UiT THE ARCTIC UNIVERSITY OF NORWAY

School of Business and Economics

Demand Analysis of the Whitefish Market in the EU

- Has Pangasius Taken Over Market Shares in the Whitefish Market?

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I. Acknowledgement

With this master thesis I complete my master degree in Economics (MSc) at the School of Business and Economics at UiT, the Arctic University of Norway.

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II. Abstract

The market for seafood has changed significantly during the last couple of decades. This is mainly due to two prevailing trends, that is the stagnation in harvest of wild fish and increased production of aquaculture species. The growth in the supply of aquaculture products is caused by both new species entering the market and an increased production of already established species. Given the vast changes in the global seafood markets, the Linearized Almost Ideal Demand System (LA/AIDS) is applied in order to investigate the impact pangasius as a new species has had on the demand for imported whitefish species (cod, Alaska pollock, and saithe) to the European Union. By looking at the development in market shares from 1988 to 2014, pangasius has seemingly taken over parts in the whitefish market. However, the estimation results from the LA/AIDS illustrate another story: While the increasing supply of pangasius imports has not had a significant effect on the demand of the other whitefish species in question, the elasticities differs for the periods before and after the increased supply. The degree of the substitution effects varies across species, though the expenditure elasticities are all close to one and positive apart from that of saithe.

Keywords: *Linearized Almost Ideal Demand System (LA/AIDS), whitefish, European Union, aquaculture, elasticities, pangasius, Alaska pollock, saithe, cod, haddock.*

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1. Introduction

During the last couple of decades, the seafood industry has been exposed to several changes - both in supply and demand. World population is growing rapidly, and people have never before consumed as much fish or depended so greatly on the fishery sector as a source of both wealth and of health as they do today (FAO, 2014). Another important factor that has contributed to the vast changes in the seafood sector is the development in aquaculture. Since the 1980s aquaculture production has increased substantially and has become one of the worlds fastest growing food production technologies (Frank Asche, Kristin H. Roll, & Trine Trollvik, 2009a).

While aquaculture has started to thrive, the catch of wild fish has started to stagnate. This has caused the structure of the global supply of seafood to change (Anderson, 2002; Asche et al., 2009a; Asche & Zhang, 2013; Subasinghe, 2005-2015). FAO (2014) reported that in 2012, aquaculture production reached a new all time record by producing almost half of all fish consumed by people. They have also projected that by 2030 this share will rise to a staggering 62% worldwide. The rapid growth in aquaculture is a result of increased production of already established species, as well as new species entering the market (Bostock et al., 2010).

As production in the seafood sector is intensely growing, an increasing amount of aquaculture products are being traded across borders (Valdimarsson, 2007). This may in turn change several segments of the international seafood market, where the whitefish market is the largest seafood segment (Asche et al., 2009a). The whitefish market is especially of interest for new aquaculture species such as pangasius, as it contains a large amount of product forms, including processed products (Asche & Zhang, 2013). Pangasius and tilapia are examples of relatively new aquaculture products that are often regarded as natural additions to the whitefish market, due to their characteristics. An interesting feature of these species is that they are low cost species. Hence, if they work as substitutes for already established species in the whitefish market, they may also cause the overall price of whitefish to decline.

Pangasius, which is considered as a new aquaculture species, has seemingly gained a substantial share of the whitefish market following its entry (figure 1). But, it is far from apparent as to which already established species that experiences the keenest competition from pangasius (Asche & Zhang, 2013). Hence, the aim of this master thesis is to investigate potential changes in demand for already established wild species (cod, Alaska Pollock and saithe), given the entry of new aquaculture species such as pangasius. Is cod still dominating the market, or have other species started to compete alongside cod over market shares in the European whitefish market? Findings by Muir and Young (1999) show that in the US market, high-quality tilapia is indeed competing with high-valued whitefish species like cod. Tilapia is similar to pangasius in the sense that they share similar characteristics, as well as they are low-cost species. It will therefore be interesting to see if pangasius compete with high-valued whitefish species in the European Union.

Despite an explosion in the amount of studies done on the demand structure for various seafood markets, there is a lack of demand studies conducted on the whitefish market in the EU. Hence, this master thesis will contribute to this field of research. Knowing the demand relations of the various species in a market is of great value for the participants in that particular market. From the decision-making perspective of both policy makers as well as for both aquaculture- and wild fish producers, knowledge on demand relations can help them to evaluate the effect of adjusting prices, as well as it may give them an insight into how changing quotas will effect the demand for the species. Following the increase of pangasius imports there have been debates around the effect it has had on already established species, like cod. There are those who believe that the increase of pangasius imports has had a negative impact on the demand for cod (Eriksen & Martinsen, 2008; Lysvold, 2009). Hence, by investigating demand relations, one may gain further insight into whether or not this is the case.

