Stockholm School of Economics
Department of Economics
659 Degree Project in Economics
Spring 2016

– DISSECTING THE HOLY COW –

investigating structural change in the price elasticity of demand for Swedish milk

Edvin Hertegård (23099) and Hjalmar Skog (23085)

Abstract: Using data from the Swedish Board of Agriculture (Jordbruksverket), we investigate if there has been a structural break in the price elasticity of demand for Swedish milk. The aim is to attempt to answer the research question if opening up a market affects the price elasticity of demand for goods of cultural importance. The results of previous studies estimating the price elasticity of demand for milk indicate an inelastic price elasticity of demand for milk in Sweden. However, demand studies tend to assume the elasticities to be constant over long periods of time. We hypothesise that Swedish consumers do not have the same attitudes towards milk as they used to. This may manifest as a change in the estimated elasticities. Due to the complexity of describing aggregate consumer demand, Deaton & Muellbauer's Almost Ideal Demand System is used to estimate the price elasticity for milk during 1967–2014. Using this method, a structural break at the hypothesised break time of 1995 is tested for by using a Chow test. The results indicate a significant structural break in 1995 and the two subsequent years, which we believe is due to Sweden becoming a member of the EU. The reasons for the structural break are complex and may depend on existing cultural elements and market factors in Sweden. Although the presence of autocorrelation is noted in parts of the data, we view the observed structural break and the change in price elasticity as an indication that our hypothesised result is reasonable.

Keywords:	Price elasticity, Milk, Structural change, Almost Ideal Demand System, Consumer demand
JEL Classification:	Q11, D12
Supervisor:	Chloé Le Coq
Date submitted:	14 May 2016
Date examined:	9 June 2016
Discussants:	Sara Babiker and Carl Magnus Magnusson
Examiner:	Karl Wärneryd

Acknowledgements

To begin with, we would like to thank our supervisor Chloé Le Coq and course director Örjan Sjöberg. We would also like to thank Rickard Sandberg at the Center for Economic Statistics at SSE and Yves Surry at the Department of Economics at the Swedish University of Agricultural Sciences for econometric guidance. We thank Kristofer Wahlgren at ICA Flygfyren for insights into the retail industry. A special thanks is directed to Marie and Peter in Norrtälje for their self-sacrificing behaviour to risk their driver's licences while chasing a bus headed for Stockholm. Finally, we would like to thank members of the Hertegård family and the Skog family for sharing their interdisciplinary academic expertise.

Table of Contents

1 Introduction

"Get off your horse and drink your milk."

– John Wayne

Every year, the average Swedish consumer drinks approximately 83 litres of milk (LRF Mjölk, 2016a). In addition, a large quantity of cheese, cream and yogurt is consumed. This makes dairy products one of the cornerstones of our diet. The consumption of milk in Sweden has experienced a negative trend since the 1950s. The same trend has adversely affected the Swedish dairy farmers (LRF Mjölk, 2015). In order to help the dairy farmers, campaigns that advocate consumers paying extra for Swedish milk have been introduced by political parties and retailers (Centerpartiet, 2016; ICA, 2016). It is rare to make people voluntarily pay extra for a specific product. This occurrence indicates that milk has a greater value for many consumers than the price they are currently paying.

The fact that the consumers to some extent are indifferent regarding the price of the good could indicate that the price sensitivity of milk consumption is low for consumers in Sweden. However, the popularity of milk can be looked upon as unexpected considering the negative externalities associated with dairy production. For instance, it has long been reported that dairy production is associated with substantial emission of greenhouse gases, eutrophication and animal welfare issues (Steinfeld, Gerber, Wassenaar, Castel & de Haan, 2006; Ishler, 2016). With the positive health aspects of milk consumption also being questioned, most recently in a widely disseminated 2014 study from Uppsala University, it could be argued that the view on milk has been tarnished in recent years (Michaëlsson et al., 2014; DN, 2014; SVT, 2014b). At the same time, a number of plant-based substitutes such as soy milk, almond milk and oat milk have appeared and increased their market shares in recent years (Nielsen, 2014). It could be argued that the tarnished reputation of milk and the increased importance of milk substitutes are symptoms of milk losing its status as a good of cultural importance. It is difficult to determine if any single event has been instrumental in changing the price sensitivity for milk, since consumer demand is influenced by a multitude of factors. However, it is likely that some types of events have been more influential than others. To investigate the current situation and whether or not there has been a structural break in the demand for milk, the price elasticity for milk can be estimated and used to quantify the consumers' sensitivity to price changes.

Looking at current research, the price elasticity for milk has previously been estimated using Swedish data, most recently by Säll and Gren (2015) at the Swedish University of

Agricultural Sciences (SLU). In their study, Säll and Gren use yearly Swedish consumption data during 1980–2012 from the Swedish Board of Agriculture (Jordbruksverket) to estimate the price elasticity for general food groups such as meat and dairy products. Following this, Säll and Gren estimate the price elasticity for specific food products (e.g. milk and beef). These estimates are based on the assumption that elasticities are static over the estimated time period. In our view, there is a priori reason to suspect a change in elasticities over the years. Several major reforms have taken place since the beginning of the 1990s, including deregulation of the agricultural sector in Sweden, removal of the target rate of self sufficiency in case of war and the EU entry. Earlier elasticity studies have not captured these effects in their estimations, leading to estimates not fully representing consumer behaviour in Sweden today. To the best of our knowledge, testing for a change in elasticities for milk has not previously been performed on Swedish milk consumption data.

This research gap leads to questions in need of an answer. Is milk a must-have product for Swedish consumers, or are the consumers' preferences regarding milk the same as any other food product? Has a structural break in demand occurred which could help us predict the way the demand for milk is likely to shift in the future? The answer to these questions could help shedding light on what kind of event affects the demand of goods of cultural importance.

1.1 Purpose and scope

It is for various reasons common in agricultural economics to estimate the price elasticity of demand for food products, e.g. to evaluate policy decisions of subsidies or test consumer preferences. For example, elasticities can be used to determine the effects of taxes on consumption behaviour. However, the assumption of elasticities being constant over long periods of time is unlikely to hold true in case of exogenous shocks affecting consumers or endogenous preference changes. This is an area that can be further investigated by estimating the price elasticity for a good and then testing for a structural break. The scope of this thesis will be limited to testing for change in Swedish consumers' demand for milk during the time period of 1967–2014. A necessary basket of goods will be chosen to calculate the price elasticity for milk consumption and other food products. The aim is to test for a structural break in the price elasticity of demand for milk and assess whether a change in the Swedish consumers' demand for milk has occurred or not.

2 Research focus

> *"Price elasticity is determined by two main factors: how dispensable they [the services or goods] are in consumption, and the availability of substitutes."*
>
> – Lennart Schön (2012)

In this thesis, we define milk as the food product of cow's milk intended for drinking. Thereby, we disregard the milk used as the main ingredient in other dairy products.

There are many factors in favour of the proposition that Swedish consumers view milk as a product one could not live without. Previous price elasticity estimates for milk speak in favour of such a view. The uncompensated price elasticity for milk was estimated to be –0.205 when using data from 1980 to 2012, indicating that for every per cent increase of the price of milk the consumed quantity falls by 0.205 per cent (Säll & Gren, 2015). This result can be compared with the estimated uncompensated price elasticity to –0.538 for beef, which indicates that beef consumption is more than twice as sensitive to price changes compared with milk consumption. By definition, this estimated elasticity indicates that milk is a necessity good since the elasticity is larger than –1 and smaller than 0. However, due to the substantial changes regarding milk production and the way media portraits milk, consumer attitudes towards milk may have changed over time, especially in recent years.

In order to narrow the scope of the research focus, we have chosen to investigate a change in the price elasticity of demand for milk and a possible structural break of demand at the time Sweden became a member of the EU. This specific event was chosen due to Sweden's EU entry being the most substantial change in Swedish agricultural policy in modern times. Our reasoning behind investigating the EU entry links back to the quote by the recently deceased professor of economic history at Lund University, Lennart Schön, which states that elasticities mainly are dependant on how dispensable a good is in consumption and the number of substitutes it has. While these two factors to some extent overlap, they provide a good starting point for investigating a possible structural break. The EU entry with its subsequent increased threat of competition from new market entrants has, arguably, shaken the milk market at its core and contributed to some more or less closely linked substitutes of traditional milk, for example various kinds of plant milk. With a wider variety of substitutes and other dairy products present in the stores, the importance of milk is likely to have decreased. In addition, the increased mobility within the EU and the immigration to Sweden may have affected the consumption behaviour in Sweden. For the reasons stated above, the time period of the

EU entry should be investigated to determine any linkage to a structural break in the demand for milk.

2.1 Research question

The general research question is formulated as follows:

> *Does opening up a market affect the price elasticity of demand for goods of cultural importance?*

With the specific subquestion that can be tested for being:

> *Did Sweden's entry into the EU cause a structural break in the Swedish consumers' price elasticity of demand for milk?*

2.2 Hypothesis

To summarise the previous section and state our hypothesis, we note that our prior belief before performing the tests is a structural break of the demand for milk occurring at the year of 1995. In our view, Sweden's entry into the EU 1 January 1995 is likely to have spurred increasing competition in the milk market and led to diversification of different product ranges, which in turn may have led to a shift in consumer preferences. The result would be consumers being more sensitive to price changes.

3 Historical background and description of the market

3.1 Milk consumption in Sweden – creating an everyday food product

In 1923, the dairy industry in Sweden seized the opportunity to expand its market by launching the lobbying organisation Mjölkpropagandan (The Milk Propaganda) with the intention of making milk into an everyday food product (Arla, 2016c). The campaigns launched by the organisation were successful in raising demand for milk and gaining political support. By 1932, the Social Democrats and the Farmers' League, two out of three leading political parties at the time, decided to support the dairy farmers by regulating the price of milk. This being the starting point of agriculture regulations in Sweden (Arla, 2016b). Besides gaining the support of the Farmers' League in other policy matters, the Social Democrats intended to use milk as a way to improve the health of the working class by encouraging them to substitute beer and coffee with milk which was believed to be a healthier option (SVT, 2014a). Milk consumption was used to reduce health inequalities within the population and thereby became intertwined with the rise of the Swedish welfare state (Jönsson, 2005). In the year of 1950, the policy decisions and campaigns had taken effect and milk consumption was soaring as the average Swedish consumer at that time consumed 216 litres of milk per year (Jordbruksverket, 2016b).

However, dairy consumption in Sweden has ever since dwindled substantially. As of 2014, the average Swedish consumer drinks approximately 83 litres of milk per year (LRF Mjölk, 2016a). The number of people employed in dairy production has also decreased substantially. Since 2005, the number of dairy farmers in Sweden has been more than halved from 8,500 to 4,200 (Jordbruksverket, 2016). The dairy industry's lobbying organisation, Mjölkpropagandan, continues to propagate through its new organisation LRF Mjölk, but has had little success in reversing the negative trend (LRF Mjölk, 2012). Partly, the poor outlook for dairy farmers may stem from the increased competition from European dairy farmers since Sweden entered the EU in 1995. It has long been reported that Swedish farmers are forced out of business due to lack of profitability, even though dairy farmers within the EU receive billions of euros in subsidies every year (European Commission, 2013).

3.2 Agricultural reforms when entering EU

Before becoming member of the EU, agricultural and food policies were decided upon by domestic policy makers in Sweden (Jordbruksverket, 2011a). Since the 1930s, the political focus regarding agriculture has been self-sufficiency. Due to fear of war and uncertainty about the future, the dominating reasoning behind the policy decisions has been that as much as possible of consumed food should be produced within the country. These ideas were maintained even after World War II and affected agricultural policies throughout the preponderant part of the 20$^{\text{th}}$ century. Goals were set to ensure that farmers could provide for themselves through agriculture, and the government therefore took an active role in rationalising Swedish agriculture. In the 1960s, overproduction was a fact, and the government took an even more active role in agriculture with extensive price regulations being implemented. In the 1980s, subsidies were affecting the governmental budget in a substantially negative way and several reforms of liberalisation took place from 1985 to the early 1990s. In the 1990s, the self-sufficiency policy and price regulations were abolished (but with governmental subsidies to farmers kept on as compensation). This resulted in a relatively free market of agriculture within the country (SCB, 1999; Jordbruksverket, 2011b). International trade was, however, very limited (Jordbruksverket, 2011a).

The following major change for the agricultural sector took place 1 January 1995 at the time Sweden entered the EU. Overnight, Sweden opened up for competition within the union while unconditionally adapting to the EU's policies. The substantial break in agricultural policy compared to before the EU entry resulted in taking a step towards regulations and increased subsidies once again, while at the same time abandoning the protectionist policies. Ever since, Swedish farmers started competing with other farmers on the market within the EU due to the tariffs between Sweden and the EU member countries being removed. Simultaneously, tariffs on imports from countries outside the EU were imposed (Jordbruksverket, 2011a).

The agriculture policies within the EU invariably led to overproduction of food products. To stem this development, production quotas were implemented for various food products, including milk. This led to individual member nations being provided a quota which they could fill, but any food production above the quota was to be subject to a levy. By the end of March 2015, the milk quotas were removed (European Commission, 2015).

The development of agriculture in Sweden after entering the EU and adopting its policies has varied depending on the food group. Vegetable production has been declining mildly but steadily both before and after 1995. Production quantity of animal products, on the other hand, has been more volatile. The production has increased for some products, while production of milk and dairy products, together with beef and pork, has decreased (Jordbruksverket, 2011a).

3.3 Defining the product – what is milk and how is it produced?

In order to understand the milk market in Sweden, we briefly describe the production chain of milk from cow to store. Cows have an expected life span of more than 20 years (Dewey & Ng, 2016). The average life span of a Swedish dairy cow is five years. Thereafter, dairy cows become less productive and are subsequently euthanised (Ahlman, Berglund, Rydhmer & Strandberg, 2011). The milking of a productive dairy cow is performed 2–3 times per day (Arla, 2016d). The quantity and composition of the milk produced is highly affected by the cows' diet. On a natural grass-only diet, a cow produces 15 to 20 litres of milk per day (Nilsson, 2009). Modern dairy cows can produce approximately 50 litres of milk per day if fed a more energy and protein dense diet (Björklund, Holmgren & Johansson, 2008). A typical Swedish cow's diet consists of 40–70 % hay and silage (fermented hay) and the residual part consists of compound feed (cereal and protein blend) (Sundberg, 2010). The composition of the compound feed differs; a substantial part consists of soy because of soy's high content of protein and fat. Other crops such as wheat, oat and peas are also used (Sundberg, 2010; Nilsson, 2009). Most of the soy is imported from South America, primarily Brazil (Naturskyddsföreningen, 2009).

