2006). By using an estimate of both the extensive and the intensive margins of variety growth, I generate an upper and a lower bound to the gains from variety. Of these, I argue that the true gains from variety between 1995 and 2011 are most likely to be close to the lower bound of 0.578 percent of GDP. This implies that the Swedish consumer would be willing to pay 0.032 percent of his or her income in order to obtain the new set of product varieties imported each year.

In addition to this, I test the hypothesis that the gains from variety are decreasing over time. For the period investigated I am unable to reject this hypothesis. This, I argue, is due to the important roles played by a few large trading partners in Swedish imports. Another important factor may be the inability of the method to capture some of the change in the character of trade which the "Digital Age" has brought with it.*

Keywords: Gains from Trade, Gains from Variety, Globalization, Imports, Sweden

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1. Introduction

As the term “globalization” is becoming more and more used in economic analysis, the actual magnitude of the gains from trade is still very much an open debate. Much of the focus of this debate is being aimed at the potential growth effects owed to improved productivity or the effects of an increase in exports. Another effect of globalization, however, is often overseen; the increase in imports which is also likely to follow in its wake.

Since Sweden joined the European Union its imports has increased by roughly 11 percentage points, from 33 percent of GDP in 1995 to 44 percent of GDP in 2011 (World Bank, 2012). Such an increase is likely to have had a large effect on Swedish consumers, as not only new products are being made available to them, but also new product varieties. The fact that product varieties are playing a large part in our daily lives can be seen all around us. As consumers, there is nowadays hardly a single product available to us for which we do not have to choose between a large number of different varieties. Of nearly all of these it can easily be claimed that many of us have our own particular favorite; be it of toothpaste, potato chips or chocolate bars. For some consumers the introduction of a new product variety has even become a ritual on to itself, where the introduction of a new iPhone is a large media event followed by millions of people online. Others choose to camp outside a store for days in order to be the first to purchase a new pair of sneakers from their favorite shoe manufacturer.

In the “New Trade Theory” (NTT), introduced by Krugman (1979, 1980, 1981), Lancaster (1980) and Helpman (1981), consumer preferences for product diversity played a key role. The model signified a great improvement in the understanding of international trade, and has influenced other groundbreaking models such as the dynamic models of endogenous growth and the heterogeneous firms model. NTT predicted three major sources of gains from trade: a reduction in firm markups due to increased competition, an increase in industrial productivity and the increase in the number of product varieties available to the consumers (Feenstra, 2010). The gains from variety is therefore predicted to play an important part in the gains from trade, and ignoring that will most likely cause an underestimation of the increase in welfare which can be provided by trade.

Even so, estimating the actual welfare effects from an increase in product varieties was long put aside in favor of a more general, and conceptual, discussion. Some of the reasons for this were the vast amount of data needed, and the lacking of satisfactory statistical techniques. This restricted researchers who tried to measure these welfare effects to the use of case studies or oversimplifications (Feenstra, 2006).[1]

One the most influential papers on the estimation of variety-based welfare effects was published in 1994 by Robert Feenstra. By showing how to estimate the elasticity of substitution of individual products, and applying these to a constant-elasticity-of-substitution (CES) utility function, Feenstra demonstrated that new product varieties lead to an increase in consumer utility. What made Feenstra's approach more attractive than previous attempts was that it could rather effortlessly be expanded to a larger set of products at the same time.

Using, and developing, this technique, Broda and Weinstein (2006) estimated more than 30,000 elasticities and used these in order to create an import price index (IPI) adjusted for new and disappearing varieties. Using this IPI, they measured the value that consumers attached to new product varieties. By doing so they found that the total gain from the introduction of new varieties in the United States was 2.6 percent of GDP between 1972 and 2001. This meant that consumers would, on average, be prepared to pay 0.1 percent of their income in order to obtain the new set of varieties imported each year. They did, however, also find that the gains from variety were larger between 1972 and 1990 than from 1991 to 2001. This, they suggest, could be caused by the fact that by the early nineties the effects of globalization in the United States had started to wear off.

The technique developed by Broda and Weinstein (B&W) has since been used in a number of other papers. In an investigation of the Chinese economy, Chen and Ma (2012) find that the welfare gain from new imported product varieties amounted to 4.9 percent of GDP between 1997 and 2008. In Spain, Minondo and Requena (2010) found the gains from variety between 1988 and 2006 to be 1.2 percent of GDP. In a comparative study of Switzerland and the United States, Mohler (2009) estimates a lower and an upper bound of the gains from variety. He finds that during the period from 1990 to 2006, the gains from variety in Switzerland were between 0.3 and 4.98 percent of GDP and that in the United States the gains from variety were between 0.5 and 4.7 percent of GDP.

Mohler and Seitz (2010) applied the B&W methodology to the 27 European Union membership countries for the period 1999 to 2008, and found that smaller and newer members of the European Union have

[1] One example is Hausman (1997), who used detailed micro-data in order to calculate the value of new varieties in specific industries. Unfortunately, the attention to detail needed for this approach made it hard to apply to an aggregate study. A more general attempt was made by Rohmer (1994), who calculated gains from variety following trade liberalization.

gained the most from new product varieties. Bulgaria, Estonia, Hungary, Latvia and Slovakia were countries for which the gains from variety exceeded 1 percent of GDP, and of these Slovakia had gains from variety of 2.34 percent of GDP while Estonia had gains from variety of 2.74 percent of GDP. One of their more interesting results is that two of the largest economies in the group, France and Germany, both had negative gains from variety. The reason for this, they argue, is that these larger economies were already heavily integrated in the European economy and did therefore not experience the increase in product varieties as did the “new”, smaller economies. They also perform what, to my knowledge, is the only use of the B&W methodology on the Swedish economy. They find that the welfare gained from new product varieties between 1999 and 2008 was 0.21 percent of GDP.

Following the reasoning of both B&W and Mohler and Seitz, the rather small gains from variety found for Sweden implies that, speaking in the terms of new product varieties, the globalization process of Sweden had already started to wear off by 1999. If this is indeed the case, the gains from variety prior to 1999 should be larger than those found by Mohler and Seitz, and smaller after 2008. However, Mohler and Seitz only discuss the effects of joining the European Union, even though other factors should also affect the gains from variety.

The rapid development of technology and worldwide communications are two such factors. Technological development is progressing at a fast rate, causing a constant inflow of new products to the world markets. New products spawn new product varieties and new consumer behavior. This means that even if Sweden is already as integrated in the European economy as it will ever be, which is unlikely, new and disappearing product varieties might still have a significant effect on the economy.

Also, the improvements in communications will improve the ability to trade with countries outside of the European Union even further. Countries like China, India and Brazil are expanding rapidly and should be able to provide an increase in product variety even as the gains from European variety may be declining. Geographical areas such as South America are also likely to play a larger role in the world economy, and thus continue to increase the diversification of product varieties available to the Swedish consumer.

In previous papers, most analysis regarding the development of gains from variety has been obtained by comparing countries in different stages of development. If one is interested in how the gains from variety develop over time, however, this is not the best approach. Since most countries have different conditions, the behavior of their imports will differ depending on their own factors of production, geographical local, etc. Therefore, in order to more accurately study the development of the gains from variety in Sweden over time, I will also estimate them on a yearly basis. By starting with 1995, when Sweden joined the European Union, and continue up until 2011 I will test the hypothesis that the gains from variety are indeed declining.

One of the weaknesses of the import price index developed by Feenstra and B&W is that it uses the Armington (1969) definition of a product variety. By this definition a variety is a particular good produced in a particular country. The problem with this definition is that I may underestimate the number of imported varieties. It is not unlikely that Sweden imports at least 50 different varieties of red wine from France, but in my data I will only be able to register one variety; French red wine. In order to control for this I will follow the example of Mohler (2009), who creates a lower and upper bound of the gains from variety by using different measures of product variety growth. This gives an interval in which the true gains from variety is likely to be found, which has to this date not been estimated for the Swedish economy.

The disposition of this thesis is therefore as follows: Chapter 2 contains a presentation of the theoretical foundations of this thesis, such as a short explanation of the heterogeneous good and the description of the Feenstra price index which is used to estimate the gains from variety. Chapter 3 begins with a description of the data sample used for the thesis, followed by a presentation of the general development of Swedish imports between 1995 and 2011. Since one of the most important elements of the Feenstra index is the estimation of the elasticities of substitution, chapter 4 presents the methodology used for this estimation. In chapter 5 I present the results of the estimated elasticities, the increase in product varieties and the estimated gains from variety. These results are discussed in chapter 6, while in chapter 7 I present my conclusions regarding the gains from variety in the Swedish economy.

2. Theoretical Background

2.1. Heterogeneous goods

The methodology used in this thesis follow the monopolistic competition model, mainly developed by Paul Krugman. In this model, goods can be divided into two different categories; homogeneous and heterogeneous goods. The term "homogeneous goods" is usually used for those goods which can be sold at a reference price on organized exchanges. Most goods, however, can be classified as being more or less heterogeneous. The difference between the two is that heterogeneous goods can be differentiated by the producer, giving each producer monopolistic power. That is, a producer of black t-shirts will possess monopolistic power as long as some consumers prefer black t-shirts over white t-shirts. The demand of heterogeneous goods therefore not only depends on price, but also the intrinsic properties of each individual product of that good (Helpman and Krugman, 1985).

Following this reasoning, the preferences of the representative consumer can be represented by a two-tier utility function for which the upper tier is expressed as

$$U = U[u_1(\cdot),\, u_2(\cdot), \dots,\, u_G(\cdot)\,], \tag{2.1}$$

where U is the overall welfare obtained by consumption and $u_g(\cdot)$ is the sub-utility obtained from consuming the good *g*. Defining $U(\cdot)$ as being both increasing and homothetic in its arguments, it is clear that welfare increases with the number of goods consumed. If *g* is a homogeneous good, the sub-utility $u_g(\cdot)$ will depend only on the quantity consumed of that good. If it is a heterogeneous good on the other hand, another sub-utility function will have to be defined. A common approach to this is to use the Spence-Dixit-Stiglitz's (SDS) love of variety approach, based on Spence (1976) and Dixit and Stiglitz (1976). In this case the utility obtained from consuming *g* can be expressed with the CES function

$$u_g(q_{g1},\, q_{g2} \dots, q_{gC}\,) \equiv \left(\sum\nolimits_c q_{gc}^{\frac{\sigma_g - 1}{\sigma_g}}\right)^{\frac{\sigma_g}{\sigma_g - 1}}, \qquad \sigma_g > 1 \tag{2.2}$$

where q_{gc} is quantity consumed of variety c, and σ_g is the elasticity of substitution. In this framework consumers value varieties per se, meaning that the sub-utility $u_g(\cdot)$ increases with the number of varieties available of good *g.* As the elasticity of substitution approaches one, the utility obtained from new varieties increases. That the elasticity of substitution is larger than one also ensures monopolistic competition. An increase in the price of variety c will lead to a substitution effect, but since the consumer values the variety itself the substitution effect will always be less than one (Helpman and Krugman, 1985).

Obviously, eq. (2.2) is heavily reliant on how one chooses to define a "variety". Such definitions could be characteristics such as color, size, capacity or brand. As mentioned in the introduction, the definition used for this thesis is the Armington (1969) definition where a variety is the production of a particular good in a particular country. In this definition therefore, an apple is a product while Swedish and Danish apples are varieties of apples.