The European Union is among the largest importers of seafood products, which makes it a good representative for this research. The Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer is applied for the purpose of this master thesis. The AIDS model has been adopted by many aquaculture and agriculture economists as the demand system of choice in most applications during the last decade (Alston & Chalfant, 1993). The model is consistent with demand theory, and permits testing for the underlying theoretical restrictions of symmetry and homogeneity.

This introductory chapter has covered the aim of this master thesis, as well as it has given reasons behind the importance of studying demand relations in the Whitefish market. The remaining 8 chapters are organized as follows; Chapter 2 describes the whitefish market in the EU and provides a brief description of pangasius; Chapter 3 presents similar demand studies done on the whitefish market; Chapter 4 presents the theory of demand, the LA/AIDS model and a derivation of the elasticities; Chapter 5 gives a description of the data; Chapter 6 presents the estimation procedure and accounts for issues that might arise when estimating the model; Chapter 7 presents the theoretical model; Chapter 8 presents the empirical results, and finally chapter 9 presents the concluding remarks and recommendations for further studies.

2. Background- The Whitefish Market

The whitefish market is one of the largest segments among the seafood markets, which makes it particularly attractive for fish suppliers (Frank Asche, Kristin Helen Roll, & Trine Trollvik, 2009b). According to Asche et al. (2009a) the most important wild fish species in the whitefish market are cod, Alaska Pollock, haddock, hake and saithe. Pangasius, tilapia, catfish and seabass are among the most traded farmed species. In the global seafood market whitefish species are traded at enormous quantities. The quantities traded varies from 6 million tons, if only the most important wild species are included, to 15 million tons if the farmed species are included (Asche et al., 2009b).

The European market for seafood has changed substantially since the 1980s. Until 1985, cod, haddock and saithe were dominating the whitefish market, however during the following years new species started to enter the market, as shown in table 1. In the 1990s Alaska pollock started to enter the market, closely followed up by hake and hoki around 1995. Around 2000 and 2005 subtropical aquaculture produced species such as tilapia and pangasius started to enter the market. It is worth noting that the species in table 1 below had already entered the market at an earlier stage, however not to a significant extent. In other words, during the years that are illustrated in table 1, the species had become a larger part of the whitefish market.

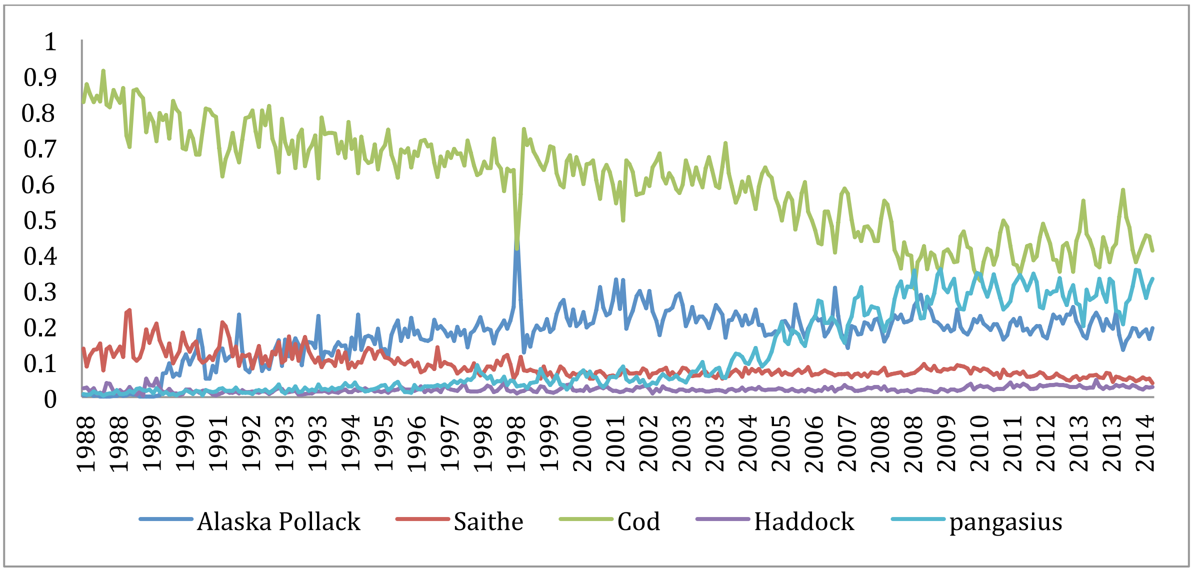
Despite the introduction of new species cod has continued to dominate the market. As shown in figure 1 cod still has the largest market share. Though, its market share has stagnated since the late 1980s, and around 2008 its market share was not considerably much larger than that of pangasius and Alaska Pollock. The market share of cod started to stagnate during the same period as when the market share of pangasius started to incline. This suggests that pangasius may have taken over parts of the market for cod. Since the 1990s when Alaska Pollock was first introduced to the market its market share has had a steadily growth. But, at the beginning of 2001 Alaska Pollock started to loose market share up until its market share started to stabilize around 2005. Both saithe and haddock have had small market shares throughout the periods. Saithe started to slowly loose its market share around the beginning of the 90s however the stagnation started to stabilize around 2000. The market share of haddock has on the other hand remained small but stable.