More than 10 % of the milk produced in Sweden is organic (Naturvårdsverket, 2016). Organic milk in Sweden is generally sold under the KRAV-label (Arla, 2016; Skånemejerier, 2016; Norrmejerier, 2016). The requirements for being sold as part of the KRAV-label includes the fact that the newborn calf cannot be removed from the cow prior to one day after birth and the fact that the calves must be fed fresh milk instead of milk from powder. Furthermore, half the amount of the cows' diet must originate from the same farm as where the cow is kept, and the feed cannot be cultivated with the help of pesticides. There are also stricter rules for giving medication and antibiotics (Arla, 2016d; KRAV, 2015).

When the milk is retrieved, it is controlled concerning nutrition and bacteria content and transported to the dairy where the processing is taking place. Processing includes separation, homogenisation, addition of vitamins and pasteurisation. After processing, the milk is packed into cartons and transported to the store. In order to stay fresh, milk must be kept cool. However, the pasteurisation of milk postpones the best before date to more than two weeks after production (Lindmark Månsson, 2016). Thereby, it is possible for milk to be transported long distances and across national borders.

3.4 Description of the milk market today

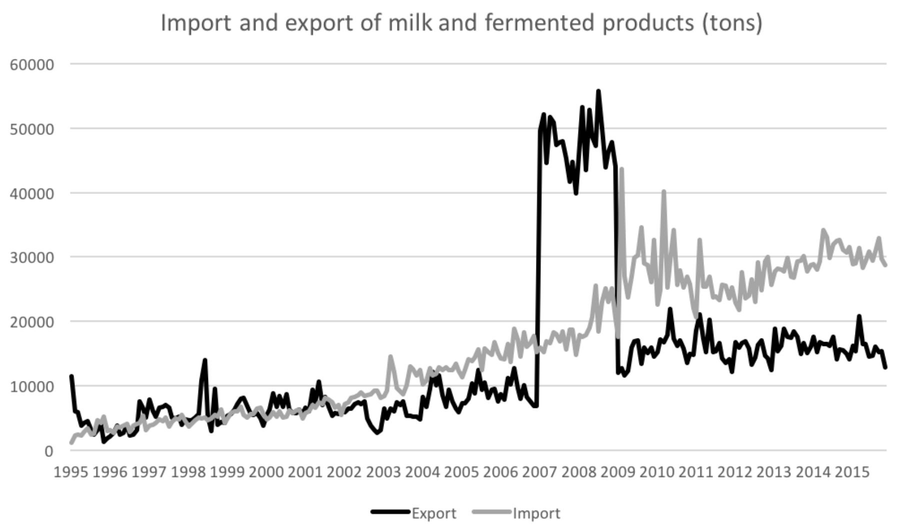

Figure 1: Volume of imported and exported milk and fermented products (yogurt, etc) per month in tons from the EU entry in 1995 to 2015. Source: Statistics Sweden

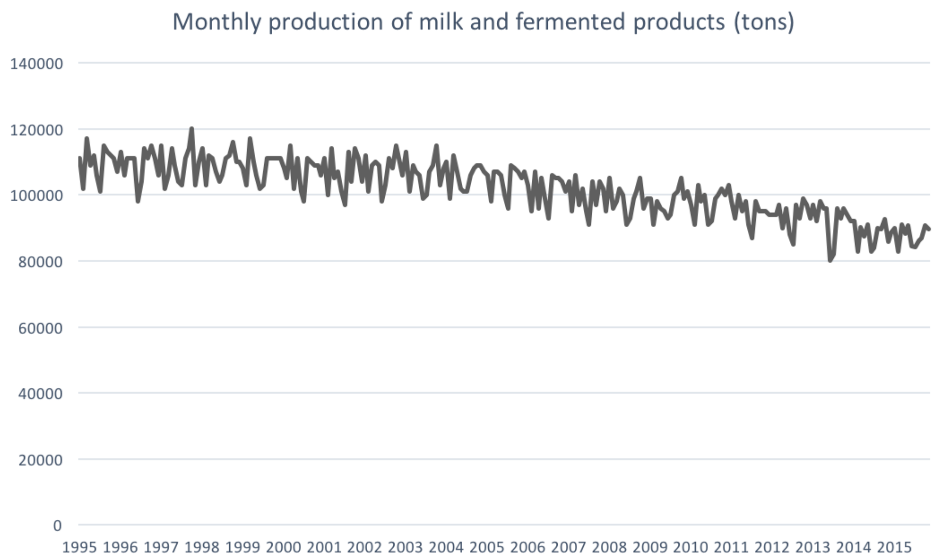

Figure 2: Volume of produced milk and fermented products (yogurt, etc) per month in tons from the EU entry in 1995 to 2015. Source: Statistics Sweden

Out of the total amount of milk produced in Sweden, about 30 % is intended for drinking (LRF Mjölk, 2016d). The remaining part is used to produce cream, milk powder, cheese, fermented products and other dairy products. Traditionally, the international trade with dairy products has been negligible. Since the EU entry, trade has increased substantially. An export peak is noted during the financial crisis in 2008 as shown in Figure 1.

In Sweden, the farms are most often owned by the farmers and as of December 2015, there are 4,117 farms registered as companies (LRF Mjölk, 2016d). The farms are connected to one of the cooperative dairy companies which handles the milk after being transported from the farm. The supply side market structure of dairies can be characterised as an oligopoly, with a few companies dominating the market. The production of the dairy companies Arla Foods, Skånemejerier, Norrmejerier, Falköpings Mejeri, Gefleortens Mejeriförening and Gäsene Mejeri answer for 98 % of all milk produced in Sweden (LRF Mjölk, 2016c). As of 2014, approximately 70 % of all milk produced in Sweden originated from an Arla Foods connected farm and approximately 15 % from a Skånemejerier connected farm (Jordbruksverket, 2016a; Arla, 2016a; Skånemejerier, 2015).

If solely looking at the amount of milk produced in Sweden, there has been no major break in the negative trend, as shown in Figure 2. Looking at prices, the consumer price of milk has developed similarly to the consumer price index (CPI) as well as to the consumer prices of agricultural products in total as shown in Figure 3. Despite this fact, the number of milk companies has decreased, as well as the number of dairy cows. From 2014 to 2015, the number of milk companies registered in Sweden decreased by 5.8 % and the number of dairy cows decreased by 3.9 % to 270,000 (LRF Mjölk, 2016b). In general, dairy production in Sweden is developing towards more large scale production.

Regarding demand and consumption, there has been a negative trend from the beginning of the 1980s and on, as shown in Figure 4. Since the EU entry, the total consumption of milk has declined by 1.4 % per year on average (Jordbruksverket, 2016a).

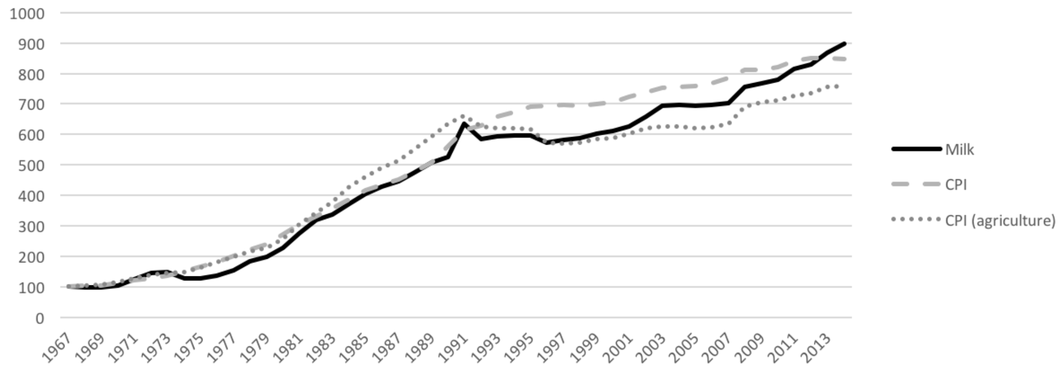

Figure 3: Price index for milk as well as CPI and CPI for agricultural products in Sweden with 1967 as base year. Source: Statistics Sweden and the Swedish Board of Agriculture

Figure 4: Yearly total consumption of milk in Sweden from 1950 to 2014 in million litres. Source: Statistics Sweden

4 Understanding the consumers' view on milk

In order to understand milk consumption and consumer behaviour in Sweden, knowing an average consumer's view on milk is of importance. The following is a revision of positive and negative effects and externalities associated with consuming milk which appear in the public debate, and thus have a reasonable chance to affect consumer preferences. The effects can be divided into either direct effects on the consumers' health or indirect effects in form of externalities affecting a third part (e.g. the environment). The externalities are presented and summarised below.

4.1 Milk and health

One of the most prominent arguments brought forward to promote milk consumption is the health aspects of milk. The following section is a non-exhaustive summary of the current research on the health aspects of milk.

The ability to consume dairy products with high lactose content in adulthood is to a great extent prevalent in many Western countries, including Sweden. However, about 14 % of the younger part of the population in Sweden is believed to be lactose intolerant, making a substantial and increasing part of the population unable to consume milk without suffering from adverse health effects (Almon, Engfeldt, Tysk, Sjöström & Nilsson, 2007).

The health effects of milk consumption have been widely studied. A British study following a cohort from the 1930s evaluated the effects of childhood milk consumption and found positive health effects later in life linked to milk consumption during childhood. While the authors note problems with attrition in their sample along with the difficulties of separating the effects of increased nutrition and socioeconomic background from the effects of consuming milk, this article provides support for the claims that milk consumption is associated with positive health effects (Birnie, K., Ben-Shlomo, Y., Gunnell, D., Ebrahim, S., Bayer, A., Gallacher, J., Holly, J.M.P. & Martin, R.M., 2012). However, there are also studies questioning the positive effects of milk consumption. An example of this is a widely disseminated Michaëlsson et al. (2014) cohort study with over 100,000 participants. This study indicated the linkage between high milk intake and an increased mortality for some cohorts and increased risk of hip fractures among women.

In our opinion, even with negative health aspects being brought forward, the general consumer is more likely to hold a positive view of the health effects of drinking milk.

4.2 Milk and environmental externalities

The environmental externalities of animal products have become an increasingly discussed topic, with livestock causing 18 % of global greenhouse gas (GHG) emissions, a share greater than that of the entire global transport sector. The emissions stem from the crops produced to feed the animals, but also the extensive emissions produced by the animals themselves and the necessary means to keep them alive (e.g. shelter). In addition to the GHG emissions, animal food production has been linked to eutrophication of farm lands and bodies of water (Steinfeld et al., 2006). However, the public debate has mostly ignored the environmental effects of dairy products to focus the critique on meat production.

The positive externalities often emphasised concerns animal food production supplying jobs to rural areas and in the process keeping the landscape open and free from forestry. The open landscapes provide increased biological diversity, since a myriad of insects and animals inhabit the open fields created by grazing animals (Svenskt Kött, 2016). Also, the open landscape is preferred by some people to the dense forestry that would otherwise cover much of the rural areas. Swedish law states that cows must be out to pasture during at least two months per year. However, this policy has frequently been questioned by farmers feeling they themselves should be able to decide how to breed their animals. This notion is supported by the Farmers' association, LRF (ATL, 2013). The value created by open landscapes is hard to quantify compared with the GHG emissions, but should still be included in an externality analysis as some consumers attribute great value to open landscapes in rural areas. However, it must be noted that Sweden imports roughly 385,000 tons of soy protein per year used for animal food production, and the fact that the restrictions on the amount of fodder needed to be grown on the own farm in organic farming is limited to a minimum of 50 %. This indicates that a substantial part of the livestock's food is comprised of imported soy, most of which originates in Brazil. The soy is in turn often grown on land on which rainforest was cut down to make room for agrarian production (SVT, 2010). This results in animal food products also contributing to open landscapes in other parts of the world, although this is most likely not the same open landscapes as the kind the consumers in Sweden value.

We believe most that Swedish consumers hold a positive view of the environmental aspects of milk, most likely due to the open landscapes and the fact that the negative environmental aspects are to a greater extent associated with meat production.

4.3 Animal welfare and milk production

Apart from environmental and health aspects, a topic frequently discussed regarding the milk debate is animal welfare. Plenty of research is found on the issue in other disciplines than economics. The following paragraph is an attempt to briefly describe how to assess the animal welfare aspect in economic terms. We argue that animal welfare externalities emerge when milk is produced due to the fact that consumers seem to care about animal welfare.

Mayfield, Bennett, Tranter and Wooldridge (2007) performed a study on Swedish consumer attitudes towards animal welfare. Regarding the question "How important in general is farm animal welfare to you?", 56 % answered "Very important" and 27 % answered "Important". Regarding the question "How often do you contemplate on farm animal welfare when purchasing meat?", 25 % provided the response "Always" and 28 % "Often". Regarding the question "I feel sufficiently well-informed concerning animal welfare", 45 % gave the answer "Disagreeing". Thus, it seems as though Swedish consumers in general value animal welfare when purchasing animal products, but do not find themselves very well informed. Hence, it seems likely that perceptions about how the animals are treated in the production would affect demand and consumer behaviour. Given that consumers care about animal well-being, the questions whether or not Swedish dairy cows are being treated well can be debated. If treated badly, milk production constitutes negative externalities for consumers, since they experience disutility relating to the fact that they do not want animals to be treated badly. If, on the other hand, dairy cows are not treated badly, milk production would instead perhaps produce positive externalities.