2.2. The Feenstra Index

2.2.1. Utility Functions

Eq. (2.1) from the previous section can easily be adjusted to represent the aggregate utility obtained by the consumption of imported goods as

$$U_t^M = \left(\sum_{g\in G} u_{gt}^{(\gamma-1)/\gamma}\right)^{\gamma/(\gamma-1)}, \gamma > 1, \tag{2.3}$$

where the total utility obtained from imported goods depends on the total number of imported goods, G, and the elasticity of substitution, γ, between them. As before, total utility increases with the number of imported goods. The utility derived from good g, in turn, depends on the number of varieties available and the good-specific elasticity of substitution. This utility function is expressed as

$$u_{gt} = \left(\sum_{c\in I_{gt}} d_{gct}\left(q_{gct}\right)^{(\sigma_g-1)/\sigma_g}\right)^{\sigma_g/(\sigma_g-1)}, \sigma_g > 1 \ \forall\ g \in G,\ d_{gct} > 0, \tag{2.4}$$

where I_{gt} is the set of varieties of g consumed in the time-period t. Notice that this equation also contains a new variable, d_{gct}, which is a quality or taste variable (Feenstra, 1994).

Finally it is worth pointing out that on an economy-wide scale there is another utility level above eq. (2.3). This overall utility function can be expressed as $U_t = U(U_t^D, U_t^M)$ where the total utility in period t depends on the utility obtained by the consumption of domestically produced goods, U_t^D, as well as of the imported goods, U_t^M (Broda and Weinstein, 2006).

2.2.2. The Unit-Cost Function

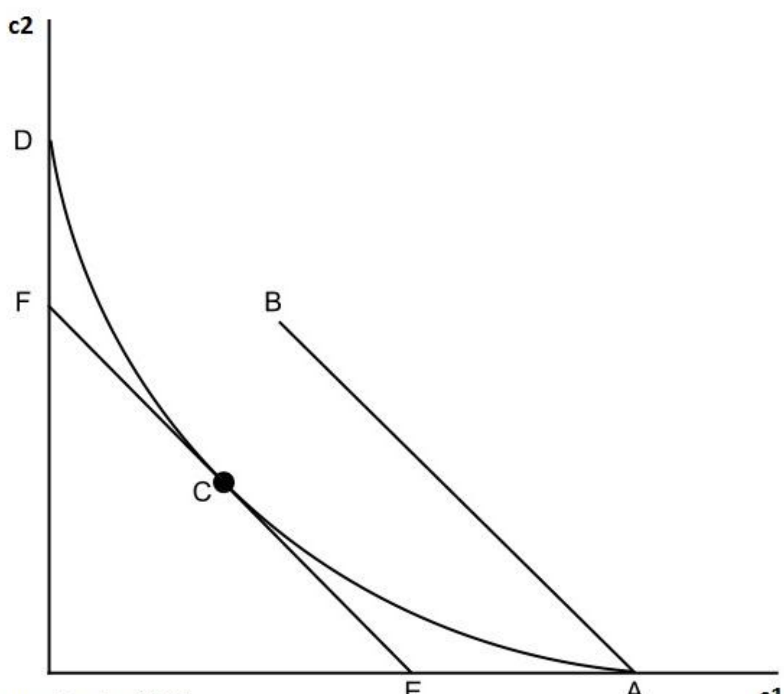
The first step in creating the price index is to define a cost function. The cost of obtaining one unit of the utility u_{gt} in eq. (2.4) is therefore expressed in the following unit-cost function:

$$\emptyset_{gt}^{M}(I_{gt}, \boldsymbol{d}_{gt}) = \left(\sum_{c \in I_{gt}} b_{gct}(p_{gct})^{1-\sigma_g}\right)^{1/(1-\sigma_g)}, b_{gct} \equiv d_{gct}{}^{\sigma_g}, \quad (2.5)$$

where p_{gct} is the price of of the variety c. From the assumption σ_g>1 it is clear that that an increase in the taste parameter b_{gct} or an increase in the number of varieties c will, all else equal, reduce the minimum expenditure required in order to obtain a certain level of utility (Broda and Weinstein, 2006).[2]

The reasoning behind this can be seen in figure 2.1. Initially, the only existing product variety is c1, which means that consumption is restricted to the point where the budget line AB intersects with the X axis. At this point the consumer minimizes the expenditure needed to obtain the utility level indicated by the CES indifference curve AD. As a new variety is introduced to the market, the consumer can still obtain the same level of utility by consuming any combination of c1 and c2 along the indifference curve. Nonetheless, since he always minimizes his expenditure he will choose point C, situated on the new and lower budget line EF. With the introduction of a new variety he can thus maintain the same level of utility, but with a lower level of expenditure (Feenstra, 2010).

Figure 2.1. The CES Utility Function



Source: Feenstra (2010)

[2] Eq. (2.5) also requires the assumption that the consumer is expenditure minimizing.

2.2.3. The Exact and The Conventional Price Indices

What Feenstra demonstrated was how to calculate an import price index which accurately measures the change in the unit-cost function (2.5). Initially, however, this requires a reference index, which does not incorporate new and disappearing varieties. Assuming that the same set of varieties are available in all periods, such that $I_{gt} = I_{gt-1} = I_g$, and taste and demand parameters are constant, such that $b_{gct} = b_{gct-1}$, it is possible to measure the change in cost of living from one period to the next. Following the exact price index for a CES function, developed by Sato (1976) and Vartia (1976), this conventional reference import price index (CIPI) is written as

$$\frac{\emptyset_{gt}^{M}(I_g, \boldsymbol{d}_g)}{\emptyset_{gt-1}^{M}(I_g, \boldsymbol{d}_g)} = P_g(\boldsymbol{p}_{gt}, \boldsymbol{p}_{gt-1}, \boldsymbol{x}_{gt}, \boldsymbol{x}_{gt-1}, I_g) = \prod_{c \in I_g} \left(\frac{p_{gct}}{p_{gct-1}}\right)^{w_{gct}}. \quad (2.6)$$

$\boldsymbol{p}_{gt}$ and $\boldsymbol{p}_{gt-1}$ are price vectors and $\boldsymbol{x}_{gt}$ and $\boldsymbol{x}_{gt-1}$ are the quantities of these varieties given the prices. As for the example in figure 2.1, it is assumed that the consumer always chooses the expenditure-minimizing quantity of each variety. The variety-specific weights, w_{gct}, are constructed from the expenditure share $s_{gct} \equiv \frac{p_{gct}x_{gct}}{\sum_{c \in I_g} p_{gct}x_{gct}}$ of each variety such that,

$$w_{gct} \equiv \frac{(S_{gct} - S_{gct-1})/(lnS_{gct} - lnS_{gct-1})}{\sum_{c \in I_g}(S_{gct} - S_{gct-1})/(lnS_{gct} - lnS_{gct-1})}. \quad (2.7)$$

w_{gct} is important in the index since in practice the taste parameter b_{gc} will remain unknown, especially when measuring a large number of products at once. However, varieties with a high $b_{gct} = b_{gct-1}$ are likely to have a larger market share than other varieties and will therefore also get a larger weight in the index. This way it is possible to incorporate the changes in taste into the index, even if b_{gct} cannot be observed directly (Feenstra, 2010).

Of course, the problem with the CIPI is that it cannot measure the effects of new or disappearing varieties.[3] Therefore I use the set of common products for the CIPI, while for those products for which $I_{gt} \neq I_{gt-1}$ a new term is added, often referred to as the Feenstra index. With this additional term I can generate a variety adjusted exact import price index (VAIPI)

[3] Since non-existing varieties have no price, the equation falls apart.

$$\frac{\emptyset_{gt}^{M}(I_{gt},\boldsymbol{d}_g)}{\emptyset_{gt-1}^{M}(I_{gt-1},\boldsymbol{d}_g)} = P_g(\boldsymbol{p}_{gt},\boldsymbol{p}_{gt-1},\boldsymbol{x}_{gt},\boldsymbol{x}_{gt-1},I_g)\left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{\frac{1}{\sigma_g-1}} = CIPI_g\left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{\frac{1}{\sigma_g-1}}, \qquad (2.8)$$

where

$$\lambda_{gt} = \frac{\sum_{c\in I_g} p_{gct}x_{gct}}{\sum_{c\in I_{gt}} p_{gct}x_{gct}} \text{ and } \lambda_{gt-1} = \frac{\sum_{c\in I_g} p_{gct-1}x_{gct-1}}{\sum_{c\in I_{gt-1}} p_{gct-1}x_{gct-1}}.$$

The measurement of the Feenstra index, $\left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{\frac{1}{\sigma_g-1}}$, is the main objective of this thesis and therefore deserves some special attention. The numerator of the lambda ratio, λ_{gt}, measures the expenditure on varieties common to both time periods, relative the total expenditure on all varieties in period t. This means that if the expenditure on new varieties in period t is increasing, λ_{gt} will be smaller than one and the CIPI will be adjusted downwards. λ_{gt-1} on the other hand measures the disappearance of old varieties, since λ_{gt-1} is smaller than one if, and only if, there were many varieties in period $t-1$ that are no longer present in period t. Disappearing varieties will therefore push eq. (2.8) above the CIPI, representing an increase in the unit-cost function (2.5).

The importance of the elasticity of substitution can be seen in the Feenstra index. As could be seen in chapter 2.1; the larger the value of σ_g, the less utility is attached to new varieties. Therefore, in eq. (2.8) a large value of σ_g makes $\left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{1/(\sigma_g-1)}$ approach unity and new and disappearing varieties will have no effect on the CIPI. The closer σ_g gets to one, on the other hand, the more consumers value varieties and the larger the effect of $\left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{1/(\sigma_g-1)}$ on the CIPI (Broda and Weinstein, 2006).

By referring back to figure 2.1 and eq. (2.5), it is possible to gain a more intuitive sense of the Feenstra index. The adjustment in the CIPI caused by the Feenstra index corresponds to the reduction in the unit-cost function (2.5) caused by the increase in varieties. This is equivalent to saying that it measures the actual value of the move from point A to point C in figure 2.1. If the Feenstra index is larger than one, the unit-cost have increased and utility at any given level of expenditure has been reduced. In figure 2.1, this would represent a move back from point C to the initial point A, where the same utility is obtained at a higher cost. Since the curvature of the indifference curve is determined by the elasticity of substitution; the larger the value of σ_g, the smaller is the change in the budget line.

Using expenditure shares instead of count data in the Feenstra index provides a great advantage. Even if there is a large increase in the number of new varieties, this does not mean that the market shares of these new varieties are of any significant sizes. If the market share of a new variety is not significant enough, it will not reach many consumers and its effect on aggregate welfare will be trivial. By using expenditures this problem is avoided, since only those new varieties of which a larger amount is consumed will be able to affect the CIPI (Feenstra, 1994).

By combining the results of eq. (2.8) over all imported goods, an aggregate price index is obtained:

$$P^M(\boldsymbol{p}_t, \boldsymbol{p}_{t-1}, \boldsymbol{x}_t, \boldsymbol{x}_{t-1}, I) = \prod_{g \in G} P_g^{w_{gt}} \left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{w_{gt}/(\sigma_g - 1)}, \qquad (2.9)$$

where $\prod_{g \in G} P_g^{w_{gt}} = CIPI(I)$ is the aggregate conventional import price index and w_{gt} is the log-change ideal weights of each good. The overall price index of all goods, domestic and imported, is thus given by

$$\Pi = \left(\frac{p_t^D}{p_{t-1}^D}\right)^{W_t^D} (P^M)^{W_t^M} \qquad (2.10)$$

where p_t^D / p_{t-1}^D is the aggregate price index of all domestic goods. w_t^M and w_t^D are the share of import over GDP and share of domestic products over GDP respectively.