Table 1: Species entering the market.

1900-1985 →	1990→	1995→	2000→	2005→	2015
Cod, Haddock, Saithe	Alaska-Pollack	Hake, Hoki	Tilapia, Nile, Perch	Pangasius	-

Source: Asche (2014)

Figure 1: Market share for period 1988-2014.

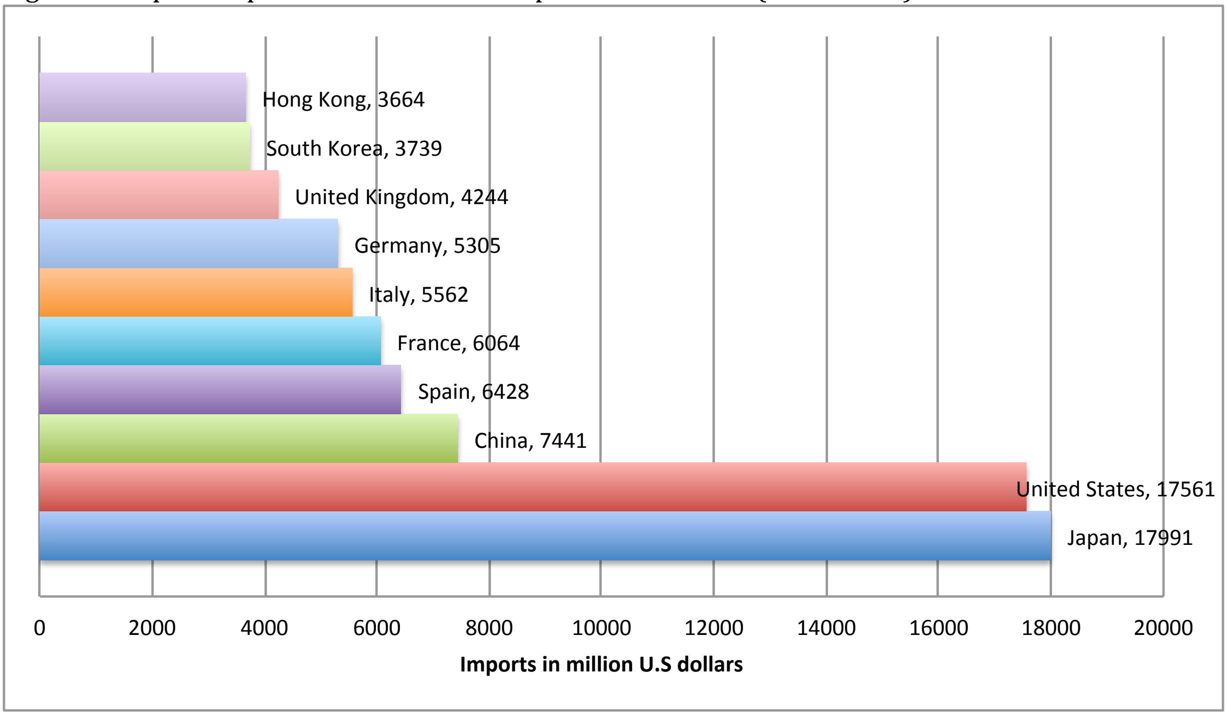


The development in the whitefish market is of huge interest due to several reasons. Firstly, it is an important source of income for several countries. Small fishing villages in the UK, Norway and Iceland depend greatly on the capture and processing of cod and haddock specifically. Competition from new low cost species is therefore of great interest to these countries as it may harm their economy (NOFIMA, 2015). Secondly, the pangasius industry has had an incredible impact on the economic development in Vietnam, hence it is also of importance for Vietnam to maintain and increase their exports of pangasius. Thirdly, the whitefish market has become an important source of food for the growing population.