Proponents of Swedish animal food production often claim that Swedish animal welfare laws are among the strictest in the world (Centerpartiet, 2016). The average Swedish consumer is likely to be affected by these claims, with the effect that animal welfare is viewed as a positive externality, regardless of the reality. Sweden's animal welfare laws have been highly ranked by international comparisons, but are not considered the best (World Animal Proctection, 2016; Djurens rätt, 2009). In Sweden, the Swedish regulations ensuring the cows to be out on pasture are believed to be unique, even though Norway, Finland and Switzerland have similar legislation (Djurens rätt, 2009).

4.4 Summarising and weighting the effects and externalities

In summary, direct effects such as nutrition for the consumer and indirect effects such as effects on the environment and animal welfare can be linked to milk consumption. How consumers weigh these effects and externalities is decided by the individual. In our view, it is likely that the positive externalities outweigh the negative for the average consumer, even though the negative externalities have received more attention in recent years. These aspects and further reasoning of the consumers' view on milk will be addressed in the discussion part of the thesis.

5 Method

The method used to address the research question in this thesis is based on analysing consumer behaviour in form of price elasticities. Calculating the price elasticity of goods is a common application in microeconomic theory to observe in what way households and consumers adapt their consumption behaviour to price changes. This application is in general associated with a flaw; to perfectly calculate the price elasticity for a good in an economy, one would need a separate equation system for every household describing the preferences of that specific household. This would lead to a very large number of equations in order to describe demand in society at large. For reasons of keeping it simple, the estimations used in practice approximates the price elasticity of consumers by aggregating consumption over households in the economy, being able to use changes in per capita consumption and price changes to pin down the price elasticity in the economy. The approach utilises basic microeconomic theory of utility maximisation and cost minimisation to calculate the price elasticities. The fact remains that the estimated elasticities are approximations used to model reality. Luckily, there are a number of methods available that have been successful in modelling consumer behaviour and estimate elasticities. The method used in this thesis is one of the most prominent models used to approximate consumer behaviour: Deaton & Muellbauer's an Almost Ideal Demand System.

Following the estimation of the price elasticity for milk, the results will be used to attempt to answer the research question by testing for a structural break in connection with Sweden's EU entry 1 January 1995. In order to test for a structural break in the price elasticity of demand for milk, estimates of own-price elasticities, income elasticities and cross-price elasticities for milk for the different time periods before and after Sweden entered the EU will be calculated. Following this, a Chow test with a break point at the year of 1995 will be performed to detect if there is a structural break in the expenditure share residuals used to calculate the price elasticity.

5.1 Choosing how to model consumer demand

Several methods can be used in order to estimate price elasticities. Due to the complexity of describing consumer demand, the modelling has evolved from estimating simple demand equations towards using systems of equations. Two types of such models frequently used are the Rotterdam model and the Almost Ideal Demand System (AIDS). Out of these two models, the AIDS model has the advantage of imposing homogeneity and symmetry on the demand systems along with allowing for the Slutsky equation to be incorporated in the model. A crude description of the model would be by taking a basket of goods and plotting in what way the weights of the individual goods change over time when the relative prices of the goods in the basket change. The AIDS model was launched in 1980 by Angus Deaton, the Nobel laureate of 2015, together with John Muellbauer (Deaton & Muellbauer, 1980). AIDS has several advantages over other models by satisfying the axioms of choice, aggregating perfectly over consumers without invoking parallel Engel curves and is known to coincide with empirical household budget data (Taljaard, Alemu & van Schalkwyk, 2004).

After investigating which specification of the AIDS model to apply in our study, we chose to use the original version proposed by Deaton & Muellbauer in 1980. The difference between the original AIDS model and the linear version LA/AIDS (the most frequently used alternative) is the differing price indices applied in the models. As suggested by Deaton & Muellbauer, the linear approximation utilises a price index referred to as the Stone index. However, there has been a substantial amount of criticism regarding the usefulness of the Stone index since it invariably leads to prevailing unit roots in the estimation (Moschini, 1995). In practice, there are a multitude of specifications of the AIDS model (e.g. AIDS, LA/AIDS, Dynamic AIDS) being used to match different types of data. The reason behind our choice to apply the original AIDS model is the econometric simplification of estimating the output of the model. Furthermore, the original AIDS model provides a more plausible output in line with estimates produced in other studies. Choosing a different model specification would most likely produce slightly different results, but not change the outcomes at large.

The AIDS model functions by choosing a basket of goods and assuming weak separability of the goods in the basket. This means that the goods are assumed to be somewhat related in consumption, e.g. if the price of one good in the basket changes, it will affect the consumption of the other goods in the basket. In demand analysis, groups of goods where weak separability can be assumed is often used, such as food items. In our application of the AIDS model, we chose to use a basket of goods including milk, beef and potatoes. The reason for us choosing beef and potatoes is to fulfill the weak separability criteria. It is highly plausible that the consumption of potatoes and beef are affected by the milk price and vice versa, since the goods often are included in a typical Swede's diet. The three goods have also been consumed to a large extent in Sweden during the entire time period we are studying, in contrast to e.g. soy milk. Other goods could have been chosen, but because of the reasoning described above and data limitations, beef and potatoes were found to be the most appropriate. Adding more goods to the basket leads to more coefficients being estimated, which in turn requires more observations for the estimated coefficients to be significant. In our case, performing AIDS using four goods instead of three produced less significant coefficients as a result. This result is probably explained by a lack of data points. The share (or weight) of total expenditures that is spent on a specific good i is calculated and denoted w_i. The weights are used as the dependent variable in the estimations. The independent variables including nominal prices, total expenditure and a price index. Below follows the specification of the AIDS model.

5.2 The specification of an Almost Ideal Demand System

The AIDS model can be described as a seemingly unrelated regressions (SUR) model. This means that instead of only the coefficients of a single equation being estimated, the model is an equation system. The coefficients of the equation system are estimated under the assumption that although the equations can stand on their own, they seem to be related. In the case of the AIDS model, the equation system which constitutes the model can be expressed as follows:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln(p_j) + \beta_j \left(\ln x - \ln P\right) + \mu_i \tag{1}$$

$$\ln P = \alpha_0 + \sum_k \alpha_k \ln(p_k) + \frac{1}{2} \sum_k \sum_l \gamma^*_{kl} \ln p_k \ln p_l \tag{2}$$

$$\gamma_{ij} = \frac{1}{2}\left(\gamma^*_{ij} + \gamma^*_{ji}\right) = \gamma_{ji} \tag{3}$$

With the notations:

p_j: the price good j

P: the price index

w_i: the share of total expenditure spent on good i

x: the total expenditure spent on all goods in the basket

α: an intercept parameter

β: a parameter representing changes in real expenditure

γ: a parameter representing changes in the relative price

To satisfy the axioms of demand, the following restrictions are imposed:

The adding up constraints

$$\sum_j \alpha_i = 1 \tag{4}$$

$$\sum_i \beta_i = 0 \tag{5}$$

Homogeneity

$$\sum_{j=1} \gamma_{ij} = 0 \tag{6}$$

Symmetry

$$\gamma_{ij} = \gamma_{ji} \tag{7}$$

By imposing the restrictions and at the same time providing values for the expenditure share of every good in the chosen basket, the total expenditure and prices for all goods in the basket, the coefficients α_i, β_i and γ_{ij} can be estimated through solving the equation system consisting of eqs. (1) to (7). In order to avoid problems with collinearity, the value of α_0 is usually assigned beforehand. α_0 can be understood as the lowest possible total expenditure when prices are at the index's unity (Deaton & Muellbauer, 1980). For practical reasons, $\alpha_0 = 0$ is often used (Michalek & Keyzer, 1992).

When values for α_i, β_i and γ_{ij} have been estimated, the values can be used to compute different types of elasticities. Regarding price elasticities, two types are often computed: Marshallian (or uncompensated) elasticities, noted with a superscript M as $\varepsilon^M_{i,j}$, and Hicksian (or compensated) elasticities, noted with a superscript H as $\varepsilon^H_{i,j}$ (Säll & Gren, 2015). In the Marshallian elasticity estimate both the income and the substitution effects are included, while in the Hicksian elasticity the income effect is compensated for, leaving the estimate only representing the substitution effect. The focus in this thesis will be to report the estimated Marshallian price elasticities in order to provide a complete picture of the effects of price changes on milk consumption (including the income effect). Substituting the Marshallian elasticities for the Hicksian elasticities will not change the analysis in a significant way. These elasticities can be computed using the following formulas:

$$\varepsilon_{i,j}^{M} = \frac{\gamma_{i,j} - \beta_i w_j}{w_i} - \delta_{i,j} \tag{8}$$

$$\varepsilon_{i,j}^{H} = \frac{\gamma_{i,j}}{w_i} + w_j - \delta_{i,j} \tag{9}$$

where

$$\delta = 1 \text{ if } i = j \tag{10}$$

$$\delta = 0 \text{ if } i \neq j \tag{11}$$

That is, when calculating own-price elasticities, $i = j$, $\delta = 1$ is used and when calculating cross-price elasticities, $i \neq j$, $\delta = 0$ is used. The income elasticity, ε_i^I, for good i can be computed using the following formula:

$$\varepsilon_i^I = 1 + \frac{\beta_i}{w_i} \tag{12}$$

Further information regarding the statistical package used in Stata to perform the AIDS estimations can be found in the article by Poi et al. (2012).

5.3 Testing for structural change

After estimating the price elasticity for milk, we will proceed with testing for a structural break in the observed elasticities using the Chow test. A common application of the Chow test is testing for a structural break in a time series when the time of the break is known. This is done by calculating an F-statistic from the estimated results before and after the break point along with the entire time period, and further on testing the null hypothesis of no structural break against a critical value determined by the F-distribution and the level of significance. If the F-statistic should exceed the critical value, the null hypothesis of no structural break can be rejected at a certain significance level. Due to the nature of the Chow test, the two groups compared must be disjoint, i.e. they cannot include the same years. For this reason, the number of observations are few for the time period of 1995–2014 (20) when testing for a structural break in the year of 1995. Therefore, the results are interpreted with caution. The F-statistic is computed with the following formula:

$$F = \frac{(SSR_P - (SSR_1 + SSR_2))\,/k}{(SSR_1 + SSR_2)/(n_1 + n_2 - 2k)} \tag{13}$$

SSR_P is the sum of squared residuals from the weights predicted by AIDS for the entire time period (also referred as the pooled period). SSR_1 is the sum of squared residuals for the period before the breaking point. SSR_2 is the sum of squared residuals for the period after the breaking point. The number of observations is denoted by n and the number of parameters estimated is noted by k.

A problem with this approach is the fact that the structural break could have occurred both before and after the proposed break time. In order to test for the possibility of a structural break within a certain range, the Quandt likelihood ratio (QLR) test is often used. The basic approach is similar to the Chow test, but the QLR critical value follows a slightly different probability distribution. The test is performed by varying the time of break in the Chow test to be able to observe when the break is the most significant (Andrews, 1993). To be more precise, the QLR and Chow tests are used to test for parameter instability. Thus, it is not the stability of the elasticity estimate which is tested, but the stability of the parameters α_i, β_i and γ_{ij}. Since these parameters constitute the estimated elasticity, by extension a structural break in these parameters will indicate a structural break in the estimated elasticity. In practice, the end and start value of the test is often trimmed at 15 %, i.e. the test is performed within the central 70 % observations in the sample. However, the size of the sample used must always be taken into consideration when deciding how extensive the trimming should be. Due to data restrictions, there were not enough observations to perform a robust QLR test with sufficient amount of trimming. Thus, we will focus on testing for a structural break in 1995 by using the Chow test, with the addition of a modified version of the QLR test used as a sensitivity analysis.

6 Data

In order to conduct our elasticity study and test for a structural break, data from the Swedish Board of Agriculture is used. The data contains information on yearly per capita direct consumption of different food products in Sweden over time and is used as well as price indices for the foods (Jordbruksverket, 2016a). Using actual prices in the year of 2000, provided by the Swedish Board of Agriculture, the nominal prices (in SEK per kilogram of the good) are calculated for every year in the data set. A basket of basic goods including milk, beef and potatoes was chosen and used along with price and consumption data from 1967 to 2014 for the goods in the basket. Summary statistics for the data can be observed in Table 1. The development over time for this data can be seen in Figures 5 and 7.

Table 1: Summary statistics of milk, beef and potatoes sold in Sweden from 1967 to 2014. Quantities (Q) are in kilograms per capita per year and prices (P) are in SEK per kilogram. Source: The Swedish Board of Agriculture (Jordbruksverket, 2016a)

Variable	Obs	Mean	Std. Dev.	Min	Max
Milk P	48	4.898	2.628	1.024	9.389
Beef P	48	56.755	25.761	13.609	98.191
Potatoes P	48	5.72	3.349	.918	11.635
Milk Q	48	147.987	15.51	112.6	182.9
Beef Q	48	7.523	2.873	2.7	12.7
Potatoes Q	48	57.427	9.97	43.3	74.8

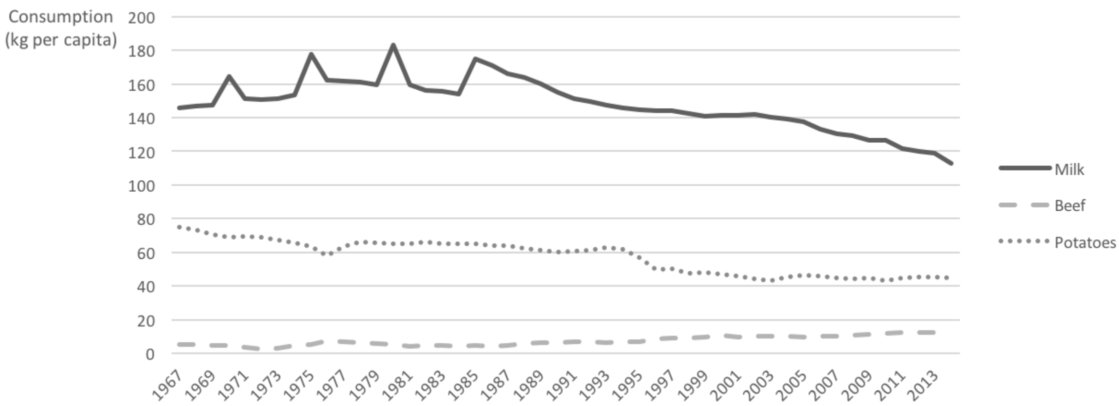

Figure 5: Direct consumption in kilograms per capita of milk, beef and potatoes in Sweden from 1967 to 2014. Source: The Swedish Board of Agriculture (Jordbruksverket, 2016a)