2.3. The Gains from Variety

With the use of eq. (2.10), the total bias in the overall price index by ignoring new and disappearing imported varieties can be defined. This bias is called the end-point ratio and is the ratio between eq. (2.9) and the aggregate CIPI(I):

$$EPR = \frac{\Pi^M(\boldsymbol{p}_t, \boldsymbol{p}_{t-1}, \boldsymbol{x}_t, \boldsymbol{x}_{t-1}, I)}{CIPI(I)} = \prod_{g \in G} \left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{w_{gt}/(\sigma_g - 1)}. \qquad (2.11)$$

An EPR is smaller than one would imply that the exact price index is smaller than the conventional price index, i.e. there has been a growth in imported product varieties. For example, if the EPR was to display a value of 0.98 this would mean that ignoring new and disappearing product varieties in the conventional price index had led to an upward bias of 2.04 percent. This is the same thing as saying that import price inflation is overstated by 2.04 percent.[4]

[4] $Total\ Bias = \frac{1}{EPR} - 1$

Besides the actual change in imported varieties, the total welfare gain also depends on the weight of imported goods in the overall price index (2.10). Since this allows for a separation of domestic and imported goods, the total welfare gain from an increase in product varieties, expressed as percent of GDP, can be calculated as follows;

$$GFV = \left(\frac{1}{EPR}\right)^{W^M} - 1 \qquad (2.12)$$

where W^M is the share of imports in GDP (Mohler, 2009). The use of the share of imports of GDP ensures that there can only be a large welfare effect if imported goods constitute a large part of domestic consumption. What eq. (2.12) essentially does, therefore, is to measure the total value of the changed budget line in figure (2.1), or the aggregate change in the cost of living.

3. Data

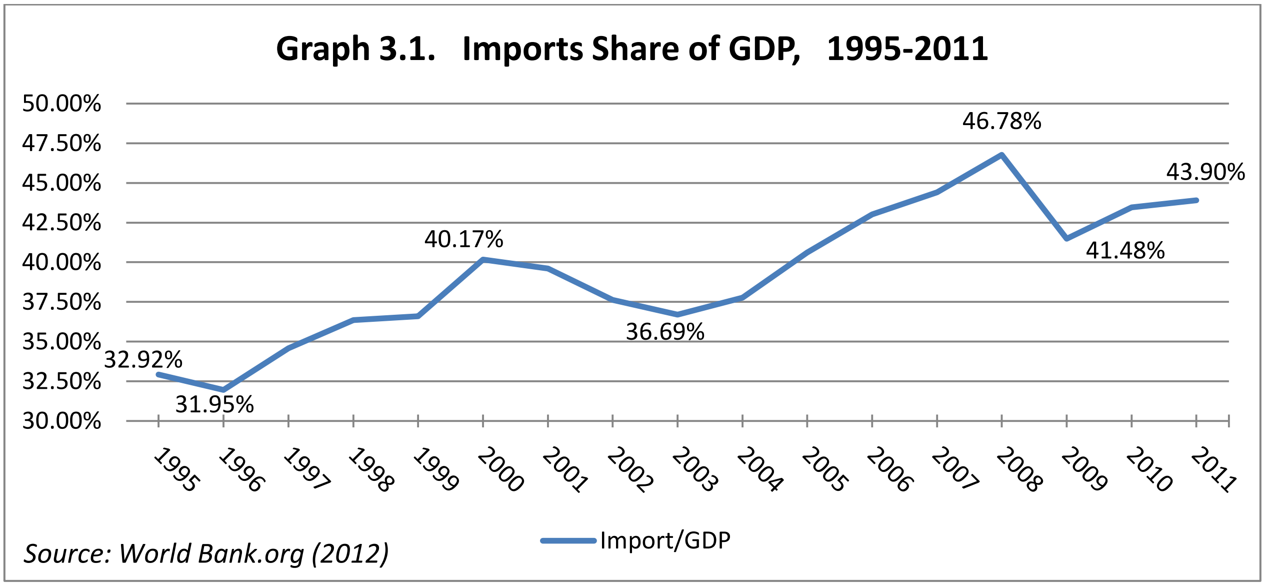
3.1. Data Sample

The data used in order to calculate the indices of the previous chapter is collected from Statistics Sweden (Statistiska Centralbyrån, SCB) and contains information on the total value, quantities and trading partner of registered product imports to Sweden from 1995 to 2011. Other relevant data regarding gross domestic product (GDP) and import shares were taken from the World Bank Databank.

All of the data obtained from Statistics Sweden is categorized under the sub headings of the Combined Nomenclature (CN); the tariff system used by European-Union customs. The CN system follows roughly the same headings as the Harmonized System used by the World Customs Organization, and states that all goods imported or exported within the European Union must be declared under a numerical system organized by type of good. These categories can be more or less precise depending on the number of digits used for the definition of the product, where a 2-digit (CN2) classification gives a wide-ranging product definition and an 8-digit (CN8) classification gives a more narrow classification. As an example we can use an apple which at a CN2 level would be defined as an “Eatable fruit as well as eatable berrie and nut”. Using the CN8 level, however, its product definition will be detailed enough as to differ depending on its price and its quality. I will use the CN8 classification as the definition of a product and, as mentioned earlier, a variety is defined as a particular product from a particular country.

3.2. The Development of Imports, 1995 - 2011

Following the admittance into the European Union in 1995, the role played by imports in the Swedish economy has increased substantially. This can be seen in graph 3.1, where the development of imports between 1995 and 2011 is presented. In 1995, the share of imports of GDP was roughly 33 percent, but has since experienced an average growth of more than two percent each year and had by 2011 reached nearly 44 percent of GDP. In monetary value this represents a growth of roughly 157 percent, from 595,662 million SEK in 1995 to 1,533,263 million SEK in 2011 (See table 3.1).



There are of course a large number of factors which could explain this growth. One of these is likely to be the European Union, which has reduced trade costs with some of the largest trading partners of Sweden such as Germany, Denmark and Great Britain. Another explanation could be that reduced trade costs and worldwide improvements in communications have provided Sweden with a large number of new trading partners. The number of countries from which Sweden imported increased from 191 in 1995 to 218 in 2011, a growth of roughly 14 percent. During the entire period, there were 243 countries from which Sweden imported at one time or another.

Even as the number of countries from which Swedish imported increased, however, the bulk of the import growth still came from the larger trading partners. Table 3.1 shows the ten biggest contributors to the growth of Swedish imports since 1995, and all but two of those countries are also on the list over the ten biggest trading partners of 1995.[5] These two countries are Russia and China. As table 3.1 shows, Russian imports grew by more than 2,300 percent between 1995 and 2011, which moved them from being the 20th largest import country to being the 6th. Imports from China on the other hand, grew by more than 1,400 percent and moved them from the 18th position to the 10th on the same list. Although the number of trading partners increased, the share of total imports provided by the 30 biggest trading partners increased from 60 percent to 68 percent.

[5] In terms of import value. See appendix A for details.

Table 3.1
Contribution to Growth in Swedish Imports - Import Value

Pos.	Country	Imported Value (1995)	Imported Value (2011)	Increase	Percentage Growth	Share of total Growth
1	Germany	78,901	198,789	119,888	151.946%	12.787%
2	Norway	28,910	96,403	67,493	233.458%	7.198%
3	Russia	2,613	63,108	60,495	2315.342%	6.452%
4	Denmark	28,041	87,761	59,720	212.972%	6.369%
5	Netherlands	24,299	67,427	43,128	177.486%	4.600%
6	China	2,847	44,380	41,533	1458.705%	4.430%
7	Finland	22,781	58,137	35,356	155.201%	3.771%
8	Belgium & Luxemburg	15,065	44,942	29,877	198.323%	3.187%
9	France	20,808	49,881	29,073	139.725%	3.101%
10	Great Britain	35,403	63,939	28,536	80.603%	3.044%
	Total	259,669	774,767	515,099	198.368%	54.938%
	All Imports	595,662	1,533,263	937,601	157%	100.000%

Note: All data from SCB (2012) except "All Imports" which is collected from the World Bank Database (2012). Values are expressed in MSEK

3.2.1. The Growth of Products and Product Varieties

An interesting development in Swedish imports is revealed as one takes a closer look on the number of product categories that were imported over the period. Even though the value of imports and the number of trading partners increased substantially, the actual number of CN8 products imported did not grow between 1995 and 2011. Instead, the number of products imported did in fact decline. In 1995 Sweden imported a total of 8,690 different CN8 products, while by 2011 that number had dropped to 8,634. Even more peculiar is the fact that the number of product types imported peaked in 1998 with a total of 9,651 different product types, and has since then been falling at a rather steady rate. This development is displayed on the left axis in graph 3.2.

In column A of table 3.2 the number of different products imported in 1995 and 2011 are reported, as well as the number of products that were common to both years. What these numbers show is that the total change of products is far greater than indicated by the product growth. This is, however, quite natural due to technological progress; new products are invented while others die off. A perfect example of this is the product category “Videophones”, which did not appear in the data until 2007. Among the products that apparently have “gone out of fashion” and have therefore disappeared since 1995 are “Record-players, with loudspeakers” and “Cassette-type Telephone answering machines” (SCB, 2012). This type of “birth” and “death” is even more common for varieties than they are for the products themselves.

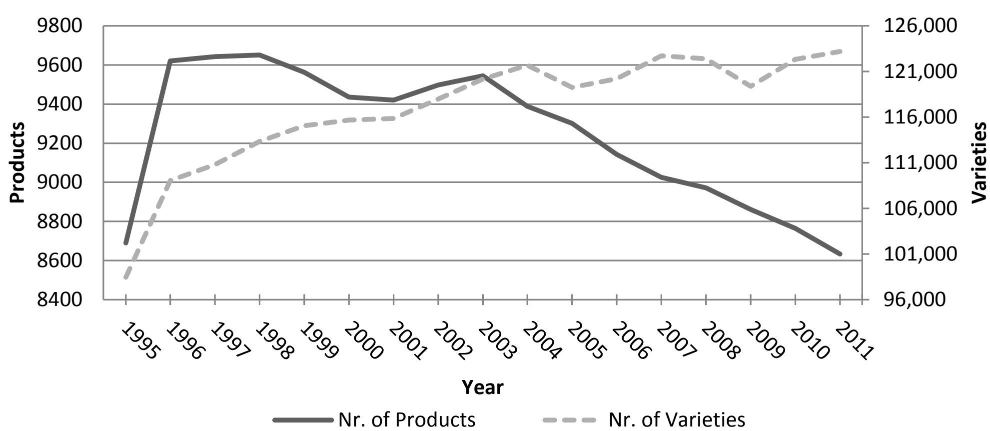
Table 3.2
Swedish Product Imports , 1995-2011

	Year	Number of products (A)	Number of varieties (B)
All 1995 products	1995	8,690	98,461
All 2011 products	2011	8,634	123,180
Common 1995-2011	1995 & 2011	5,100	40,604
In 1995 not in 2011	1995	3,590	57,857
In 2011 not in 1995	2011	3,534	82,576

Source: SCB (2012)

Looking at column B of table 3.2, it is apparent that the growth of Swedish imports has also been accompanied by a large increase in the number of new product varieties, which grew by more than 25 percent over the sample period. The average number of varieties imported of each product grew from 19 in 1995 to nearly 26 in 2011. As can be seen on the right axis in graph 3.2, much of this growth took place prior to 2004, after which the number of varieties have fluctuated around 120,000. What is noticeable on the right axis is that, even though the number of products imported fell rather drastically between 2003 and 2011, the number of imported varieties remained fairly constant. As was the case with the growth in the number of products, table 3.2 shows that the total change in product varieties was larger than the increase alone. More than half of the varieties imported in 1995 had disappeared by 2011, while nearly two thirds of the varieties imported in 2011 were not imported in 1995.

Graph 3.2. Nr. of Products & Varieties, 1995-2011



Source: World Bank.org (2012)

In 1995, the 30 biggest trading partners accounted for 85.57 percent of the imported product varieties, a number which had dropped to 78.26 percent in 2011.[6] Germany, the largest source of Swedish imports reduced its share in the total number of varieties imported; from 6.5 percent in 1995 to 5.4 percent in 2011. What can be concluded from this information is that the Swedish product market grew more diversified over the period, with imports spreading out over a larger set of smaller countries of origin. Table 3.3 presents the countries which contributed the most to the growth in imported varieties over the period.

Table 3.3
Contribution to Growth in Swedish Imports - Products per Country

Pos.	Country	Imported products (1995)	Imported products (2011)	Increase	Percentage Growth	Share of total Growth
1	China	1,698	4,485	2,787	164.134%	11.275%
2	Turkey	850	2,172	1,322	155.529%	5.348%
3	Belgium & Luxemburg	3,681	4,815	1,134	30.807%	4.588%
4	India	1,050	2,174	1,124	107.048%	4.547%
5	Poland	2,133	3,036	903	42.335%	3.653%
6	Vietnam	253	1,012	759	300.000%	3.071%
7	Spain	2,277	3,026	749	32.894%	3.030%
8	Thailand	1,207	1,902	695	57.581%	2.812%
9	Czech Republic	1,461	2,109	648	44.353%	2.621%
10	Hongkong	2,195	2,840	645	29.385%	2.609%
	Total	16,805	27,571	10,766	64%	43.554%
	All imports	98,461	123,180	24,719	25%	100.000%

Note: All data from SCB(2012)

Not surprisingly, the country from which the number of imported products increased the most over the period is China, with a product growth of almost 165 percent. The dominance of China in this aspect is so large that its growth is almost twice as large as number two in the list. What is common for most countries in table 3.3 is that they are fast growing developing economies, which have experienced an impressive development over the last decades. Another interesting fact is that only half of them are European, of which Belgium & Luxemburg should be excluded since they are aggregated in the data sample.

Even though the sheer number of product varieties on the market has increased greatly since 1995, it is hard to say what effect these varieties have had on the consumers. The larger market shares taken by the largest trading partners suggest that new product varieties, even though their numbers have increased, may have been forced to share an ever smaller part of the market. These numbers, therefore, show that making a welfare analysis on the basis of count data alone would likely cause an overestimation of the welfare gained.

[6] See appendix B.

4. Method

4.1. Supply and Demand

In order to estimate the elasticity of substitution, it is initially necessary to define the supply and demand functions of imported goods. Beginning with the demand function of variety c, this is obtained by transforming the unit-cost function (2.5) in chapter 2 and to rewrite it in the form of expenditure shares;

$$s_{gct} = d_{gct}\left(\frac{\emptyset_{gt}^{M}}{p_{gct}}\right)^{(\sigma_g - 1)}{}^{7}, \tag{4.1}$$

where s_{gct} is the share of variety c in the total expenditure on good g. [8] As in chapter 2, σ_g is the elasticity of substitution, and thus the parameter of which I am interested in estimating. Since eq. (4.1) is not very well suited for estimation procedures, I will first have to transform it to better suit my needs. This is done by first taking the log, followed by the first difference. Doing so produces the following equation:

$$\Delta \ln s_{gct} = \varphi_{gt} - (\sigma_g - 1)\Delta \ln p_{gct} + \varepsilon_{gct}\,, \tag{4.2}$$

where

$\varphi_{gt} = (\sigma_g - 1)\ln[\emptyset_{gt}^{M} - \emptyset_{gt-1}^{M}]$ and $\varepsilon_{gct} = \Delta \ln d_{gct}$.

ε_{gct} is an error term with expected value zero, since d_{gct} is expected to be more or less constant over time. In this new form it is easy to see that the elasticity determines how many percent the expenditure share of variety c will change following a percentage change in price. The higher the elasticity, the larger the change in demand (Broda and Weinstein, 2006).

In order to properly identify the demand curve I will also need a supply curve, which is defined as

$$p_{gct} = \exp(v_{gct})\, {x_{gct}}^{\omega_g},\ \omega_g \geq 0, \tag{4.3}$$

---

[7] This is obtained by setting the demand of all varieties to one: $1 = \sum_{c \in g} d_{gct}\left(\frac{\emptyset_{gt}^{M}}{p_{gct}}\right)^{(\sigma_g - 1)}$

[8] Since it is not possible to obtain exact prices of the products, p_{gct} is the unit value of variety c. Expenditure shares are used instead of exact quantities in order to avoid the measurement error which is likely to be produced by using unit value instead of prices. If we were to use exact quantities in the demand function we would also have to use exact prices otherwise the estimation process would be biased, due to the correlation between the explanatory price variable and the error term (Verbeek, 2008).

where v_{gct} is an error term with the expected vale of zero and ω_g is the inverse supply elasticity.[9] By taking the log and first difference of this equation and combining it with eq. (4.2) and the definition of expenditure share in chapter 2, I obtain the following reduced form supply curve: [10]

$$\Delta \ln p_{gct} = \vartheta_{gt} + \rho_g \frac{\varepsilon_{gct}}{\sigma_g - 1} + \delta_{gt}, \ 0 \leq \rho_g < 1 \qquad (4.4)$$

where

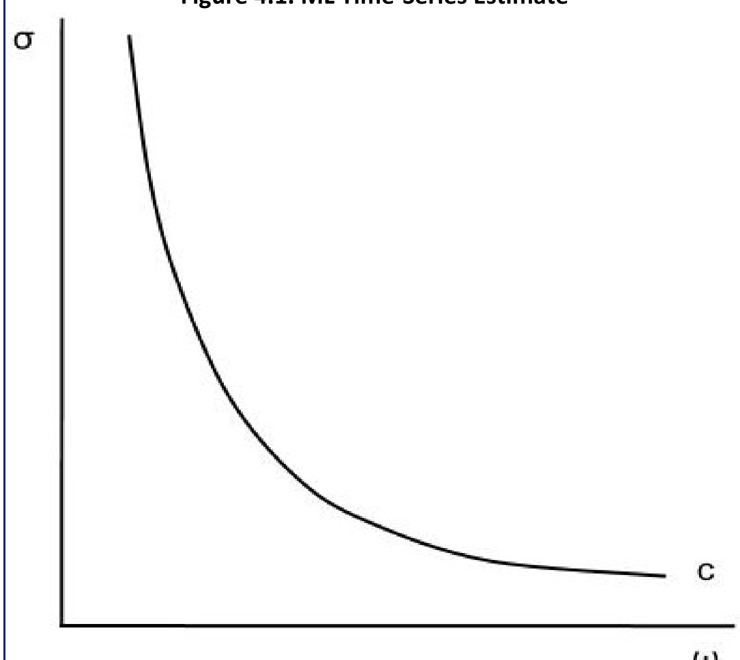
$\vartheta_{gt} = \omega_g(\varphi_{gt} + \Delta \ln E_{gt})/(1 + \omega_g \sigma_g)$, $\delta_{gt} = (v_{gct} - v_{gct})/(1 + \omega_g \sigma_g)$ and $\rho_g = \omega_g(\sigma_g - 1)/(1 + \omega_g \sigma_g)$

Remembering that $\varepsilon_{gct} = \Delta \ln d_{gct}$, it is clear that ρ_g represents the correlation between changes in the equilibrium price and exogenous changes in the demand of variety c (Broda and Weinstein, 2006).

4.2. Identification of Supply and Demand Elasticities

What can be seen in eq. (4.2) and eq. (4.4) is that no exogenous explanatory variables are used in the estimation of neither supply nor demand elasticities. Instead, the panel-data nature of the sample is used to obtain a maximum likelihood estimate of both demand and supply elasticities.

Figure 4.1. ML Time-Series Estimate



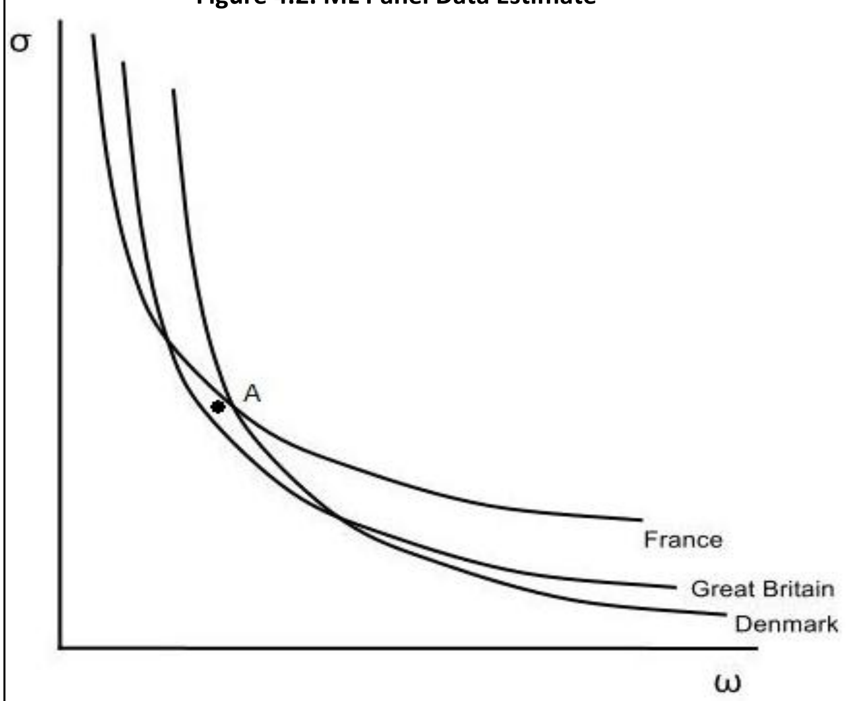
Source: Feenstra (2010)

[9] A critical assumption in the estimation of the elasticities of substitution is that both the elasticity of demand and the elasticity of supply are constant over all countries and time periods.
[10] See appendix C for proof.

Leamer (1981) showed that by using information on both prices and quantities of a given product over time, the estimates of ω_g and σ_g can lie anywhere on a hyperbolic curve such as the curve c in figure 4.1. This curve represents all the possible combinations of supply and demand elasticities for one variety, obtained through time-series estimation. The problem with this estimation is that when using import data from one country alone, neither of the estimates are unique. This means that it is not possible to identify the demand and supply elasticities unless further information is obtained.

This additional information is found in the cross-section nature of the data, together with the restrictive assumption that σ_g and ω_g are identical across all varieties of the same good. Instead of the time-series estimation on one variety alone, there are three estimates in the example displayed in figure 4.2, permitting the identification of an intersecting point of the different varieties. One important necessity for this is that the variances and covariances of the demand and supply curves are different from one variety to another, which depends on country-specific macroeconomic factors such as exchange rate fluctuation, environmental shocks or political changes. Since these are factors which are almost bound to differ between countries, this does not pose a particular demanding restriction (Feenstra, 2010). In the case that there are no differences in variance and covariance between countries all hyperbolas would look exactly the same, resulting in the same situation as in figure 4.1, and no estimate of the elasticity is obtainable.

Figure 4.2. ML Panel Data Estimate



Source: Feenstra (2010)

In the example in figure 4.2, point A is the closest point to any intersection of the three curves and therefore gives the estimates of σ_g and ω_g. The accuracy of such an estimate will consequently increase with the number of countries added to the sample. Using this technique poses a restriction on my sample since I will only be able to estimate the elasticity of substitution for goods of which Sweden imports from three countries or more.