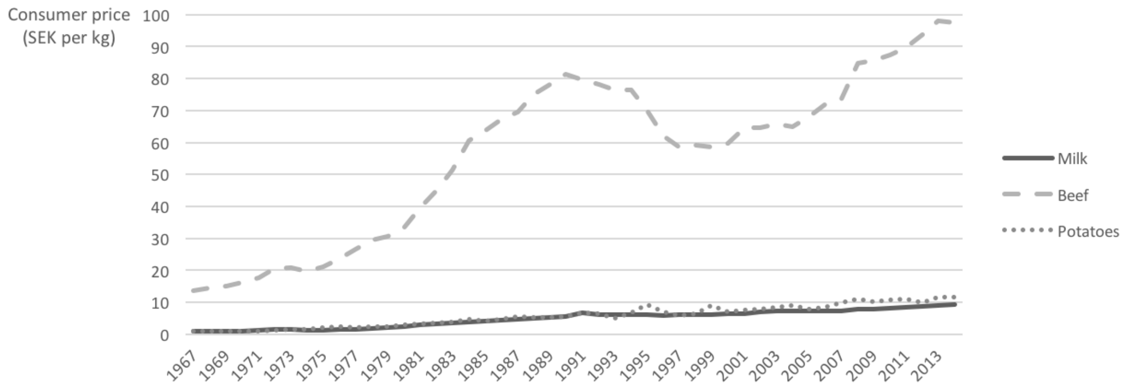

Figure 6: Average nominal consumer prices in SEK per kilogram of milk, beef and potatoes in Sweden from 1967 to 2014. Source: The Swedish Board of Agriculture (Jordbruksverket, 2016a)

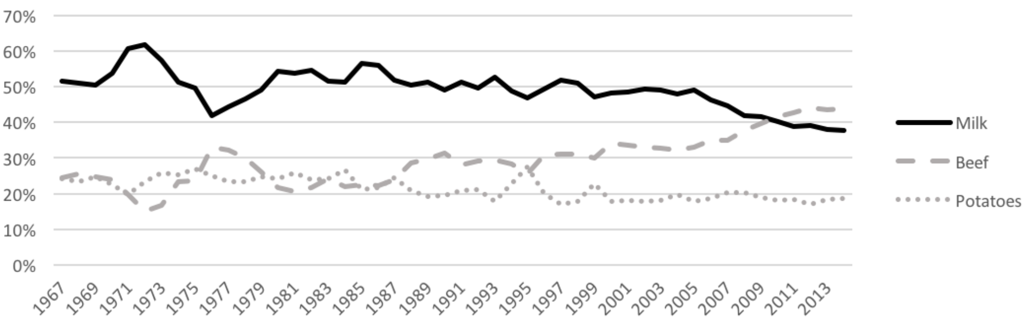

Figure 7: The expenditure of milk, beef and potato as percentage of total expenditure over time for the goods milk, beef and potatoes, calculated with help of the data in Table 1.

7 Results

The results of the AIDS estimations and the estimated elasticities are presented below.

7.1 Presenting the results

Table 2: AIDS performed on data from the Swedish Board of Agriculture on consumption volumes and prices of milk, beef and potatoes from 1967 to 2014 ($n = 48$). $\alpha_0 = 0$ was used in the estimation. $R^2_{milk} = 0.586$ (calculated for milk only, since this is the main point of interest).

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	.467851	.1946829	2.40	0.016	.0862795	.8494225
α_{beef}	.3023807	.6116281	0.49	0.621	-.8963884	1.50115
α_{potato}	.2297683	.4270163	0.54	0.591	-.6071684	1.066705
β_{milk}	-.1338465	.0750367	-1.78	0.074	-.2809158	.0132228
β_{beef}	.3619749	.0936421	3.87	0.000	.1784396	.5455101
β_{potato}	-.2281284	.0296538	-7.69	0.000	-.2862488	-.170008
$\gamma_{milk,milk}$	-.055061	.1870512	-0.29	0.768	-.4216746	.3115526
$\gamma_{beef,milk}$	.5041585	.3705607	1.36	0.174	-.2221271	1.230444
$\gamma_{potato,milk}$	-.4490975	.1851227	-2.43	0.015	-.8119313	-.0862637
$\gamma_{beef,beef}$	-1.321894	.6661299	-1.98	0.047	-2.627485	-.0163038
$\gamma_{potato,beef}$	.8177359	.3067748	2.67	0.008	.2164683	1.419003
$\gamma_{potato,potato}$	-.3686384	.1410601	-2.61	0.009	-.6451112	-.0921656

Table 3: AIDS performed on data from the Swedish Board of Agriculture on consumption volumes and prices of milk, beef and potatoes from 1967 to 1994 ($n = 28$). $\alpha_0 = 0$ was used in the estimation. $R^2_{milk} = 0.885$

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	-1.38154	.3667528	-3.77	0.000	-2.100362	-.6627178
α_{beef}	3.598384	.4783675	7.52	0.000	2.660801	4.535967
α_{potato}	-1.216844	.1742705	-6.98	0.000	-1.558408	-.8752798
β_{milk}	-.3753299	.0521784	-7.19	0.000	-.4775977	-.2730621
β_{beef}	.6837888	.0631293	10.83	0.000	.5600577	.8075199
β_{potato}	-.3084589	.0260687	-11.83	0.000	-.3595526	-.2573652
$\gamma_{milk,milk}$	-.7946874	.133222	-5.97	0.000	-1.055798	-.5335771
$\gamma_{beef,milk}$	1.627777	.1314024	12.39	0.000	1.370233	1.885321
$\gamma_{potato,milk}$	-.8330899	.0235913	-35.31	0.000	-.8793279	-.7868518
$\gamma_{beef,beef}$	-2.916447	.0814576	-35.80	0.000	-3.076101	-2.756793
$\gamma_{potato,beef}$	1.28867	.1068822	12.06	0.000	1.079185	1.498155
$\gamma_{potato,potato}$	-.45558	.0957703	-4.76	0.000	-.6432863	-.2678737

Table 4: AIDS performed on data from the Swedish Board of Agriculture on consumption volumes and prices of milk, beef and potatoes from 1995 to 2014 (n = 20). $\alpha_0 = 0$ was used in the estimation. $R^2_{milk} = 0.915$

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	-3.055055	.2445639	-12.49	0.000	-3.534391	-2.575718
α_{beef}	5.845056	.1785033	32.74	0.000	5.495196	6.194917
α_{potato}	-1.790002	.3638916	-4.92	0.000	-2.503216	-1.076788
β_{milk}	-.9546829	.2908014	-3.28	0.001	-1.524643	-.3847226
β_{beef}	1.384448	.4872227	2.84	0.004	.4295091	2.339387
β_{potato}	-.4297651	.2050659	-2.10	0.036	-.831687	-.0278432
$\gamma_{milk,milk}$	-1.52729	.5533595	-2.76	0.006	-2.611855	-.4427259
$\gamma_{beef,milk}$	2.578253	.6022799	4.28	0.000	1.397806	3.7587
$\gamma_{potato,milk}$	-1.050962	.0922816	-11.39	0.000	-1.231831	-.8700936
$\gamma_{beef,beef}$	-3.896118	.6288345	-6.20	0.000	-5.128611	-2.663625
$\gamma_{potato,beef}$	1.317865	.1562298	8.44	0.000	1.01166	1.62407
$\gamma_{potato,potato}$	-.2669031	.0951018	-2.81	0.005	-.4532992	-.080507

The results from using the AIDS model to estimate the price elasticities for the time period of 1967–2014 are shown in Tables 2, 5 and 8. Chavas and Segerson (1987) claim that heteroscedasticity always appears in allocation models such as AIDS. Therefore, robust standard errors have been used in the estimations. Testing for the validity of the results and its implications will be discussed further on. As seen in Table 2, all β coefficients (representing the change in real expenditure) are significant at a 10 % level and α_{milk} (the intercept parameter) is significant at a 5 % level. The γ coefficients (representing relative price changes) are not as significant for the time period of 1967–2014. The γ coefficients are significant at a 1 % level in our AIDS estimation for the periods 1967–1994 and 1995–2014 as shown in Tables 3 and 4. The α coefficients for potatoes and beef for the time period of 1967–2014 do not display the same high level of significance as α_{milk}. This will not be a problem in our study since the main objective is to test for a structural break in the parameters constituting the price elasticity for milk. Only the expenditure share residuals of milk are used in the Chow test for structural breaks.

Moving on to the estimated elasticities, the expenditure elasticity for milk is estimated to 0.728. This estimate is in line with previous research, as seen in Table 5. As comparison, Säll and Gren (2015) estimated the expenditure elasticity to 1.020. The reason for our estimates not being the same as Säll and Gren's is likely due to different time periods used (we use 1967–2014, while Säll and Gren use 1980–2012). Säll and Gren also included other goods than potatoes in the basked. Furthermore, Säll and Gren used two-staged AIDS along with different model specification, while we used a one-stage estimation.

Table 5: Expenditure elasticities for the entire period (1967–2014) calculated from the results in Table 2. Robust standard errors are reported in parenthesis.

	Milk	Beef	Potatoes
ε^I	.72754601	2.2304481	-.06325826
	(.15274261)	(.31831437)	(.13821018)

Table 6: Expenditure elasticities for the period 1967–1994 calculated from the results in Table 3.

	Milk	Beef	Potatoes
ε^I	.23598947	3.3243786	-.43766189
	(.10621283)	(.21459301)	(.1215007)

Table 7: Expenditure elasticities for the period 1995–2014 calculated from the results in Table 4.

	Milk	Beef	Potatoes
ε^I	-.94332457	5.7061042	-1.0030444
	(.5919469)	(1.6561985)	(.95576906)

Table 8: Price elasticities for the entire period (1967–2014) calculated from the results in Table 2.

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	-.29717595	.44516874	-.14799279
	(.04576794)	(.04893417)	(.02275748)
Beef	.7434091	-1.2464521	.50304295
	(.08263127)	(.10296113)	(.03455375)
Potatoes	-.33886554	.68974141	-.35087587
	(.05177643)	(.04860831)	(.04999177)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	-.65459218	.23113829	-.30409212
	(.09122299)	(.05719897)	(.04652138)
Beef	-.35232691	-1.9026083	.02448704
	(.18936633)	(.12023147)	(.08627239)
Potatoes	-.30778911	.70835081	-.33730343
	(.09736102)	(.04726899)	(.06100938)

Table 9: Price elasticities for the period 1967–1994 calculated from the results in Table 3.

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	-.5106522	.65424725	-.14359505
	(.10597663)	(.11958485)	(.03388498)
Beef	1.1089174	-1.6343809	.52546346
	(.20921532)	(.22674155)	(.07859297)
Potatoes	-.35122969	.74291609	-.3916864
	(.08226264)	(.10546294)	(.07398646)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	-.62658503	.58482356	-.194228
	(.08937132)	(.13954516)	(.03482836)
Beef	-.52422584	-2.612351	-.18780175
	(.16934856)	(.26938432)	(.0849629)
Potatoes	-.13622272	.87166804	-.29778344
	(.07845967)	(.12810478)	(.07107253)

Table 10: Price elasticities for the period 1995–2014 calculated from the results in Table 4.

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	1.8296466	-2.3817087	.55206211
	(.17297321)	(.25690189)	(.14219322)
Beef	-3.9361561	5.2398716	-1.3037155
	(.4083444)	(.79835613)	(.46852855)
Potatoes	1.2076406	-1.7311462	.52350554
	(.27267262)	(.58569967)	(.32548862)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	2.2930668	-2.1042003	.75445801
	(.40861829)	(.15671823)	(.25644922)
Beef	-6.7393524	3.5612423	-2.5279941
	(1.1390034)	(.44414382)	(.7970287)
Potatoes	1.700399	-1.4360692	.73871469
	(.71875093)	(.34808866)	(.52020236)

Regarding price elasticities, all own-price elasticities are negative (the expected sign) for the time period of 1967–2014, as seen in Table 8. The uncompensated own-price elasticity for milk is estimated to –0.65, an estimate in line with the expected sign and magnitude. The magnitude of some other estimates, such as beef, differs from previous elasticity estimates using Swedish data, e.g. the elasticity estimations of Säll and Gren. For further comparison, Edgerton et al. (1996) estimated the average expenditure elasticites for milk, cheese and eggs in Sweden to 0.5, and the uncompensated own-price elasticities for these foods to 0.0. The expenditure elasticities for meat and potatoes were 0.6 and –0.1, and the uncompensated own-price elasticities of these goods were –0.4 and 0.1. The expenditure elasticities for beef and potatoes estimated in our study deviate more from the result of previous studies compared to those for milk. This fact poses no hindrance concerning the upcoming tests since the aim being detecting a potential structural break in the price elasticity for milk. Reasons for these deviations could be differences in method (Edgerton et al. use the Dynamic AIDS model, or DAIDS), differences in price indices, different data sources or different time periods.

In an attempt to observe if the own-price elasticity for milk has changed over the years, the time period of 1967–2014 is split into two separate periods (1967–1994 and 1995–2014). The result is the estimated uncompensated own-price elasticity for milk equal to –0.63 for the time period of 1967–1994 and 2.29 for the time period of 1995–2014. The results can be seen in Tables 9 and 10. The estimated price elasticity for milk for the first time period is of expected sign and magnitude (–0.63), but the estimate of the second time period deviates from both the expected sign and magnitude by being substantially positive (2.29). This result contradicts the hypothesis by indicating the reduced price elasticity of demand for milk for consumers. This result will be addressed further on in the thesis.

In summary, the estimations of the different kinds of elasticities for the period 1967–2014 are in large measures plausible with some exceptions. The main focus of interest is the results regarding a possible structural break in the price elasticity for milk and will be presented in the following paragraphs.

In order to determine whether or not there has been a significant structural break regarding the elasticity for milk, a Chow test was performed. Despite the relatively few observations in the time period of 1995–2014, significant estimates were observed, as seen in Tables 3 and 4. The predicted residuals from these tests can be used to perform the Chow test.