In order to find these hyperbolas I will first have to simplify the supply and demand equations by removing the random variables φ_{gt} and ϑ_{gt}. By doing so, all unobservable factors that are equal between countries are removed, improving the accuracy of identification. This is achieved by taking the first differences of both supply and demand functions relative a reference country k, yielding new demand and supply equations[11]:

$$\tilde{\varepsilon}_{gct} = \left(\sigma_g - 1\right)(\Delta \ln p_{gct} - \Delta \ln p_{gkt}) + \left(\Delta \ln s_{gct} - \Delta \ln s_{gkt}\right), \qquad \tilde{\varepsilon}_{gct} = \varepsilon_{gct}\text{-}\varepsilon_{gkt} \tag{4.5}$$

$$\tilde{\delta}_{gct} = (\Delta \ln p_{gct} - \Delta \ln p_{gkt}) - \tilde{\varepsilon}_{gct}\ \rho_g/(\sigma_g - 1), \qquad \tilde{\delta}_{gct} = \delta_{gct} - \delta_{gkt} \tag{4.6}$$

By multiplying these two equations together and dividing them by $(\sigma_g - 1)(1 - \rho_g)$ I obtain a single equation, from which the parameters σ_g and ρ_g can be extracted:

$$Y_{gct} = \theta_1 X_{1gct} + \theta_2 X_{2gct} + u_{gct} \tag{4.7}$$

where

a) $Y_{gct} = (\Delta \ln p_{gct} - \Delta \ln p_{gkt})^2$
b) $X_{1gct} = \left(\Delta \ln s_{gct} - \Delta \ln s_{gkt}\right)^2$
c) $X_{2gct} = \left(\Delta \ln s_{gct} - \Delta \ln s_{gkt}\right)(\Delta \ln p_{gct} - \Delta \ln p_{gkt})$
d) $u_{gct} = \tilde{\delta}_{gct}\tilde{\varepsilon}_{gct}/(\sigma_g - 1)(1 - \rho_g)$
e) $\theta_{1g} = \frac{\rho_g}{(\sigma_g-1)^2(1-\rho_g)}$
f) $\theta_{2g} = \frac{(2\rho_g-1)}{(\sigma_g-1)(1-\rho_g)}$

Since the error term in eq. (4.7) is correlated with both unit values and expenditure shares, the equation needs to be transformed once more to obtain consistent estimates. By taking the sample mean for each

[11] Instead of choosing an existing reference country I will create an average "reference country" within each good, which simplifies estimation. Since the goal is to remove any unobservables common over all countries this will have the same effect. This is the same as generating within estimations of the supply and demand over each product (Verbeek, 2008). By doing so I also obtain more elasticities, since I do not loose as many observations.

variety, I obtain the following results; $E[\bar{u}_{gc}] = 0$, $E[\bar{u}_g X_{1gc}] = 0$ and $E[\bar{u}_g X_{2gc}] = 0$. This means that I will obtain consistent estimates by running a WLS regression on eq. (4.8) in order to correct for heteroskedasticity[12]:

$$\bar{Y}_{gc} = \alpha + \theta_1 \bar{X}_{1gc} + \theta_2 \bar{X}_{2gc} + \bar{u}_{gc} \tag{4.8}$$

By including the constant one may obtain parameters that are consistently estimated, even in the presence of measurement errors caused by the unit values. Once estimates for θ_1 and $\theta_2$are obtained, it is possible to solve for $\hat{\rho}_g$ and $\hat{\sigma}_g$, using equations 4.8e and 4.8f. These solutions follow three possibilities:

i) If $\hat{\theta}_1 > 0$ and $\hat{\theta}_2 > 0$ the estimates $\hat{\rho}_g$ and $\hat{\sigma}_g$ are extracted as;

$$\hat{\sigma}_g = 1 + \frac{1}{\hat{\theta}_{2g}} \left[\frac{(2\rho_g - 1)}{(1-\rho_g)} \right] \text{ with } \hat{\rho}_g = \frac{1}{2} + \left[\frac{1}{4} - \frac{1}{4 + \frac{\hat{\theta}_{2g}}{\hat{\theta}_{1g}}} \right]^{\frac{1}{2}}$$

ii) If $\hat{\theta}_1 > 0$ and $\hat{\theta}_2 < 0$ the estimates $\hat{\rho}_g$ and $\hat{\sigma}_g$ are extracted as;

$$\hat{\sigma}_g = 1 + \frac{1}{\hat{\theta}_{2g}} \left[\frac{(2\rho_g - 1)}{(1-\rho_g)} \right] \text{ with } \hat{\rho}_g = \frac{1}{2} - \left[\frac{1}{4} - \frac{1}{4 + \frac{\hat{\theta}_{2g}}{\hat{\theta}_{1g}}} \right]^{\frac{1}{2}}$$

iii) In the case that $\hat{\theta}_1 < 0$, the estimation procedure is not as straight forward as in the previous propositions. In this case I have to perform a grid search over the feasible values of $\hat{\sigma}_g > 1$ and $0 < \hat{\rho}_g < 1$. The combination of these two restrictions that give the smallest residuals in the sample is the chosen $\hat{\sigma}_g$[13] (Broda and Weinstein, 2006).

4.3. Estimation Procedure

In order to calculate the gains from variety I will start by estimating all the possible $\hat{\sigma}_g$´s in the sample after which I will estimate the change in varieties of each good g by estimating the λ_{gt}-ratios. Once this is done, it is possible to obtain the variety adjusted exact price index by piecing together the variety growth

[12] The WLS estimates are obtained by first running an OLS regression on eq. (4.8) and saving the residuals. From that initial regression the inverse of the standard deviation of the residuals are used to weight the variables in eq. (4.8). The same result can be obtained by running an IV-regression on eq. (4.7). This technique is described in Feenstra (1994).

[13] In my grid search I set $\hat{\sigma}_g$ to a maximum of 150 and a minimum of 1.05 and perform the search over intervals that are 5 % apart.

with the estimated $\hat{\sigma}_g$´s. Aggregating these, reveals the gains from variety in the Swedish economy between 1995 and 2011.

The biggest, and by far the most time-consuming, challenge in estimating the gains from variety is the estimation of the elasticities of substitution. One reason for this is that not all elasticities can be estimated directly from the CN8 level of product definitions, due to an insufficient number of observations. In these cases I use the elasticities of the CN6 product definitions and apply these to all corresponding CN8 products.[14] When the CN6 elasticity is not available I have instead used elasticities from the CN4 products, and as a last resort elasticities obtained from the CN2 product definitions are used.[15]

A similar problem exists in the estimation of the lambda ratios. The reason for this is that the correct estimation of the lambda ratio requires that at least one common variety is available in both the first and the last period. If this is not the case, the lambda ratio is not defined and cannot be used in the Feenstra index. This is solved by both Mohler (2009) and Broda and Weinstein (2006) by using the lambda ratio of the CN6 (CN4) products for all missing CN8 (CN6) products within the CN6 (CN4) category.[16] In this case I therefore simply treat new product groups as new varieties of the wider product definition, and assume that the new product has the mean elasticity of the other products within this group.

4.4. Sensitivity Analysis

As mentioned in the introduction, the Feenstra index has one weak spot; namely the use of the Armington (1969) definition of a product variety. In this case it is assumed that all growth in imports of a particular product from a particular country takes place in the intensive margin, i.e. an increase in the imported value of an already existing variety. By doing so, however, the ability to say anything about the growth in the extensive margin of imported varieties from that country is lost.

Mohler (2009) therefore propose the use of two different measures of import variety growth. The first of the two is the Feenstra index as presented earlier. The second measure, Mohler uses as the upper bound of the variety growth, since it measures all growth in the extensive margin. This gives a simplified version of the Feenstra index:

[14] As an example; if no elasticities can be estimated for the CN8 products 12 34 56 78 and 12 34 56 77, the elasticity of the CN6 product 12 34 56 is used for both.
[15] This is the procedure suggested by Broda and Weinstein (2006) and the procedure which has been used in later papers as well.
[16] In a few cases the CN2 level is used as well.

$$\frac{\lambda_{gt}}{\lambda_{gt-1}} = \frac{\sum_{c \in I_{gt-1}} p_{gct-1} x_{gct-1}}{\sum_{c \in I_{gt}} p_{gct} x_{gct}}. \tag{4.9}$$

In addition to estimating the gains from variety using the Feenstra index, I will therefore also include an estimate using the Mohler index in order to test for variety growth in the extensive margin of imports. This provides me with both an upper and a lower bound of the total gains from variety.

5. Results

5.1. Elasticities of Substitution

As mentioned in previous chapters, the elasticity of substitution is one of the most important factors of the Feenstra index, since it determines the size of the welfare effect caused by new and disappearing varieties. In table 5.1 I present the summary statistics of the estimated elasticities of substitution.[17] The first thing to mention is that all of the different groups show large standard deviations of the mean value. This is especially true when looking at the CN8 level where the extremely large maximum elasticity drives up both the mean value and the standard deviations. As in the case of the elasticity found by Mohler and Seitz, therefore, the elasticities I obtain for Sweden are on average larger than those obtained in previous studies for other countries. Even though the large maximum elasticities in the CN8 category may initially be a cause for concern, their impact on the welfare effect is more or less nonexistent. Since there are only a few products that take on these extreme values, 15 out of 12,214 take on values above 1,000, they do not affect the general results. As I showed in figure 4.2, a small number of observations reduces the precision of the estimation procedure, causing these rather unrealistic values.[18]

Table 5.1.
Sigmas for all differenct Aggregation Levels

	CN8	CN6	CN4	CN2
Mean	48.09	35.31	14.70	5.45
Median	4.91	6.050	4.04	4.20
Standard Deviation	2,223.72	60.36	35.06	2.62
Maximum Elasticity	236,523.90	591.70	230.81	9.99
Minimum Elasticity	1.05	1.01	1.20	3.96
Nr obs	11,353	256	600	5

Source: SCB (2012)

The expectations regarding these elasticities are that they should increase as the product definitions become narrower. As an example, one would expect the elasticity of substitution between a green and a red apple to be larger than between an apple and a pear, simply because they are more substitutable. A first glance at the mean values in table 5.1 suggests that this is exactly what is found. At the CN8 level

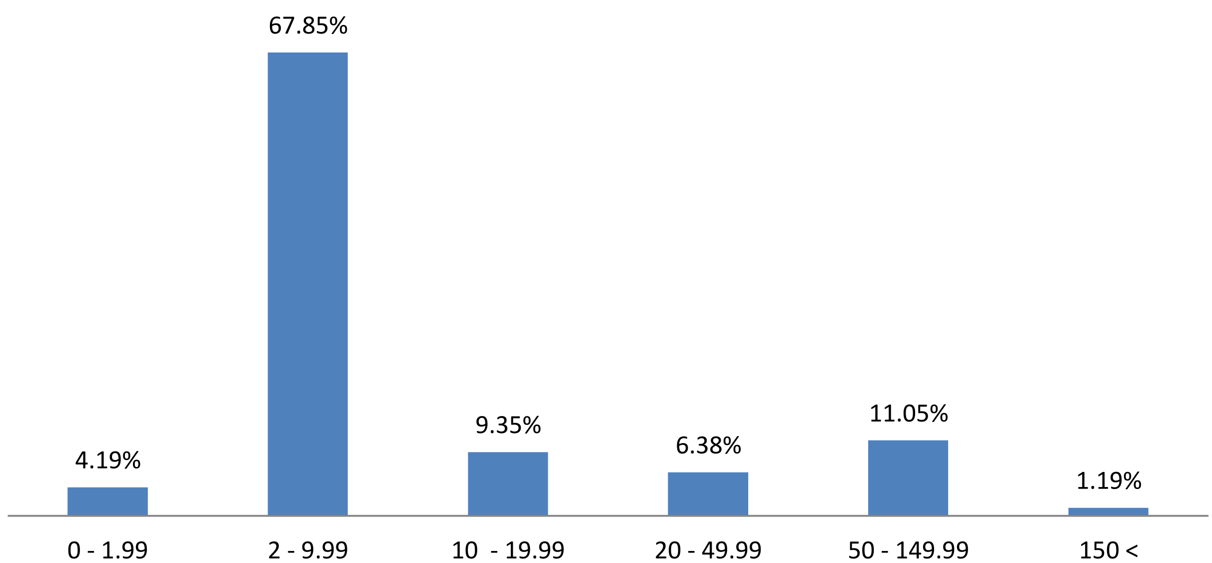
[17] Of the total of 14,196 products at the CN8 level, I have obtained elasticities for 14,160. This means that 36 products were dropped owing to the estimation issue described in the previous chapter.

[18] I do not take the maximum elasticity of the CN8 category into account when estimating the mean elasticity of the CN8 products. Since the maximum value is so extreme, it cannot possibly be said to represent the other products in its group.

the mean elasticity is the largest of the four followed by, in turn, the CN6 level, the CN4 level and finally the CN2 level. However, the large standard deviations of the mean values make it impossible to reject that the mean values of the four groups are the same. Neither do the median values follow the expected results. CN8 and CN6 do indeed have the two largest median values, but the CN6 level is larger than the CN8 level. The maximum elasticities, however, also point to the trend that elasticities seem to increase as the product definition grows narrower. A possible reason why these values are somewhat unexpected is the large difference of the number of observations for each category, where only 5 elasticities were estimated for the CN2 products.

Aggregating the number of estimated elasticities shows that I obtain 12,214 elasticities for the 14,160 products used in the welfare evaluation. Of these 12,214 elasticities, 5,536 were obtained using the grid search procedure as proposed by Broda and Weinstein (2006). In graph 5.1 the distribution of all of the estimated elasticities are presented.

Graph 5.1. The Distribution of Estimated Elasticities



As can be seen in this graph, the majority of the estimated elasticities lie below 20, while a small number of observations take on extremely large values. What is interesting is that only a very small share of the elasticities lies below 2, which means that only for a rather small number of products the elasticity of substitution actually enhances the observed change in imported product varieties. The fact that the post

"50 – 149.99" is as large as it is likely to be caused by the restriction put on the grid search, where many of the estimated elasticities take on the value 149.55. [19]

Examining different products of the CN8 level more closely supports the use of the elasticities estimated. The products with the highest elasticities in the sample were all products that would be characterized as being sold at a reference price such as wax, copper tubes and frozen salmon. On the other end of the specter, some of the lowest elasticities found are those for seal fur and for women underskirts, both with an elasticity of 1.05. Another highly differentiated product with a low elasticity of substitution is "Cut Orchids" with an elasticity of substitution of 1.84.

Table 5.2
Product Groups with the Largest Variety Growth

Product Group	Growth MSEK	Share of Total Import Value Growth	Growth Varieties *	Sigma
Telephones for cellular networks or for other wireless networks	14,408	1.537%	86	3.936
Portable automatic data-processing machines, weighing not more than 10 kg, consisting of at least a central processing unit, a keyboard and a display	13,945	1.487%	84	10.543
Electronic assemblies	1,841	0.196%	85	4.544
Underwear: Other women's or girls' garments	587	0.063%	52	14.547
Underwear: Other men's or boys' garments	412	0.044%	50	10.883
Worn clothing and other worn articles	27	0.003%	43	149.550
Footwear with outer soles of rubber, plastics, leather or composition leather and uppers of textile materials	5	0.001%	34	8.239
Chocolate bars Protein concentrates and textured protein substances	1,013	0.108%	33	2.550
Taps, cocks, valves and similar appliances for pipes, boiler shells, tanks, vats or the like, including pressure-reducing valves and thermostatically controlled valves	628	0.067%	32	4.312
Chocolate and other food preparations containing cocoa	207	0.022%	31	5.702

*Note: * Growth using count data*

Table 5.2 presents some of the products for which the number of imported varieties has grown the most between 1995 and 2011. Of these ten products, the smallest elasticity belongs to protein chocolate bars while the largest belong to worn clothing. These two elasticities appear reasonable; one would assume that the demand of worn clothing is mainly determined by prices, while protein bars are highly brand dependent products. Having garments of both men and women among the ten also provides an interesting comparison. The table shows that underwear garments for women are more differentiated then they are for men, which according to traditional preconceptions would be correct. Both of the two more industrial product groups have elasticities around four. Of these it is harder to make any preconceived assumption, even if very technical industrial inputs should also be expected to have rather small elasticities of substitution. Not surprisingly, the product which has grown the most during the

[19] In Broda and Weinstein (2006) the maximum value allowed for the sigma in the grid search was 130. In this paper I extended my search to some extent and allowed for maximum value of 150. The bias caused by setting a maximum value should be small since in the unrestricted set only 1.7 percent of the estimated sigmas had a value of above 150. In any case, as can be seen in appendix D, values above 150 will have a small effect on the welfare gain.

sample period is cellular phones. As one can expect, this product group also take on a smaller than median elasticity.

In general the estimated elasticities appear to follow the expected pattern, and products which could be assumed to be more differentiated do have smaller elasticities than products which are less differentiated. However, it is very hard to classify products as being differentiated or not, and this to some extent forces the use of rather strong generalizations when controlling for the validity of the estimated elasticities of substitution.

5.2. Lambda Ratios

Table 5.3 displays the descriptive statistics of the estimated lambda ratios. In total, the estimation procedure leaves me with 2,021 product specific lambda ratios, which is in line with the number of lambdas obtained in previous studies. The lower bound estimations state that the median product merely experienced a product variety growth of 0.1 percent, while using the upper bound implies a variety growth of 81 percent.[20] Recall that the lower bound only uses variety growth of completely new varieties, while the upper bound excludes all goods from the common variety sets. This means that the smaller the set of common varieties in two time periods, the lower the median lambda ratio.

Table 5.3
Descriptive Statistics Lambda ratios

Statistic	Lower Bound	Upper Bound
Mean	1.009	2.213
Median	0.999	0.554
Min.	0.005	0.0001
Max.	5.683	1,048.096
Observations	2,021	2,021

Note: Lower bound is estimated using the Feenstra Index, upper bound using the Mohler Index

As with the estimations of the elasticities of substitution, the median values in table 5.3 are biased upwards by large maximum values which push the mean value above 1. This means that the mean value of all lambda ratios would actually imply a decline in product varieties by 0.89 percent in the lower-bound case and 54.81 percent in the upper-bound case.

In order to evaluate the aggregate effect of the changes in product variety, however, each lambda is weighted with both the appropriate elasticity of substitution and its share of the increase of imports in

[20] $Variety\ Growth = \frac{1}{lambda\ ratio} - 1$

that year.[21] Table 5.4 thus displays the yearly end-point ratios and the bias in the conventional price index, caused by ignoring new and disappearing product varieties. These are the yearly aggregate changes in the unit-cost function (2.5) of chapter 2.

In the lower-bound case the total end-point ratio is 0.9836, which is lower than both the mean and the median values. This implies that the products with the lower lambda ratios, obtain larger weights in the aggregation process. This EPR translates into a total upward bias in the conventional price index of 1.664. Another way of saying this is that the Swedish import price index overstates import inflation by 1.664 percent. Comparing the bias of the lower bound with the bias produced by using count data we can see that the count data overestimates the importance of new product varieties by as much as 15 times.

These statistics also show, however, that in four of the 17 years investigated, the conventional price index was actually lower than the exact price index. These are the years highlighted in table 5.4. This means that there were four years during which product varieties were actually declining. Of these years the bias was the largest in 2010 when the conventional price index should have been adjusted upwards by nearly one percent. Dividing the sample in two shows that the lower-bound estimation only displayed a product variety growth up until 2002, after which the market share of new product varieties have declined. Up until 2002 the end-point ratio displayed an upward bias in the CIPI of 2.162 percent, while after that there was a downward bias in the CIPI of almost 0.5 percent.

[21] See eq. (2.11).

Table 5.4
EPR and the Bias in the Swedish Import Price Index

	Lower Bound		Upper Bound		Implied by Count Data	
Year	EPR	Bias	EPR	Bias	EPR*	Bias
1995	1.0000	0	1.0000	0	1.0000	0.000%
1996	0.9995	0.055%	0.9967	0.328%	0.9020	10.863%
1997	0.9990	0.101%	0.9841	1.614%	0.9845	1.575%
1998	0.9973	0.270%	0.9981	0.189%	0.9824	1.795%
1999	0.9888	1.130%	0.9902	0.991%	0.9853	1.492%
2000	0.9982	0.185%	0.9653	3.597%	0.9958	0.424%
2001	0.9995	0.055%	**1.0049**	**-0.484%**	0.9971	0.287%
2002	0.9965	0.352%	**1.0050**	**-0.499%**	0.9833	1.696%
2003	**1.0001**	**-0.008%**	0.9903	0.977%	0.9804	1.998%
2004	0.9988	0.122%	0.9866	1.357%	0.9884	1.171%
2005	0.9997	0.031%	0.9747	2.594%	**1.0209**	**-2.050%**
2006	**1.0005**	**-0.050%**	0.9795	2.090%	0.9923	0.773%
2007	**1.0002**	**-0.019%**	0.9889	1.124%	0.9798	2.057%
2008	0.9976	0.245%	0.9780	2.247%	**1.0026**	**-0.261%**
2009	0.9993	0.066%	**1.0380**	**-3.656%**	**1.0254**	**-2.475%**
2010	**1.0089**	**-0.887%**	0.9689	3.207%	0.9757	2.486%
2011	0.9999	0.015%	0.9892	1.096%	0.9933	0.672%
Total	0.9836	1.664%	0.848	17.895%	0.8044	24.313%

Notes: * Calulated as (Nr. of varietes t-1)/ (Nr. of varietes t)

This inconsistency of product variety growth is not displayed in the upper-bound case, where the upward bias in the CIPI over the entire period was 17.895 percent. Even though this index also displays a few negative observations, these have little effect on the aggregate values. Between 1995 and 2002 we see an upward bias in the conventional price index of 5.814 percent, and of 10.339 percent in the years following 2002. Even though the upper-bound case displays a total bias in the conventional price index which is closer to the bias measured using count data, it still shows that count data overestimates product variety growth by 35 percent.

The ten countries that contributed the most to the bias in the price index are seen in appendix E. Regardless of whether one looks at the upper or the lower bound case; Germany contributed the most to the increased welfare produced by new imported varieties. Another thing that is similar regardless of what bound is used is the overrepresentation of European countries. Even though Sweden imported many new varieties from China, Russia and other Asian countries, the value of these imports are not large in comparison to the value of imports from the European countries. In the lower bound case China is only the tenth biggest contributor to variety growth, while Russia only makes it on to the list in the upper-bound case, when any increase in import value is counted as variety growth.

5.3. Gains from Variety

Using the data from table 5.4 it is finally possible to estimate the total welfare gain from the growth of product varieties between 1995 and 2011. The results of both the lower-bound case and the upper-bound case are displayed in table 5.5.[22]

Table 5.5
Gains from Variety, 1995 - 2011

Statistic	Upper Bound	Lower Bound
EPR	0.848	0.984
Total Bias	17.90%	1.66%
Avg. Bias	1.05%	0.10%
GFV	6.82%	0.578%

These numbers show that using the lower bound EPR, the welfare gains produced by the increase in imported product varieties accounted to 0.578 percent of GDP, while the upper bound EPR registered a welfare gain of 6.82 percent of GDP. In monetary value, this implies a welfare gain of somewhere between 78,871 and 3,190 million SEK. On average, this means that the representative consumer in Sweden would be willing to pay between 0.401 and 0.032 percent of his or hers yearly income in order to gain access to the new set of product varieties imported that year.