When performing AIDS on the period 1967–2014 ($n = 48$) the sum of squared residuals for milk is calculated as $SSR_p = 0.058$. For the period 1967–1994 ($n = 28$),

$SSR_1 = 0.016$ and for 1995–2014 ($n = 28$) $SSR_2 = 0.012$. Thus, the Chow statistic can be computed through

$$\frac{(SSR_P - (SSR_1 + SSR_2))/(k)}{(SSR_1 + SSR_2)/(n_1 + n_2 - 2k)} \approx \frac{(0.058 - (0.016 + 0.012))/5}{(0.016 + 0.012)/(28 + 20 - 2 \cdot 5)} \approx 8.108 \qquad (14)$$

with $k = 5$ since five parameters are estimated for milk (α_{milk}, β_{milk}, $\gamma_{milk,milk}$, $\gamma_{milk,beef}$ and $\gamma_{milk,potato}$) and the intercept α_0 is set to 0 beforehand.

The test statistic follows the F-distribution with k and n_1+n_2-2k degrees of freedom, where critical value at a 1 % significance level is 3.54. Thus, the null hypothesis of no structural break at the year of 1995 can be rejected at every relevant significance level.

Moving on to the adapted QLR test, the results of the Chow tests for breaking points ±2 years of our suspected break at the year of 1995 can be seen in Table 11. When comparing the statistics with the critical value in a QLR test, the critical value depends on the trimming. Since only 5 break points in a time period of 48 years were calculated, the same type of trimming as an in an ordinary QLR test is not used. Therefore, the calculated test statistics were compared to the most restrictive critical value of the QLR distribution at a 1 % level (4.77) (Andrews, 2003). As seen in Table 11, the test statistics are greater than 4.77 for 1995, 1996 and 1997, indicating structural breaks at a 1 % level regardless of trimming. The QLR test statistic is the highest of the F-statistics in the interval, in our case the QLR test statistic of 1997. The test statistic value of 11.225 is well over 4.77, hence the null hypothesis of no structural break is rejected at a 1 % level. Due to the errors prevailing when performing AIDS on the previously mentioned periods, we choose to rely on the observed break at 1995 with more significant parameters. The outputs from performing AIDS on the remaining periods can be seen in Appendix A. While the estimates produced by the second time period (1995–2014) deviates from the expected sign and magnitude, the parameters used to calculate the elasticities are mostly significant. The fact that the elasticity estimate deviates from the expected value could be seen as further indication of a structural break taking place. However, the results of our test should be interpreted cautiously. The validity of the results will be discussed more extensively in the following subsection and in the discussion part of the thesis.

In summary, the tests indicate a structural break in the price elasticity for milk around the year of 1995. Whether the break took place exactly in year 1995 or some years later would be suited for further studies in future research. Additional testing requires better data on milk consumption and prices in Sweden and possibly better model specification.

Table 11: The results from Chow tests for breaking points ±2 years of the hypothesised break in 1995 (an adapted QLR test). When calculating the test statistics, $k = 5$, $n_1 + n_2 = 48$ and $SSR_p = 0.058$ were used.

Periods	SSR_1	SSR_2	Statistic	Comment
1967–1992, 1993–2014	0.015	0.023	3.763	The estimated coefficients for 1993–2014 were not significant at a reasonable level, but the uncompensated own-price elasticity for milk was plausible with an estimated magnitude close to zero.
1967–1993, 1994–2014	0.016	0.022	3.857	The estimated coefficients for 1994–2014 were not significant at a reasonable level, and the uncompensated own-price elasticity for milk was substantially positive, hence not in line with previous research.
1967–1994, 1995–2014	0.016	0.012	8.108	The baseline Chow test. For 1967–1994, all estimated coefficients were significant at a 1 % level, and the estimated elasticity was of the expected sign and magnitude. For 1995–2014, all estimated coefficients were significant at a 5 % level, but the uncompensated own-price elasticity for milk displayed an unexpected sign and magnitude (2.293).
1967–1995, 1996–2014	0.017	0.008	9.709	For the period 1996–2014, all estimated coefficients were significant at a 5 % level, but the estimated own-price elasticity for milk was not in line with previous research (1.990)
1967–1996, 1997–2014	0.018	0.006	11.225	Every coefficient except α_{milk} and $\gamma_{potato,potato}$ were significant at a 5 % level. The uncompensated own-price elasticity for milk 1997–2014 was not of the expected sign or magnitude (1.855).

7.2 Testing the validity of the results

In order to validate the results, various robustness tests of the statistical properties of the data have been performed. Due to the price elasticity for milk being the main focus of this thesis, the testing is limited to milk expenditure share residuals and the variables affecting the milk elasticities.

As previously noted, Chavas and Segerson (1987) claim that heteroscedasticity always is present in allocation models such as AIDS. Heteroscedasticity appears when the residuals are correlated with the independent variables in the model. In some cases, this can cause the estimated standard errors to be underestimated, indicating a higher level significance than the actual results. Since some degree of heteroscedasticity always appears in allocation models, this problem has been taken into account by using robust standard errors for the parameters that constitute the estimated elasticity. The high level of significance observed while using robust standard errors indicates that any heteroscedasticity did not bias the standard errors in a way that changes the significance of the parameters.

When working with time series data, there is always a risk of problems with residuals being correlated over time (autocorrelation). A positive correlation of the residuals over time can cause the standard errors to be underestimated, leading to an inaccurately high level of significance observed. To remedy this, a Durbin-Watson test is performed to test for autocorrelation of the expenditure share residuals for milk from the AIDS estimations. The test statistic for the Durbin-Watson test is calculated

$$d = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2} \tag{15}$$

with e_t being the residual for milk from the AIDS estimation at time t. The result of the performed Durbin-Watson test is a test statistic of $d = 0.454$ for the time period of 1967–2014, indicating that the null hypothesis of no autocorrelation in the residuals cannot be rejected at any relevant significance level. This result also indicates a positive autocorrelation of the residuals and thereby increases the likelihood of problems associated with residuals being correlated over time. This result reduces the strength of the statistical inference of the performed tests by indicating that any F-tests performed will display an inflated F-statistic. This is due to the fact that if the Durbin-Watson test produces a test statistic with a value below 1, it is likely that the residuals are positively correlated over time, which in turn could cause the true standard errors to be underestimated. When performing the Durbin-Watson test on the residuals of the AIDS estimation for the time period of 1967–1994, the test statistic is calculated as 1.493, which indicates that there is no no cause for alarm regarding autocorrelation for this time period. Performing the Durbin-Watson test for the time period of 1995–2014, the test statistic is equal to 0.642, which indicates the likelihood of positive autocorrelation of the residuals. In summary, two of the three time periods tested (the full length time period of 1967–2014 and the subperiod of 1995–2014) are likely to have positive serial correlation in the data. Thus, the estimations and tests could indicate a too high level of significance for the estimated parameters and structural breaks. The solution to the problem could be to re-specify the model or include a time lag variable to account for any non-stationary trend in the data (Ng, 1997). However, we argue that the increase in F-statistic from the insignificant 3.857 (with the break point in 1994) to the highly significant 8.108 (with the break point in 1995) is enough to indicate the presence of a structural break. This topic will be further discussed in the following section of the thesis.

Table 12: Dickey-Fuller test for the variables included in the AIDS model specification in equation (1). The 1 % critical value is –3.600, the 5 % critical value is –2.938 and the 10 % critical value is –2.604.

Variable	Statistic
Expenditure share milk	-1.194
Expenditure share beef	-0.644
Expenditure share potatoes	-3.138
log Milk P	-1.993
log Beef P	-2.920
log Potato P	-1.647
log Total expenditure	-2.441

The presence of a prevailing unit root in time series analysis could potentially lead to spurious results when variation is explained by a non-stationary process. In order to test for stationarity in the time series sample, an augmented Dickey-Fuller test is performed, as seen in Table 12. The results of the test indicate that the presence of a unit root cannot be rejected for the tested variables at a reasonable significance level, except for the log form of beef prices at a 10 % level and the expenditure share of potatoes at a 5 % level. The inability to reject a prevailing unit root most likely stems from the the relatively few number of observations in our estimations compared to time series analysis in general or possibly the model specification. Earlier studies, such as Edgerton et al. (1996), have also experienced prevailing unit roots in their time series sample. Since earlier studies in general do not take measures to remedy this problem, we choose to note the existence of prevailing unit roots in our time series sample (with decreased statistical inference as a result) and note that this problem possibly could be remedied by altering the model specification or increasing the number of observations.

8 Discussion

8.1 Discussion of the results

As shown, the results of estimating the price elasticity for milk for the entire period of 1967–2014 yields an estimated uncompensated elasticity of –0.65. This result is of the expected sign and magnitude and in line with previous research. Although, it must be noted that two of the five parameters for the 1967–2014 time period fail to live up to a reasonable significance level. A possible solution to this problem could be to use a slightly different version of the AIDS model and incorporate a quadratic term into the model, as suggested by Stata economists Poi et al. (2012). To detect any differences in the produced elasticities, the uncompensated price elasticity for milk was again estimated for the time period 1967–2014, but this time with the quadratic term coefficient λ incorporated, as shown in Appendix B. This model specification is also known as QUAIDS. The produced estimate using QUAIDS differed slightly from the estimate produced with the original AIDS model. To be more precise the estimate decreases by 12 % (from –0.65 to –0.73) when using the QUAIDS model compared to the original AIDS model. The parameters of milk, when using the QUAIDS model, were significant on a 1 % level, except λ_{milk} which was significant on a 5 % level. This result indicates the relative robustness of the original AIDS estimate. However, the statistical inference problem of underestimated standard errors caused by the most likely autocorrelated expenditure share residuals should prompt some scepticism to whether or not the estimates actually are significant on this high level.

When the entire period is split in two (1967–1994 and 1995–2014) in order to perform the Chow test and QLR test, every parameter is noted as significant on a 1 % level for both subperiods. The uncompensated milk price elasticity estimate produced for the time period 1967–1994 is of the expected sign and similar magnitude to the entire time period. For the period of 1995–2014 the uncompensated elasticity for milk produced is equal to 2.29. The magnitude and sign of this estimate differs from what can be expected given previous research by being substantially positive. By removing the years following 2008, the estimate produced for the time period of 1995–2008 is –0.18, in line with the expected value of around -1 to 0. These results give merit to the idea that elasticities are unlikely to remain constant over long periods of time. In this case, the price elasticity of milk appears to have become substantially more inelastic over time for the estimations including the years up to 2008. When including the time period of 2009–2014, the results indicate that milk has become a Giffen good over time, which is not likely to be true. However, we argue that removing observations for such a long time period (2009–2014) would be to trim reality to fit our needs. The differing estimate of 2.29 could also be a symptom of the hypothesised structural break in 1995. Removing these observations would thereby be equal to removing part of the variation we set out to detect. For these reasons, we chose to keep the data points following 2008 in the tests for a structural break in 1995, and thereby use the full length of the two subperiods.

The result of the Chow test indicates a structural break in 1995 of the expenditure share residuals. The result is significant at a 1 % level. However, the result must be viewed with some caution, as the likelihood of positive autocorrelation in parts of the data tends to inflate the test statistic of F-tests. It is possible that the actual level of significance is lower. Given the high level of significance observed for the year of 1995, the result of the Chow test should, in our view, be seen as an indication of a structural break. For this reason, the QLR test with moving break points has been used to test if the break could have occurred during an adjacent year instead. The result shows no significant structural breaks in 1993 and 1994 when using the most restrictive critical value (test statistic of about 3.8 for both years), and significant structural breaks occurring at 1995, 1996 and 1997 (test statistic of 8 or higher for all three years), with the most significant structural break occurring in 1997. According to our view, this result gives merit to the hypothesis of a structural break in 1995 since no break can be observed in 1994 or 1993. Also, the fact remains that the test statistic of the QLR test increases by roughly 110 % from 1994 to 1995 with both time periods being inflated by the positive autocorrelation. The significant breaks in 1996 and 1997 could be explained by the break occurring during multiple years, instead of being instantaneous. This is also reasonable due to consumer demand being subject to the hysteresis associated with consumer habits being slow to alter. The structural break could thereby have occurred, and then increased in strength when the consumer habits changed over the adjacent years.

The result of the elasticity estimations along with the statistically significant structural break at 1995 give merit to the idea that consumer preferences regarding milk have shifted during the time period of Sweden entering the EU. However, the question regarding causality of the EU entry associated with this structural break remains to be discussed. Since elasticities depend on a number of factors which combined lead to different consumer preferences, there are various factors which potentially could have caused the structural break in the price elasticity for milk. Other exogenous events or endogenous changes in consumer preferences could be a possible cause of the structural break. In the end, this method cannot prove the hypothesised causality, but could give an indication if the hypothesis is reasonable. In our view, the qualitative arguments combined with the Chow test and QLR test provide a clear indication of a structural break. Thereby the case of changing price elasticities caused by the EU entry can be made.

Another implication of the results is that of model specification for demand systems. Given that a structural break takes place after opening up a closed market, the short run effects of such a structural break must be taken into account in the model if the long run trend is what is sought to estimate. Furthermore, since elasticity estimates often are used to predict the effect of consumption taxes or environmental taxes, the structural breaks should be accounted for in the model to produce a more accurate prediction. In our case, it is hard to determine whether the break remains in future time periods since more data points from the period after 1997 are required to extend the QLR test further. How to model in order to account for shocks related to trade liberalisation should be subject to further studies. In comparison, Isengildina-Massa, MacDonald et al. (2009) studied the aspect of structural change linked to trade liberalisation in modelling cotton prices in the US. A similar approach as the one used in their study may be suitable for demand systems.

8.2 Discussion of the qualitative aspects

This thesis is based on the marketing activity observed by the authors at a local supermarket in Stockholm, 2015. The information screens close to the register counters, which usually display what goods are on sale during the week, displayed roughly the following message:

Due to the strained situation of the dairy farmers', the price of milk is increased by 1 SEK for a period of six months on a voluntary basis. The increased sales proceeds will be donated directly to the dairy farmers as extra compensation.

We later learned that this campaign generated about 113 mn. SEK as extra compensation for the farmers (ICA, 2016). This economic behaviour was not coherent with our view of how consumers are expected behave. The usage of a price increase to advertise a staple good should, in our view, be met with scepticism and complaints. If milk had been replaced by another product in a similar campaign, this campaign would likely have been met with scepticism.

The question that arose was the following: how would this status be reflected in economic terms? We believed that this was most likely to translate into a low price elasticity of demand for milk, meaning that consumers are not as price sensitive to changes in milk compared with other goods. This hypothesis was confirmed by the estimated uncompensated price elasticity of –0.65 for milk which was attained using the AIDS model for the time period of 1967–2014.

Why is the price elasticity for milk inelastic? While the demand of food products in general appears to be inelastic (Säll & Gren, 2015), it is likely that milk has added values that contribute to the low price elasticity. The message of positive health effects associated with milk consumption along with the open landscape externality and a high level of animal welfare in production is in our view the three main factors behind this added value. In a more tentative reasoning, it could also be the case that people view farmers as a wronged group of entrepreneurial workers receiving little pay for their hard work. The further question that arises is if the price elasticity for milk has changed over the years. Will milk retain its position as a unique food product? It is plausible that the elasticity could have changed over time, given that there has been substantial change in agricultural policy, the supply line of milk, the way people consume milk and the number of substitutes. By performing AIDS estimations during two time periods (1967–1994 and 1995–2014) the results confirmed that the demand for milk was more inelastic during the second time period, indicating a change in the elasticity over time.

However, this approach does not indicate if and when there has been a significant structural break in the estimated elasticity. Prior to investigating this further, we believed that Sweden's entry into the EU, with substantial change in agriculture policy and internationalisation of consumer behaviour as consequence, was a likely time period for a structural break in the estimated elasticity. After testing for a structural break using the Chow test and QLR test, such a break was observed in 1995, 1996 and 1997. The most significant break in residuals of the model was found in 1997, two years after the EU entry. The increased liberalisation of the milk market when opening up for competition within the EU was hypothesised to have spurred increasing competition, as indicated by a larger variety of products and substitutes, and this led to a higher price sensitivity of milk consumers. The increased variety in the assortment of milk products at present, compared to in the 1980s, speak in favour of this view. Linking back to the initial quote in this thesis by John Wayne that urges one to simply drink their milk, we note that this command has become increasingly hard to follow without further instruction. Which kind of milk should one choose? Skimmed milk? Lactose-free milk? Oat milk?

In addition to the increased number of substitutes, the EU entry should in our view cause Swedish consumers to adapt to consumption habits to become more similar to consumers in continental Europe. The freedom of movement associated with the Schengen Agreement has caused more migration and guest workers to stay in Sweden. The increased immigration in turn may have a direct impact on consumer preferences in Sweden by demanding goods related to their own food culture, and indirectly by inspiring other consumers to try new food habits. Moreover, the simplification for companies to act across national boarders may have made the number of different food products available more diverse. The integrated European market enables smaller players to compete on the Swedish market. Notable examples being the Belgian producer of soy milk, Alpro, and the Swedish producer of oat milk, Oatly. Looking closely at Oatly's production line, it must be noted that while the lion share of their ingredients are produced in southern Sweden, for cost reasons the products are packaged in Germany (Oatly, 2016). The launching and success of the new substitutes is likely to have benefited from the increased mobility within the EU and the internationalisation of consumer food preferences. This, in turn, was hypothesised to spill over on the demand side and decrease the importance of milk in consumption. However, it appears to be the case that the importance of milk in consumption remains strong without showing signs of deteriorating. Contrary to the hypothesis, the result of the elasticity estimations indicates a reduced price sensitivity over time of milk consumers in Sweden.

In order to try to explain why the structural break occurred, but not in the expected direction, Lennart Schön's quote about elasticities being determined by the good's importance in consumption and the substitutes is yet again to be used. The number of milk substitutes, such as soy milk and oat milk, have increased after the EU entry (Nielsen, 2014). This should make consumers more sensitive to changes in the price of milk, as there are a number of available substitutes. However, many of these substitutes have very modest consumption rates and have become important in consumption only recently. Oatly, the oat milk producer, became a well-known brand after having been accused of false advertising by the Swedish milk lobby in 2014 (Aftonbladet, 2014). The substitutes could thereby not have has much impact on consumer preferences. Given that the importance of the substitutes has increased only in recent years, the substitutes could not have affected the price elasticity to a wider extent as of yet. In the long run, the increased importance of the substitutes could cause milk to become more like any other food product.

If the milk substitutes have remained negligible for most of the observed time period, the importance of milk in consumption is the factor that must have changed to affect the price elasticity. In order to explain the reduced price elasticity, the importance of milk must have increased in general. As previously noted, even with reports of negative health effects and environmental externalities associated with milk consumption, consumers are more likely to have their view affected by the substantial amount of positive advertisements of the milk industry than by scientific reports. Websites such as www.mjolk.se and advertisement slogans (e.g. “Milk – Nature’s sports drink”) are examples of the advertisement used by the milk industry. Furthermore, the inflow of immigration and new food trends may have caused a polarisation effect where some traditional food products such as milk increase in importance. While for example Thai food or tacos are by some considered the new unofficial national dishes of Sweden, Swedish consumers continue to drink milk for cultural reasons and could therefore to a greater extent than before be ignoring the price. In other terms milk could have become more of an essential good.

An increased prevalence of lactose intolerance and new consumer habits accentuated by the EU entry may also have contributed to dividing the population into two groups, the first group being an increasing share of the population with no habit of consuming milk (or people who cannot consume milk), and the second being people who for cultural reasons regard milk as an essential good no matter the price. The EU entry could have polarised this selection in the population by influencing alternative food habits for the people with little interest of consuming milk, making them even less likely to consume milk. Thus, leaving people who regard milk as an essential good to constitute a greater part of the milk consumers. This could also help explain why milk consumption per capita is decreasing along with the price sensitivity of milk consumers. Given the added values of milk production in combination with the milk consumers being less price sensitive than before, the relative success of campaigns that promote paying extra for milk would not be incoherent with rational economic behaviour.

The Swedish milk cooperatives have without exceptions maintained their dominant position on the milk market, and apart from a brief time period when milk produced in Germany was sold at Lidl stores, foreign milk as a beverage has been hard to find in Sweden. The foreign brands have for some reason not been able to establish themselves on the Swedish milk market (although Arla is Swedish/Danish in origin) despite in general having lower production costs. This compares with the averaged 42 % of cheese and fermented dairy products consumed in Sweden being produced in other countries (LRF Mjölk, 2016a). The high average of foreign production mainly applies to other dairy products such as cheese or yogurt, while milk imports have decreased during recent years (Jordbruksverket, 2016). The demand for milk seems to be inherently different from that of other dairy products. The main difference appears to be that there is less of a problem for other dairy products when the origin is not Swedish. An example of this is the aforementioned example when the retailer Lidl commenced selling German milk on the Swedish market. The result was an outrage among consumers resulting in Lidl removing the German milk brand from their stores. The same response could not be observed from Swedish consumers regarding the German cheese or yogurt sold at the same Lidl stores (Forskning & Framsteg, 2006). The differing responses from the consumers may be due to the cultural aspects of milk being more tangible for milk (the good is also the product) compared with cheese or fermented products (where milk is the main ingredient of the product and not directly visible).

To summarise, we note that contrary to our hypothesis the effects of opening up the milk market appear to have made the demand for milk in Sweden more inelastic. The result of a more inelastic demand indicates that the price elasticity of demand for milk in Sweden is unlikely to remain constant over time. The change in elasticity may stem from cultural reasons and market factors.

9 Concluding the thesis

The demand for Swedish milk is shown to be inelastic to price changes, as indicated by the uncompensated price elasticity for milk of –0.65 for the time period of 1967–2014. By testing for a structural break in the price elasticity for milk in the year of 1995, an indication of a structural break occurring around that year was found. While we hypothesised an increased price elasticity of demand for milk, the results indicated the opposite occurring. In our view, the structural break in the price elasticity for milk and the increasingly inelastic demand for milk is due to Sweden's entry into the EU and the subsequent increased importance of milk in consumption for the milk consumers. The EU entry may have caused a stricter selection of the population to occur by dividing the population into one growing part of the population not consuming milk for health reasons or cultural reasons, and another part of the population which consumes milk regardless of the price due to habits or cultural reasons. Following this reasoning, the price elasticity for milk would decrease over time. Opening up a market appears to cause a structural break in the price elasticity for goods of cultural importance, but it is unclear whether or not this claim holds for other goods than milk in Sweden. Even if our tests indicate that a structural break has occurred around the year of 1995, the causal relationship between the EU entry and the structural break in the price elasticity of demand for milk is yet to be determined. What we can say for certain is that the price elasticity of demand for goods such as milk is unlikely to remain constant over time.

An interesting topic for further studies would be to ascertain whether or not similar effects are observed in other countries which have opened up their markets. A logical step would be to look for more fine-grained data to improve the testing. Further contributions could be to test for structural change in other food products or for structural change in the demand for milk in countries with similar experiences and background as Sweden. It is clear that additional studies are needed to evaluate the effect of consumer behaviour after opening up a market.

References

Aftonbladet. (2014). *Fullt krig i mjölkhyllan.* http://www.aftonbladet.se/nyheter/article19747030.ab (Accessed: 9 May 2016).

Ahlman, T., Berglund, B., Rydhmer, L. & Strandberg, E. (2011). Culling reasons in organic and conventional dairy herds and genotype by environment interaction for longevity. *Journal of Dairy Science*, *94*(3), 1568–1575.

Almon, R., Engfeldt, P., Tysk, C., Sjöström, M. & Nilsson, T. K. (2007). Prevalence and trends in adult-type hypolactasia in different age cohorts in Central Sweden diagnosed by genotyping for the adult-type hypolactasia-linked LCT–13910C> T mutation. *Scandinavian Journal of Gastroenterology*, *42*(2), 165–170.

Andrews, D. W. K. (1993). Tests for parameter instability and structural change with unknown change point. *Econometrica*, *61*(4), 821–856.

Andrews, D. W. K. (2003). Tests for parameter instability and structural change with unknown change point: A corrigendum. *Econometrica*, *71*(1), 395–397.

Arla. (2016). *Ekologiska produkter.* http://www.arla.se/vara-produkter/ekologiskt/ (Accessed: 19 April 2016).

Arla. (2016a). *Fakta om Arla.* http://www.arla.se/om-arla/fakta/ (Accessed: 23 March 2016).

Arla. (2016b). *Mejerinäringens rationalisering.* http://www.arla.se/om-arla/arlas-historia/foretaget/mejerinaringens-rationalisering/ (Accessed: 28 February 2016).

Arla. (2016c). *Mjölkpropaganda genom tiden.* http://www.arla.se/om-arla/arlas-historia/mjolken-i-samhallet/propaganda-och-reklam/ (Accessed: 28 February 2016).

Arla. (2016d). *Vanliga frågor till Arlabonden.* http://www.arla.se/om-arla/kontakta-oss/vanliga-fragor--svar/vanliga-fragor-till-arlabonden/ (Accessed: 14 March 2016).

ATL. (2013). *Mjölkbönder vill ta ansvar för betet.* http://www.atl.nu/lantbruk/mj-lkb-nder-vill-ta-ansvar-f-r-betet (Accessed: 18 April 2016).

Birnie, K., Ben-Shlomo, Y., Gunnell, D., Ebrahim, S., Bayer, A., Gallacher, J., Holly, J.M.P. & Martin, R.M. (2012). Childhood milk consumption is associated with better physical performance in old age. *Age and Ageing*, *41*(6), 776–784.

Björklund, J., Holmgren, P. & Johansson, S. (2008). *Mat & klimat.* Värnamo: Medströms Bokförlag.

Centerpartiet. (2016). *Mjölklöftet.* https://www.centerpartiet.se/2015/01/22/

mjolkloftet-ge-svenska-bonder-en-extra-krona/ (Accessed: 29 February 2016).

Centerpartiet. (2016). *Världens bästa djurskydd.* https://www.centerpartiet.se/hallbarmat/djurskydd/ (Accessed: 18 April 2016).

Chavas, J.-P. & Segerson, K. (1987). Stochastic specification and estimation of share equation systems. *Journal of Econometrics*, *35*(2), 337–358.

Deaton, A. & Muellbauer, J. (1980). An almost ideal demand system. *American Economic Review*, *70*(3), 312-326.

Dewey, T. & Ng, J. (2016). *Adw: Bos taurus: Information.* http://animaldiversity.org/site/accounts/information/Bos_taurus.html (Accessed: 12 March 2016).

Djurens rätt. (2009). *Världens bästa djurskydd.* http://www.djurensratt.se/sites/default/files/varldens_basta_djurskydd.pdf (Accessed: 28 March 2016).

DN. (2014). *Mjölk kan korta livet.* http://www.dn.se/nyheter/vetenskap/mjolk-kan-korta-livet/ (Accessed: 29 March 2016).

Edgerton, D. L., Assarsson, B., Hummelmose, A., Laurila, I. P., Rickertsen, K. & Vale, P. H. (1996). *The econometrics of demand systems: with applications to food demand in the Nordic countries.* Massachusetts: Springer Science & Business Media.

European Commission. (2013). EU dairy farms report 2012. http://ec.europa.eu/agriculture/rica/pdf/Dairy_report_2012.pdf (Accessed: 2 March 2016).

European Commission. (2015). *The end of milk quotas.* http://ec.europa.eu/agriculture/milk-quota-end/index_en.htm (Accessed: 18 April 2016).

Forskning & Framsteg. (2006). *Den svenska mjölkpropagandan.* http://fof.se/tidning/2006/3/den-svenska-mjolkpropagandan (Accessed: 20 April 2016).

ICA. (2016). *ICAs mjölkkrona har bidragit med drygt 113 miljoner till de svenska bönderna - Pressrelease.* http://www.icagruppen.se/arkiv/pressmeddelandearkiv/2016/icas-mjolkkrona-har-bidragit-med-drygt-113-miljoner-till-de-svenska-bonderna/ (Accessed: 19 April 2016).