In the lower-bound case it is worth noting, as before, that this gain is not unambiguous. The welfare gain produced by product variety growth is obtained before 2002. Up until then, the monetary value of the gains from variety is as much as 5,665 million SEK, but as we pass 2002 and aggregate the gains from 2003 to 2011 there is actually a welfare loss due to the larger share of disappearing varieties. The value which the consumers apply to this loss of product variety is roughly 2,475 million SEK.

[22] Yearly changes are presented in appendix E.

6. Discussion

The purpose of this thesis is the estimation of the gains from variety for the Swedish economy, and to examine whether or not these gains are diminishing over time. The results in the previous chapter show that new imported varieties alone have contributed positively to Swedish welfare. Answering whether or not the gains from variety are decreasing is, however, not as straightforward, and requires an additional discussion of the results in chapter 5.

6.1. Lower and Upper Bounds of Gains from Variety

Since the answer to the question of diminishing gains depend on which of the upper and lower bounds of variety growth is closer to the true value, this is where the discussion should begin. As explained earlier, the lower-bound case uses the Armington assumption of one variety provided by each country. The upper-bound case, on the other hand, measures all import growth of a product as being an increase in product varieties. Even if, for some products, the Armington assumption may underestimate the number of varieties imported from each country, it is not clear how severe of a bias this assumption actually causes in the aggregate estimate.

The answer may lie in the precision of the CN8 product definitions. Two examples can be used, both of which are products which are among the top ten contributing product categories to the overall end-point ratio. The first of these is the product category "Meat". As one examines the CN8 products within this category, it is clear that the product definitions may indeed be narrow enough as to minimize the bias caused by the Armington assumption. Imported meat is defined depending on factors such as; animal, whether the meat is frozen or fresh, what part of the animal is used and whether the meat is boneless or not. There is a small likelihood that more than one variety is provided by each country, when a product can be defined as; "*Frozen whole wings, with or without tips, with bone, of Guinea Fowls*".

Vehicles such as cars, buses, tractors and motorcycles are also important in the growth of product varieties. They also follow a rather narrow definition, restricting the probable number of varieties that may be produced by each country. A car is defined by its motor power, whether it is used or new, using gas or diesel, used for the transportation of goods or persons, etc. Assuming that most car manufacturers have one or two models within each one of these categories would still restrict the number of varieties imported towards the lower bound of the lambda ratios.

In some cases one may argue that different colors should be used as the definition of a variety, in which case the CN8 product definition is far from being sufficiently narrow. Such a definition would most likely imply that the upper bound of the lambda ratio should be used; at least for those products where color is an issue, such as cars or clothes. Even in those cases I would, however, argue that the lower bound of the gains from variety is the correct estimate.[23] The reason for this is that the elasticity of substitution between different colors of the same variety is most likely high enough as to diminish the main part of any utility gained from adding new colors. If the entire gain from variety using the CN8 product definition is valued at 0.578 percent of GDP, adding colors should still not be able to lift the gains from variety above 1 percent of GDP.

There are also other factors speaking against the use of a welfare effect as large as the one produced by the upper-bound measure. Using the example of red wine again, it is not unlikely that an increase from one to two varieties would imply a significant increase in the welfare of the consumers. But an increase from 1000 to 1001 varieties will most likely not affect the consumers to the same extent. That the marginal utility of variety growth may be diminishing is not included in the theoretical model, but is certainly an issue which needs to be mentioned. If one assumes that there is a diminishing welfare effect on the margin, the upper bound could be dismissed simply for being too large.

The arguments above favor the assumption that the lower bound is closer to the true gains from variety. The upper bound still fulfills a very important purpose, however, insofar as it proves the importance of using expenditure shares before count data. It clearly displays that even though the sheer number of imported varieties has increased substantially over the sample period, the majority of these products are imported at values so small that they do not affect the consumers on any distinguishable level.

In concluding that the lower-bound estimate is closer to the true gains from variety, I cannot reject the hypothesis that these gains are diminishing over time. In table 5.4 it is clear that the main share of the gains from variety were gained prior to 2002, after which a number of years of negative growth suppressed the overall gains. Of the four years which show negative gains from variety, 2010 is worst by far and is most likely an outlier caused by the financial crisis. Even if 2010 is an outlier, however, there is a decline in the gains from variety after 2003. The next issue is identifying the underlying cause of this decline.

[23] Recall the difference between the lambda ratio and the end-point ratio. The lambda ratio only measures variety growth, not taking the elasticity of substitution into account.

6.2. Development of the Gains from Variety

In the introduction I made the case that there were at least two reasons why the gains from variety should not be decreasing. The first argument was that new trading partners may take the place of old ones as communications improve and trade costs are reduced. The second argument was that the progress of technology should be able to provide Swedish consumers with a constant inflow of new products and product varieties. Looking at the results in chapter 5, proof of neither argument can be found.

Initially, a comparison of the data in chapter 3 and the results in chapter 5 may appear conflicting. The first argument should be valid, since the number of trading partners as well as the average number of countries providing each product increased over the period. The problem, however, is the heavy influence of a few large countries which dominate Swedish imports. Of these, large trading partners such as the United States, France, Italy, China, and, especially, Germany contributed greatly to the product variety growth. But it was also held back due to the reduction in varieties imported from other large partners such as Great Britain, Denmark and the Netherlands. Since these countries constitute large shares of the total imports, a reduction in varieties from any of them reduces the gains from variety substantially. The dominance of these, mostly European, countries therefore inhibits any welfare effect which can be provided by new trading partners. Even though they are many, their market shares are simply too small. One reason for the larger gains from variety in countries such as China is that their imports do not originate from a concentrated group of countries to the same extent. This means that even if the imported number of varieties from a large country is decreasing, the aggregate effect of that decrease is not as large as it is in Sweden.

The second argument, that the development of new products should boost the gains from variety, is also contradicted by graph 3.2. On the contrary, it is not a very strong statement that the stagnation of the variety growth is actually rooted in the decrease in the number of imported products following 2003. The picture is quite clear; up until the point where the number of products starts to diminish, product variety is increasing. After 2003, variety growth levels out. One explanation could be that the number of products imported in 2003 was not determined by a supply-and-demand equilibrium. More specifically: supply may have been greater than demand.

Looking at graph 3.2 supports this theory. Even more dramatic than the fall in imported products between 2003 and 2011, is the increase in products imported during 1995. During the year following the entry to the European Union, the number of imported products increased by 10.7 percent. More than half of these new products, 51 percent, were provided by members of the European Union, which suggests that the accession to the EU spurred an increase in imported products. If the demand of new products was overestimated, however, this would explain why the number of products started to shrink after only a few years. The problem with this theory is that there is no overrepresentation of these products among those that disappear after 2003. Neither does the theory explain why the number of imported products is actually smaller in 2011 than in 1995. Even if it is likely that the EU membership caused an upsurge in imported products in 1995, the explanation to the decline of products lies elsewhere.

A closer look at the products which disappeared after 2003 reveals that a large share was technical equipment, such as industrial machines or measurement instruments. The development of these kinds of products over the last 17 years may therefore give a clue to the decline of imported product. As I mentioned in chapter 3, the death of old products is unavoidable as technology progress. The advancements made in computer capacity over the last decades may, however, have changed how new products are born. It is not unlikely that, in a number of different sectors of the economy, a single computer can nowadays perform tasks where earlier multiple machines were needed. This could mean that many machines that were earlier used in production, in cars or in home equipment have been made obsolete by computers and computer software. Digital products are not observed in the data sample since this only contains the imports of goods, and as most digital products are registered as "services" these are therefore not included. If computers and digital products have indeed replaced much of the machinery previously imported, this could explain the drop in the number of products. That diminishing variety growth could be explained by a reduction in the number of products needed in the economy, changes the discussion. In that case it is not only a matter of new or disappearing varieties, but also of the utility provided by different types of products.

6.3. Technological Development and the Gains from Variety

As was displayed in eq. (2.3) and eq. (2.4), the utility obtained by consumers depend on the number of products and product varieties consumed. But what happens with that theory when the products themselves disappear, while the functions they provided remain? The most obvious example of this is the computer, which have overtaken a large number of functions that were previously held by other products. The computer now functions as a typewriter, photo album, television, dvd-player, gaming station, calculator, notebook, cd-player, radio, cook book, encyclopedia, etc. The list can practically be made endless. But is utility decreasing because one product has made many others obsolete?

One could argue that it is the opposite. In the Feenstra model, the gains from variety are extracted from equation (2.5); the unit-cost function. This predicts that the cost of living is reduced as new product varieties are introduced. The development of computer technology and smart phones, it can be argued, changes that equation. The smart phones and the computers, literarily, reduce the cost of living while the same level of utility is maintained. Consumers that own a smart phone or a tablet computer do not need to buy a camera or a video camera, they do not need to buy magazines or newspapers, nor do they need maps or guide books as they are traveling. Not even books are safe, since entire libraries can be purchased online, downloaded and saved in E-book readers.

The development of digital products has obviously changed the manner in which we should look at, and measure, product varieties. The first problem lies in our inability to measure the imports of digital products. A second problem is whether these digital products produce the same utility as traditional products. The easy access to digital products online seems to make consumers unwilling to pay for digital products, but does that mean that utility is reduced? In order for us to accurately measure product variety growth in the future, we must therefore update the methodology used in this thesis. The difference between a product and a service is more diffuse now than it has ever been, and that problem needs to be solved before a truly accurate measure of gains from variety can be produced.

7. Conclusions

Swedish import data between 1995 and 2011 shows that the gains from new imported product varieties amounted to between 0.578 and 6.82 percent of GDP. This means that, on average, the Swedish consumer would be willing to pay somewhere between 0.401 and 0.032 percent of their yearly income in order to obtain the set of new varieties imported each year. Owing to the narrow product definitions provided by the data, however, the true variety growth is most likely to be close to the lower of the two estimates. These welfare effects are in line with previous research, and show that import variety growth is an important contributor to the gains from trade. The largest share of this variety growth can be traced back to European countries, where Germany stands out as the largest contributor. Some of the larger non-European economies such as the United States, Japan and China also contributed greatly to the product variety growth.

The hypothesis that these gains from variety are diminishing cannot be rejected by the data sample used in this thesis, since most of the gains from variety observed stems from the years prior to 2003. After 2003 they decline and four of the years investigated even display a drop in welfare owed to a reduction in the imported varieties. I give two possible explanations to this decline in gains from variety. One explanation is the heavy influence of a concentrated group of big economies in Swedish imports, which restricted the possibility of smaller new trading partner to produce large welfare effects. The second explanation is that the methodology used in this thesis has been unable to capture the development of the economy, from a product based economy to the more service oriented “Digital Age”. An important topic for future research would therefore be to develop the Feenstra index and the Broda and Weinstein methodology so that it can capture the growth in product variety which is provided by computer software, smart-phone applications and other digital products.