ICA. (2016). *Vi på ICA gillar Sveriges bönder.* http://www.ica.se/ica-tar-ansvar/saker-mat/svenskmat/ (Accessed: 3 March 2016).

Isengildina-Massa, O., MacDonald, S. et al. (2009). US cotton prices and the world cotton market: Forecasting and structural change. *United States Department of Agriculture, Economic Research Service Report*, *80*.

Ishler, V. A. (2016). *Nitrogen, ammonia emissions and the dairy cow.* http://extension.psu.edu/animals/dairy/nutrition/nutrition-and-feeding/

diet-formulation-and-evaluation/nitrogen-ammonia-emissions-and-the-dairy-cow-1/ (Accessed: 3 February 2016).

Jönsson, H. (2005). *Mjölk – En kulturanalys av mejeridiskens nya ekonomi.* Ågerup: Brutus Östlings bokförlag Symposion.

Jordbruksverket. (2011a). Sveriges första femton åren som medlem i EU – Jordbrukarstödens utveckling. http://www2.jordbruksverket.se/webdav/files/SJV/trycksaker/Pdf_rapporter/ra11_42.pdf (Accessed: 2 March 2016).

Jordbruksverket. (2011b). Sveriges första femton åren som medlem i EU – Utvecklingen av handeln med jordbruks- och livsmedelsvaror. https://www.jordbruksverket.se/download/18.5881b3b01336df878e780001549/Ra+11_37+Utvecklingen+av+handeln.pdf (Accessed: 13 May 2016).

Jordbruksverket. (2016). *Antal mjölkbönder 2005-2015.* https://jordbruketisiffror.wordpress.com/2015/01/21/fascinerande-fakta-om-mjolkkor-och-mjolkforetag-2005-2014/ (Accessed: 28 February 2016).

Jordbruksverket. (2016). *Handel med mjölk och mjölkprodukter.* http://www.jordbruksverket.se/amnesomraden/handel/kottmjolkochagg/handelmedkottmjolkochagg/handelmedmjolkochmjolkprodukter.4.3a3862f81373bf24eab80001786.html (Accessed: 20 April 2016).

Jordbruksverket. (2016a). *Jordbruksverkets statistikdatabas.* http://statistik.sjv.se/PXWeb/pxweb/sv/Jordbruksverkets%20statistikdatabas/?rxid=5adf4929-f548-4f27-9bc9-78e127837625 (Accessed: 3 March 2016).

Jordbruksverket. (2016b). *Konsumtion per person och år från 1950 till 2013.* https://jordbruketisiffror.wordpress.com/2015/07/30/direktkonsumtionen-av-mjolk-har-minskat-fran-216-liter-per-person-och-ar-1950-till-86-liter-per-person-och-ar-2013/ (Accessed: 28 February 2016).

KRAV. (2015). *Så här produceras ekologisk mjölk.* http://www.krav.se/sa-har-produceras-ekologisk-mjolk (Accessed: 14 March 2016).

Lindmark Månsson, H. (2016). *Mjölkens färd – från ko till bord.* http://www.mjolk.se/artiklar/mjolkens-fard--fran-ko-till-bord/#!/artiklar/mjolkens-fard--fran-ko-till-bord/ (Accessed: 22 March 2016).

LRF Mjölk. (2012). *Svensk Mjölk stängs.* http://www.svenskmjolk.se/ (Accessed: 3 March 2016).

LRF Mjölk. (2015). *Mjölkrapporten nr 4 2016.* http://www.lrf.se/globalassets/dokument/om-lrf/branscher/lrf-mjolk/mjolkrapporter/mjolkrapporten-nr-4-2015.pdf (Accessed: 3 March 2016).

LRF Mjölk. (2016a). *Konsumtion per person och år.* http://www.lrf.se/om-lrf/organisation/branschavdelningar/lrf-mjolk/statistik/konsumtion/ (Accessed: 3 February 2016).

LRF Mjölk. (2016b). *Mjölkrapporten nr 1 2016.* http://www.lrf.se/globalassets/dokument/om-lrf/branscher/lrf-mjolk/mjolkrapporter/mjolkrapporten-nr-1-2016.pdf (Accessed: 25 March 2016).

LRF Mjölk. (2016c). *Organisation och medlemsföreningar.* http://www.lrf.se/om-lrf/organisation/branschavdelningar/lrf-mjolk/om-oss/organisation-och-medlemsforeningar (Accessed: 23 March 2016).

LRF Mjölk. (2016d). *Statistik.* http://www.lrf.se/om-lrf/organisation/branschavdelningar/lrf-mjolk/statistik/ (Accessed: 23 March 2016).

Mayfield, L., Bennett, R., Tranter, R. & Wooldridge, M. (2007). Consumption of welfare-friendly food products in Great Britain, Italy and Sweden, and how it may be influenced by consumer attitudes to, and behaviour towards, animal welfare attributes. *International Journal of Sociology of Agriculture and Food*, *15*(3), 59–73.

Michaëlsson, K., Wolk, A., Langenskiöld, S., Basu, S., Warensjö Lemming, E., Melhus, H. & Byberg, L. (2014). Milk intake and risk of mortality and fractures in women and men: cohort studies. *BMJ*, *349*.

Michalek, J. & Keyzer, M. (1992). Estimation of a two-stage LES-AIDS consumer demand system for eight EC countries. *European Review of Agricultural Economics*, *19*(2), 137–163.

Moschini, G. (1995). Units of measurement and the stone index in demand system estimation. *American Journal of Agricultural Economics*, *77*(1), 63–68.

Naturskyddsföreningen. (2009). Soja som foder och livsmedel i Sverige – konsekvenser lokalt och globalt. http://www.naturskyddsforeningen.se/upload/press/rapport-soja.pdf (Accessed: 6 May 2016).

Naturvårdsverket. (2016). *Ekologisk mjölk.* http://www.miljomal.se/Miljomalen/Alla-indikatorer/Indikatorsida/?iid=233&pl=1 (Accessed: 29 April 2016).

Ng, S. (1997). *Accounting for Trends in the Almost Ideal Demand System* (Boston College Working Papers in Economics No. 368). Boston College Department of Economics.

Nielsen. (2014). Svensk dagligvaruhandel, försäljning i värde.
(The data was received by e-mail from the marketing company Nielsen.)

Nilsson, M. (2009). *Mjölkkor.* Stockholm: Natur och Kultur.

Norrmejerier. (2016). *Produkter i gruppen ekologiskt.* http://www.norrmejerier.se/

produktkatalog/ekologiskt (Accessed: 19 April 2016).

Oatly. (2016). *Havredryck färsk.* http://www.oatly.com/products/sweden/havredryck-farsk/ (Accessed: 12 May 2016).

Poi, B. P. et al. (2012). Easy demand-system estimation with quaids. *Stata Journal*, *12*(3), 433.

Säll, S. & Gren, M. (2015). Effects of an environmental tax on meat and dairy consumption in sweden. *Food Policy*, *55*, 41–53.

SCB. (1999). Svensk jordbruksstatistik 200 år - strukturomvandlingen speglas av statistiken.

Schön, L. (2012). *An economic history of modern Sweden.* London: Routledge.

Skånemejerier. (2015). *Annual report 2014.*

Skånemejerier. (2016). *Produktkatalog - ekologiskt.* http://www.skanemejerier.se/sv/Vara-produkter/Produktkatalog/ (Accessed: 19 April 2016).

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V. & de Haan, C. (2006). *Livestock's long shadow: environmental issues and options.* Food and Agriculture Organization of the United Nations (FAO).

Sundberg, I. (2010). *Author's interview by e-mail with one of Arla's farmers.* (Contact was initiated through Arla's official website.)

Svenskt Kött. (2016). *Öppna landskap med biologisk mångfald.* http://www.svensktkott.se/om-kott/darfor-svenskt-kott-fordjupning/oppna-landskap/ (Accessed: 18 April 2016).

SVT. (2010). *Sojaimport bidrar till skogsskövling.* http://www.svt.se/nyheter/inrikes/sojaimport-bidrar-till-skogsskovling (Accessed: 18 April 2016).

SVT. (2014a). *Rör inte svenskarnas mjölk.* http://www.svt.se/kultur/ror-inte-svenskarnas-mjolk (Accessed: 29 February 2016).

SVT. (2014b). *Svensk studie: Mjölk kopplas till ökad dödlighet.* http://www.svt.se/nyheter/vetenskap/uppsala-forskare-mjolkdrickande-kopplat-till-okad-dodlighet (Accessed: 29 March 2016).

Taljaard, P. R., Alemu, Z. G. & van Schalkwyk, H. D. (2004). The demand for meat in South Africa: an almost ideal estimation. *Agrekon*, *43*(4), 430–443.

World Animal Proctection. (2016). *Compare – world animal protection.* http://api.worldanimalprotection.org/compare (Accessed: 28 March 2016).

Appendix A Additional AIDS estimations

Below are the outputs from the remaining AIDS estimations for different subperiods. The residuals from these results were used in the QLR test.

AIDS model 1967–1992 (n = 26), $\alpha_0 = 0$

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	-1.18525	.4391017	-2.70	0.007	-2.045874	-.3246264
α_{beef}	3.357539	.5889524	5.70	0.000	2.203214	4.511865
α_{potato}	-1.172289	.2172766	-5.40	0.000	-1.598144	-.7464349
β_{milk}	-.3590092	.052466	-6.84	0.000	-.4618408	-.2561777
β_{beef}	.6566987	.0652953	10.06	0.000	.5287224	.7846751
β_{potato}	-.2976895	.0287167	-10.37	0.000	-.3539731	-.2414059
$\gamma_{milk,milk}$	-.7674814	.1588226	-4.83	0.000	-1.078768	-.4561947
$\gamma_{beef,milk}$	1.611498	.1577005	10.22	0.000	1.30241	1.920585
$\gamma_{potato,milk}$	-.8440164	.0298657	-28.26	0.000	-.9025521	-.7854806
$\gamma_{beef,beef}$	-2.93781	.1068714	-27.49	0.000	-3.147275	-2.728346
$\gamma_{potato,beef}$	1.326313	.1185829	11.18	0.000	1.093895	1.558731
$\gamma_{potato,potato}$	-.4822964	.1042874	-4.62	0.000	-.686696	-.2778968

	Milk	Beef	Potatoes
ε^I	.26921134	3.2322923	-.38746795
	(.10679832)	(.22195584)	(.1338423)

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	-.41297746	.53770824	-.12473078
	(.13599408)	(.15490786)	(.04926579)
Beef	.90451629	-1.4159262	.51140991
	(.27022386)	(.31429673)	(.11238273)
Potatoes	-.29461489	.71022522	-.41561033
	(.1155344)	(.15112731)	(.08157086)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	-.54523096	.45851129	-.18249167
	(.10948862)	(.17661583)	(.0496715)
Beef	-.68338841	-2.3668063	-.18209764
	(.210397)	(.36134794)	(.11212757)
Potatoes	-.10426633	.82421105	-.33247677
	(.09485061)	(.17888069)	(.07561743)

AIDS model 1993–2014 (n = 22), $\alpha_0 = 0$

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	1.458037	1.281312	1.14	0.255	-1.053289	3.969363
α_{beef}	-.6027386	1.594747	-0.38	0.705	-3.728385	2.522908
α_{potato}	.1447018	.3411257	0.42	0.671	-.5238922	.8132958
β_{milk}	-.2527971	.1800038	-1.40	0.160	-.6055981	.1000038
β_{beef}	.3434805	.3025245	1.14	0.256	-.2494567	.9364176
β_{potato}	-.0906833	.1417052	-0.64	0.522	-.3684204	.1870537
$\gamma_{milk,milk}$	-.2384803	1.063576	-0.22	0.823	-2.32305	1.846089
$\gamma_{beef,milk}$	.6660976	1.592777	0.42	0.676	-2.455689	3.787884
$\gamma_{potato,milk}$	-.4276173	.5593115	-0.76	0.445	-1.523848	.6686131
$\gamma_{beef,beef}$	-1.066849	2.389105	-0.45	0.655	-5.749408	3.61571
$\gamma_{potato,beef}$	.4007514	.8265793	0.48	0.628	-1.219314	2.020817
$\gamma_{potato,potato}$	.0268659	.2713739	0.10	0.921	-.5050171	.558749

	Milk	Beef	Potatoes
ε^I	.48541357	2.1675807	.57734416
	(.36641042)	(1.0283607)	(.66045796)

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	.33743791	-.16562974	-.17180817
	(.20456839)	(.27370493)	(.08069256)
Beef	-.26589729	-.21255311	.4784504
	(.44231791)	(.64392812)	(.21510822)
Potatoes	-.40804576	.67067297	-.26262721
	(.16298413)	(.2696444)	(.11984311)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	.09897232	-.30842935	-.27595654
	(.37426896)	(.18259297)	(.15078897)
Beef	-1.3307489	-.8502149	.01338306
	(.91025712)	(.40795424)	(.42163569)
Potatoes	-.69167342	.50082909	-.38649984
	(.45159765)	(.16604889)	(.25180079)

AIDS model 1967–1993 (n = 27), $\alpha_0 = 0$

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	-1.317497	.4044027	-3.26	0.001	-2.110112	-.5248825
α_{beef}	3.532671	.5267177	6.71	0.000	2.500323	4.565019
α_{potato}	-1.215174	.1890379	-6.43	0.000	-1.585681	-.8446664
β_{milk}	-.3679531	.0539851	-6.82	0.000	-.4737619	-.2621444
β_{beef}	.675812	.0657932	10.27	0.000	.5468597	.8047642
β_{potato}	-.3078588	.0273095	-11.27	0.000	-.3613845	-.2543332
$\gamma_{milk,milk}$	-.7749339	.1451731	-5.34	0.000	-1.059468	-.4903999
$\gamma_{beef,milk}$	1.612616	.1437632	11.22	0.000	1.330846	1.894387
$\gamma_{potato,milk}$	-.8376825	.0255286	-32.81	0.000	-.8877176	-.7876473
$\gamma_{beef,beef}$	-2.92152	.0904876	-32.29	0.000	-3.098872	-2.744167
$\gamma_{potato,beef}$	1.308903	.1146492	11.42	0.000	1.084195	1.533612
$\gamma_{potato,potato}$	-.471221	.1028518	-4.58	0.000	-.6728069	-.2696351