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Appendix

Appendix A

30 Biggest Import Sources - Import Value				
1995			2011	
Import Value MSEK	Country	Pos.	Import Value MSEK	Country
78,901	Germant	1	198,789	Germany
35,403	Great Britain	2	96,403	Norway
28,910	Norway	3	87,761	Denmark
28,041	Denmark	4	67,427	Netherlands
24,299	Netherlands	5	63,939	Great Britain
22,781	Finland	6	63,108	Russia
20,808	France	7	58,137	Finland
20,686	United States	8	49,881	France
15,065	Belgium & Luxemburg	9	44,942	Belgium & Luxemburg
12,852	Italy	10	44,380	China
10,954	Japan	11	34,357	United States
8,915	Switzerland	12	30,844	Italy
5,775	Hong Kong	13	30,717	Poland
4,803	Spain	14	19,499	Ireland
4,670	Austria	15	19,173	Estonia
3,935	Poland	16	14,567	Japan
3,498	Portugal	17	14,226	Spain
2,847	China	18	13,671	Czeck Republic
2,618	Ireland	19	12,328	Austria
2,613	Russia	20	9,257	Switzerland
2,536	Tawain	21	8,606	Hong Kong
1,835	Iran	22	8,414	Turkey
1,784	Latvia	23	8,412	South Korea
1,691	Estonia	24	7,821	Slovakia
1,659	Canad	25	6,763	Hungary
1,412	South Korea	26	6,527	Lithuania
1,411	Brazil	27	5,918	Litauen
1,365	India	28	5,618	Taiwan
1,314	Saudi Arabia	29	4,826	Latvia
1,039	Czech Republic	30	4,544	Brazil
354,421	SUM	-	1,040,856	SUM
595,662	TOTAL 1995	-	1,533,263	TOTAL 2011
59.500%	Share Top 30	-	67.885%	Share Top 30

Note: Total importvalue is obtained from the World Bank Database

Appendix B

30 Biggest Import Sources - Nr. of Products				
1995			2011	
Nr. of Products	Country	Pos.	Nr. of Products	Country
6,718	Germany	1	6,980	Germany
5,787	Denmark	2	6,165	Denmark
5,609	Great Britain	3	5,495	Norway
5,478	Norway	4	5,386	Netherlands
5,340	USA	5	5,127	USA
5,002	Netherlands	6	5,057	Great Britain
4,628	France	7	4,815	Belgium and Luxemburg
4,256	Finland	8	4,619	France
4,198	Italy	9	4,485	China
3,840	Switzerland	10	4,393	Finland
3,681	Belgium and Luxemburg	11	4,388	Italy
2,529	Japan	12	3,126	Switzerland
2,436	Austria	13	3,036	Poland
2,277	Spain	14	3,026	Spain
2,195	Hongkong	15	2,840	Hongkong
2,133	Poland	16	2,813	Austria
1,989	Taiwan	17	2,318	Japan
1,831	Canada	18	2,301	Canada
1,698	China	19	2,287	Taiwan
1,523	Estonia	20	2,174	India
1,461	Czech Republic	21	2,172	Turkey
1,293	Portugal	22	2,109	Czech Republic
1,250	South Korea	23	1,902	Thailand
1,207	Thailand	24	1,814	Estonia
1,123	Ireland	25	1,756	South Korea
1,050	India	26	1,353	Australie
989	Hungary	27	1,166	Singapore
951	Singapore	28	1,158	Ireland
931	Australie	29	1,077	Hungary
850	Turkey	30	1,060	Latvia
84,253	SUM	-	96,398	SUM
98,461	TOTAL 1995	-	123,180	TOTAL 2011
85.570%	Share Top 30		78.258%	Share Top 30

Appendix C

Derivation of supply curve

A) $\Delta \ln s_{gct} = \varphi_{gt} - (\sigma_g - 1)\Delta \ln p_{gct} + \varepsilon_{gct}$

B) $p_{gct} = \exp(v_{gct})\, x_{gct}{}^{\omega_g}$

C) $s_{gct} = \frac{p_{gct}x_{gct}}{\sum_{c \in I_g} p_{gct}x_{gct}}$

$take\ the\ \log\ of\ c\ and\ differentiate$

$$1)\quad \Delta \ln s_{gct} = \Delta \ln x_{gct} + \Delta \ln p_{gct} - \Delta \ln E_{gt}\ , \qquad E_{gt} = \sum_{c \in I_g} p_{gct}x_{gct}$$

$insert\ into\ equation\ A$

$$2)\quad \Delta \ln x_{gct} + \Delta \ln p_{gct} - \Delta \ln E_{gt} = \varphi_{gt} - (\sigma_g - 1)\Delta \ln p_{gct} + \varepsilon_{gct}$$

$$\leftrightarrow$$

$$3)\quad \Delta \ln x_{gct} = \varphi_{gt} + \Delta \ln E_{gt} - \sigma_g \Delta \ln p_{gct} + \varepsilon_{gct}$$

$take\ first\ differences\ and\ \log\ of\ B$

$$4)\quad \Delta \ln p_{gct} = \omega_g \Delta \ln x_{gct} + v_{gct} - v_{gct-1}$$

$insert\ 3\ into\ 4$

$$5)\quad \Delta \ln p_{gct} = \omega_g \left(\varphi_{gt} + \Delta \ln E_{gt} - \sigma_g \Delta \ln p_{gct} + \varepsilon_{gct}\right) + v_{gct} - v_{gct-1}$$

$$\leftrightarrow$$

$$6)\quad \Delta \ln p_{gct} = \omega_g(\varphi_{gt} + \Delta \ln E_{gt}) - \omega_g \sigma_g \Delta \ln p_{gct} + \omega_g \varepsilon_{gct} + v_{gct} - v_{gct-1}$$

$$\leftrightarrow$$

$$7)\quad \Delta \ln p_{gct} + \omega_g \sigma_g \Delta \ln p_{gct} = \omega_g(\varphi_{gt} + \Delta \ln E_{gt}) + \omega_g \varepsilon_{gct} + v_{gct} - v_{gct-1}$$

$$\leftrightarrow$$

$$8)\quad \Delta \ln p_{gct} = \omega_g(\varphi_{gt} + \Delta \ln E_{gt})/(1 + \omega_g \sigma_g) + \omega_g \varepsilon_{gct}/(1 + \omega_g \sigma_g) + (v_{gct} - v_{gct-1})/(1 + \omega_g \sigma_g)$$

$$\leftrightarrow$$

$$9)\quad \Delta \ln p_{gct} = \vartheta_{gt} + \rho_g \frac{\varepsilon_{gct}}{\sigma_g - 1} + \delta_{gt}$$

Appendix D

Gains from Variety depending on Elasticity of Substitution

Lambda Ratio	σ	EPR	Price Index Decline	Gains From Varieties *
0.95	1.5	0.903	9.750%	3.125%
0.95	2	0.950	5.000%	1.551%
0.95	3	0.975	2.532%	0.772%
0.95	4	0.983	1.695%	0.514%
0.95	5	0.987	1.274%	0.385%
0.95	10	0.994	0.568%	0.171%
0.95	15	0.996	0.366%	0.110%
0.95	20	0.997	0.270%	0.081%
0.95	30	0.998	0.177%	0.053%
0.95	50	0.999	0.105%	0.031%
0.95	100	0.999	0.052%	0.016%
0.95	150	1.000	0.034%	0.010%
0.95	200	1.000	0.026%	0.008%
0.95	300	1.000	0.017%	0.005%

Notes:

a) GFV calculated using a share of imports of GDP of 0.3. Expressed as % of GDP

Appendix E

Top Ten Contributers Product Variety Growth - Upper Bound

Position	Country	Share of Growth - Upper Bound
1	Germany	18.519%
2	Denmark	12.039%
3	Norway	11.382%
4	Great Britain	10.509%
5	Netherlands	7.568%
6	Finland	7.275%
7	Belgium and Luxemburg	6.250%
8	the United States	5.439%
9	France	3.960%
10	Russia	2.903%

Note: Contribution can be negative.

Top Ten Contributers Product Variety Growth - Lower Bound

Position	Country	Share of Growth - Lower Bound
1	Germany	65.8776%
2	the United States	34.3548%
3	Poland	22.3617%
4	Italy	16.5269%
5	Switzerland	9.0676%
6	Austria	3.4224%
7	France	3.2541%
8	Japan	2.8213%
9	Lithuania	1.6725%
10	China	1.1061%

Note: Contribution can be negative.

Appendix F

Gains From Variety

Year	Imports (Share of GDP)	Import Value	Upper Bound			Lower Bound		
			EPR	GFV(% of GDP)	Monetary gain	EPR	GFV(% of GDP)	Monetary gain
1995	0.329	595,662,000,000 kr	1.0000	0	0 kr	1.0000	0.000%	0 kr
1996	0.319	592,270,000,000 kr	0.9967	0.105%	620,651,909 kr	0.9995	0.017%	106,603,256 kr
1997	0.346	668,427,000,000 kr	0.9841	0.555%	3,710,297,353 kr	0.9990	0.035%	221,914,548 kr
1998	0.364	736,351,000,000 kr	0.9981	0.069%	505,262,759 kr	0.9973	0.098%	654,014,476 kr
1999	0.366	782,612,000,000 kr	0.9902	0.361%	2,828,352,430 kr	0.9888	0.412%	2,899,203,570 kr
2000	0.402	909,998,000,000 kr	0.9653	1.430%	13,009,597,858 kr	0.9982	0.074%	552,500,488 kr
2001	0.396	929,850,000,000 kr	1.0049	-0.192%	-1,784,730,236 kr	0.9995	0.022%	168,191,631 kr
2002	0.376	919,335,000,000 kr	1.0050	-0.188%	-1,727,886,080 kr	0.9965	0.132%	1,062,794,445 kr
2003	0.367	933,814,000,000 kr	0.9903	0.357%	3,336,607,230 kr	1.0001	-0.003%	-24,282,197 kr
2004	0.378	1,005,188,000,000 kr	0.9866	0.511%	5,132,973,091 kr	0.9988	0.046%	405,094,967 kr
2005	0.406	1,124,567,000,000 kr	0.9747	1.045%	11,755,385,630 kr	0.9997	0.013%	115,963,364 kr
2006	0.430	1,266,441,000,000 kr	0.9795	0.893%	11,315,004,477 kr	1.0005	-0.022%	-210,035,822 kr
2007	0.444	1,388,241,000,000 kr	0.9889	0.497%	6,905,282,773 kr	1.0002	-0.008%	-87,270,290 kr
2008	0.468	1,498,895,000,000 kr	0.9780	1.045%	15,661,761,817 kr	0.9976	0.115%	1,208,017,090 kr
2009	0.415	1,288,213,000,000 kr	1.0380	-1.533%	-19,750,292,184 kr	0.9993	0.027%	280,713,410 kr
2010	0.435	1,447,443,000,000 kr	0.9689	1.381%	19,995,753,033 kr	1.0089	-0.386%	-4,237,698,758 kr
2011	0.439	1,533,263,000,000 kr	0.9892	0.480%	7,357,523,059 kr	0.9999	0.006%	74,451,690 kr
TOTAL	-	17,620,570,000,000 kr	**0.8482095**	**6.82%**	78,871,544,919 kr	1.0000	**0.578%**	3,190,175,868 kr

Notes: Imports (Share of GDP) and Import Value from World Bank Database (2012)

Appendix G

Top Contributing Product Chategories, CN2 Product Definition

Lower Bound Estimates

Position	Product Chategory	EPR
1	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof	0.978416
2	Aircraft, Spacecraft, and parts thereof	0.997994
3	Vehicles such as cars, buses, tractors and motorcycles	0.999591
4	Ships and Boats	0.999679
5	Electrical machinery and parts thereof	0.999780
6	Articles of Iron and Steel	0.999903
7	Meat	0.999924
8	Chemical Elements	0.999925
9	Pharmaceutical Products	0.999933
10	Iron and Steel	0.999939

Upper Bound Estimates

Position	Product Chategory	EPR
1	Mineral Fuels, Mineral Oils and Products of their Distillation	0.929224
2	Electrical machinery and parts thereof	0.976428
3	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof	0.982948
4	Hydrocarbons	0.989501
5	Vehicles such as cars, buses, tractors and motorcycles	0.993057
6	Fish	0.993362
7	Iron and Steel	0.996742
8	Plastics and Articles theref	0.997222
9	Miscellaneous Manufactured Not Elsewhere Specified	0.998103
10	Miscellaneous Chemical Products	0.998151

Note: Category names have been interpreted