	Milk	Beef	Potatoes
ε^I	.25100535	3.2972633	-.4348651
	(.10989043)	(.22364835)	(.12728392)

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	-.48319834	.62454877	-.14135043
	(.12509359)	(.1444763)	(.04232562)
Beef	1.0564501	-1.5819735	.52552338
	(.25260139)	(.28793)	(.10044176)
Potatoes	-.34215122	.73905923	-.396908
	(.10239974)	(.13595567)	(.08139246)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	-.60650791	.55070768	-.19520512
	(.10231624)	(.16593382)	(.0422711)
Beef	-.56337242	-2.5519668	-.18192408
	(.19883987)	(.33395162)	(.10269705)
Potatoes	-.12851821	.86698842	-.30360511
	(.08863304)	(.16095465)	(.07639342)

AIDS model 1994–2014 (n = 21), $\alpha_0 = 0$

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	1.368599	2.415509	0.57	0.571	-3.365712	6.10291
α_{beef}	-.5183988	3.285502	-0.16	0.875	-6.957864	5.921066
α_{potato}	.1497998	.8743841	0.17	0.864	-1.563961	1.863561
β_{milk}	-.2788303	.2733649	-1.02	0.308	-.8146157	.2569551
β_{beef}	.3909537	.444431	0.88	0.379	-.480115	1.262022
β_{potato}	-.1121234	.1862573	-0.60	0.547	-.4771811	.2529342
$\gamma_{milk,milk}$	-.3976491	1.777591	-0.22	0.823	-3.881663	3.086365
$\gamma_{beef,milk}$	.9108083	2.662602	0.34	0.732	-4.307797	6.129413
$\gamma_{potato,milk}$	-.5131592	.9130535	-0.56	0.574	-2.302711	1.276393
$\gamma_{beef,beef}$	-1.438973	3.998967	-0.36	0.719	-9.276804	6.398858
$\gamma_{potato,beef}$	.5281648	1.367469	0.39	0.699	-2.152025	3.208355
$\gamma_{potato,potato}$	-.0150056	.4597045	-0.03	0.974	-.9160099	.8859986

	Milk	Beef	Potatoes
ε^I	.43242129	2.3289548	.47741632
	(.55645362)	(1.5107382)	(.86810608)

		Hicksian (compensated)	
	Milk	Beef	Potatoes
Milk	.44285588	-.32846957	-.11438631
	(.52297276)	(.76836289)	(.25043864)
Beef	-.5360301	.20171028	.33431983
	(1.2612363)	(1.8825916)	(.62958245)
Potatoes	-.2790346	.47551912	-.19648452
	(.54168988)	(.82963007)	(.29904625)
		Marshallian (uncompensated)	
	Milk	Beef	Potatoes
Milk	.23042343	-.45567984	-.20716487
	(.79068684)	(.61151215)	(.36525475)
Beef	-1.6801588	-.48342475	-.16537128
	(1.9788303)	(1.4635983)	(.94506895)
Potatoes	-.51357144	.33507215	-.29891703
	(.93462168)	(.61119183)	(.47677312)

AIDS model 1967–1995 (n = 29), $\alpha_0 = 0$

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	-1.385273	.4251155	-3.26	0.001	-2.218484	-.5520618
α_{beef}	3.18604	.5863861	5.43	0.000	2.036744	4.335335
α_{potato}	-.8007669	.2247675	-3.56	0.000	-1.241303	-.3602307
β_{milk}	-.3985713	.0542719	-7.34	0.000	-.5049423	-.2922003
β_{beef}	.640712	.0607587	10.55	0.000	.5216272	.7597969
β_{potato}	-.2421407	.0309872	-7.81	0.000	-.3028745	-.1814069
$\gamma_{milk,milk}$	-1.070408	.19838	-5.40	0.000	-1.459226	-.6815905
$\gamma_{beef,milk}$	1.864054	.186405	10.00	0.000	1.498707	2.229402
$\gamma_{potato,milk}$	-.7936464	.0414606	-19.14	0.000	-.8749076	-.7123851
$\gamma_{beef,beef}$	-2.944149	.144733	-20.34	0.000	-3.227821	-2.660478
$\gamma_{potato,beef}$	1.080095	.1245823	8.67	0.000	.8359178	1.324271
$\gamma_{potato,potato}$	-.2864482	.0912803	-3.14	0.002	-.4653544	-.1075421

	Milk	Beef	Potatoes
ε^I	.18867988	3.1779494	-.1285668
	(.11047434)	(.20653485)	(.14442488)

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	-.48909817	.54025153	-.05115336
	(.08109284)	(.10368063)	(.04625617)
Beef	.92582774	-1.1884004	.26257269
	(.17570784)	(.2503843)	(.10277417)
Potatoes	-.14954394	.39243744	-.2428935
	(.10334976)	(.13810846)	(.06103059)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	-.58178956	.48474543	-.09163575
	(.07914761)	(.11635783)	(.05347783)
Beef	-.6353803	-2.1232938	-.41927526
	(.16044764)	(.28156276)	(.09929243)
Potatoes	-.08638387	.4302594	-.21530873
	(.08273296)	(.16741747)	(.05783309)

AIDS model 1996–2014 (n = 19), $\alpha_0 = 0$

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	-2.742982	1.264459	-2.17	0.030	-5.221275	-.264688
α_{beef}	4.593053	1.485696	3.09	0.002	1.681143	7.504963
α_{potato}	-.8500715	.3059219	-2.78	0.005	-1.449667	-.2504756
β_{milk}	-.6907343	.1877561	-3.68	0.000	-1.05873	-.322739
β_{beef}	.8766051	.2201324	3.98	0.000	.4451535	1.308057
β_{potato}	-.1858708	.0437235	-4.25	0.000	-.2715674	-.1001742
$\gamma_{milk,milk}$	-2.539318	.2705158	-9.39	0.000	-3.06952	-2.009117
$\gamma_{beef,milk}$	3.444993	.1716691	20.07	0.000	3.108528	3.781458
$\gamma_{potato,milk}$	-.9056743	.1041161	-8.70	0.000	-1.109738	-.7016106
$\gamma_{beef,beef}$	-4.436595	.0596665	-74.36	0.000	-4.553539	-4.31965
$\gamma_{potato,beef}$	.9916018	.182459	5.43	0.000	.6339887	1.349215
$\gamma_{potato,potato}$	-.0859275	.0802882	-1.07	0.285	-.2432895	.0714346

	Milk	Beef	Potatoes
ε^I	-.40603849	3.9798121	.13369542
	(.38219087)	(.74828818)	(.20378617)

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	1.7906805	-2.1539448	.36326431
	(.28927081)	(.32740049)	(.0712741)
Beef	-3.6260074	4.2629507	-.63694333
	(.56416344)	(.64516106)	(.14552485)
Potatoes	.87160995	-.91317779	.04156784
	(.16749607)	(.20503931)	(.08695076)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	1.9901521	-2.0344959	.45038228
	(.46979151)	(.22419949)	(.13450814)
Beef	-5.5811407	3.0921643	-1.4908357
	(.91764075)	(.44875057)	(.26316663)
Potatoes	.80593037	-.95250849	.0128827
	(.25704438)	(.16662385)	(.10139106)

AIDS model 1967–1996 (n = 30), $\alpha_0 = 0$

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	-.8839044	.4076084	-2.17	0.030	-1.682802	-.0850066
α_{beef}	2.6584	.5625099	4.73	0.000	1.555901	3.760899
α_{potato}	-.7744953	.2437776	-3.18	0.001	-1.252291	-.2966999
β_{milk}	-.3410892	.0539742	-6.32	0.000	-.4468766	-.2353017
β_{beef}	.5916293	.0511348	11.57	0.000	.4914069	.6918517
β_{potato}	-.2505401	.0328464	-7.63	0.000	-.3149179	-.1861624
$\gamma_{milk,milk}$	-.8297047	.2393624	-3.47	0.001	-1.298846	-.360563
$\gamma_{beef,milk}$	1.633742	.2451993	6.66	0.000	1.15316	2.114324
$\gamma_{potato,milk}$	-.8040373	.0507092	-15.86	0.000	-.9034255	-.7046492
$\gamma_{beef,beef}$	-2.818375	.2089617	-13.49	0.000	-3.227932	-2.408817
$\gamma_{potato,beef}$	1.184633	.1618155	7.32	0.000	.8674803	1.501785
$\gamma_{potato,potato}$	-.3805955	.1319842	-2.88	0.004	-.6392798	-.1219113

	Milk	Beef	Potatoes
ε^I	.30568886	3.0111042	-.16771465
	(.10986826)	(.17382071)	(.15309016)

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	-.37090148	.44533982	-.07443835
	(.0805033)	(.07366128)	(.03849101)
Beef	.75349346	-1.0913104	.33781698
	(.12759789)	(.15779461)	(.10749338)
Potatoes	-.1838851	.47663235	-.29274725
	(.07907579)	.1370956	(.0802195)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	-.52107502	.35541187	-.14002571
	(.08335247)	(.0826271)	(.05334407)
Beef	-.72574975	-1.9771211	-.30823333
	(.15108187)	(.16579263)	(.11528883)
Potatoes	-.10149314	.52597087	-.25676308
	(.0746208)	(.17011278)	(.06606772)

AIDS model 1997–2014 (n = 18), $\alpha_0 = 0$

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	-2.014241	1.602627	-1.26	0.209	-5.155333	1.126851
α_{beef}	3.596712	1.817704	1.98	0.048	.0340783	7.159345
α_{potato}	-.5824709	.2948088	-1.98	0.048	-1.160286	-.0046562
β_{milk}	-.6117119	.1562068	-3.92	0.000	-.9178716	-.3055522
β_{beef}	.7634841	.1653267	4.62	0.000	.4394497	1.087518
β_{potato}	-.1517722	.028396	-5.34	0.000	-.2074273	-.0961171
$\gamma_{milk,milk}$	-2.588465	.5370682	-4.82	0.000	-3.641099	-1.535831
$\gamma_{beef,milk}$	3.439538	.4631011	7.43	0.000	2.531876	4.347199
$\gamma_{potato,milk}$	-.8510729	.1107101	-7.69	0.000	-1.068061	-.6340851
$\gamma_{beef,beef}$	-4.349228	.3652464	-11.91	0.000	-5.065097	-3.633358
$\gamma_{potato,beef}$	.9096897	.1991829	4.57	0.000	.5192983	1.300081
$\gamma_{potato,potato}$	-.0586168	.0901149	-0.65	0.515	-.2352388	.1180051

	Milk	Beef	Potatoes
ε^I	-.24518288	3.5952839	.29262198
	(.31797)	(.5619891)	(.13234766)

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	1.735029	-2.0626044	.3275754
	(.34006605)	(.37055664)	(.06743227)
Beef	-3.4754003	4.014941	-.53954076
	(.64104551)	(.68887936)	(.12318009)
Potatoes	.79253377	-.78226716	-.01026661
	(.157142)	(.17391842)	(.08553677)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	1.8554782	-1.9904762	.38018085
	(.49239569)	(.28220726)	(.11365932)
Beef	-5.2416292	2.9572756	-1.3109303
	(.91069694)	(.53311621)	(.19751688)
Potatoes	.6487795	-.86835109	-.07305039
	(.21065635)	(.15322714)	(.08611143)

Appendix B Quadratic AIDS

For comparison, the modified Quadratic version of AIDS (QUAIDS) was performed on data from the Swedish Board of Agriculture on consumption volumes and prices of milk, beef and potatoes from 1967–2014 ($n = 48$). $\alpha_0 = 0$ was used in the regression. In the Quadratic version of AIDS, a coefficient λ is estimated for every good in the basket.

	Coef.	Robust Std.	z	$P > \|z\|$	[95% Conf.	Interval]
α_{milk}	-2.074606	.2887495	-7.18	0.000	-2.640545	-1.508668
α_{beef}	3.305299	.2133457	15.49	0.000	2.887149	3.723449
α_{potato}	-.2306927	.3839435	-0.60	0.548	-.9832081	.5218227
β_{milk}	1.37096	.2508394	5.47	0.000	.8793238	1.862596
β_{beef}	-1.489833	.354586	-4.20	0.000	-2.184808	-.7948567
β_{potato}	.1188727	.2347624	0.51	0.613	-.3412532	.5789985
$\gamma_{milk,milk}$	-.5889243	.1672127	-3.52	0.000	-.9166551	-.2611935
$\gamma_{beef,milk}$	.85756	.0894439	9.59	0.000	.6822532	1.032867
$\gamma_{potato,milk}$	-.2686357	.0976532	-2.75	0.006	-.4600326	-.0772389
$\gamma_{beef,beef}$	-1.05528	.0853401	-12.37	0.000	-1.222543	-.8880164
$\gamma_{potato,beef}$	.1977198	.1112003	1.78	0.075	-.0202287	.4156684
$\gamma_{potato,potato}$	.0709159	.0187791	3.78	0.000	.0341095	.1077222
λ_{milk}	-.0254856	.0104798	-2.43	0.015	-.0460256	-.0049456
λ_{beef}	.0323384	.0111487	2.90	0.004	.0104875	.0541894
λ_{potato}	-.0068529	.0027661	-2.48	0.013	-.0122743	-.0014314

	Milk	Beef	Potatoes
ε^I	.76162556	2.3541331	-.31087583
	(.12665133)	(.27207596)	(.17899972)

	Hicksian (compensated)		
	Milk	Beef	Potatoes
Milk	-.35852927	.55023195	-.19170268
	(.06700046)	(.07491686)	(.02033521)
Beef	.92473952	-1.4621631	.53742363
	(.12917945)	(.16399972)	(.05002667)
Potatoes	-.44701179	.7449463	-.29793452
	(.04916725)	(.07302445)	(.06322185)
	Marshallian (uncompensated)		
	Milk	Beef	Potatoes
Milk	-.73268752	.32617592	-.35511397
	(.11066541)	(.06551183)	(.03781846)
Beef	-.23175831	-2.1547052	.03233037
	(.23010184)	(.13391539)	(.09532147)
Potatoes	-.29429008	.83640017	-.23123426
	(.11253311)	(.04741693)	(.09298378)