The fish stocks in the European Union are severely overfished; this basically means that the market delivers less fish than if the fish stocks were allowed to recover (Balata, Devlin, Esteban, & Crilly, 2014). Hence, the EU market now relies heavily on imports, due to the fact that many countries within the EU are relatively low self-sufficient in fish. Self-sufficiency in fish is here defined as *"the capacity of EU member states to meet the demand for fish from their own waters"(Balata et al., 2014, p.5)*

The countries within the European Union that import most fish and fish products are France, Germany, Italy, Spain and the United Kingdom. These countries are also among the top 10 importers of fish and fish products worldwide, as shown in figure 2, which gives an indication of the magnitude of fish and fish products being imported to the European Union (Statista, 2012).

Figure 2: Top 10 importers of fish and fish products in 2012 (worldwide).



Source (Statista, 2012)

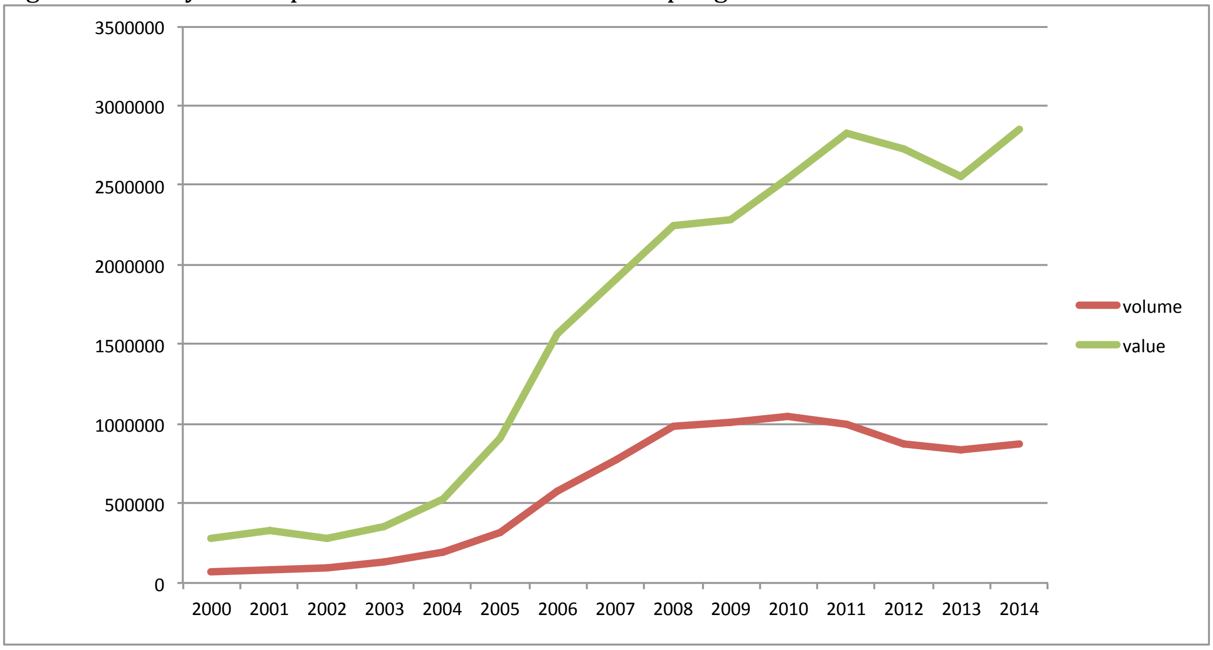
2.1 Pangasius

Pangasius is a sub-tropical species with white flesh and a neutral flavour, and it is often regarded as a natural addition to the whitefish market. However, despite the features of pangasius, that makes it natural to assume that it is a part of the whitefish market, it is somewhat uncertain whether or not the species operates in the same market segment as other whitefish species.

Vietnam stands for over 90 per cent of the world's export of pangasius. This makes pangasius production extremely concentrated geographically (Wright, 2012). In 2012, pangasius export reached a value of USD 1.74 billion, which accounts for as much as one per cent of the country's GDP- making this industry an important sector for Vietnam (WWF, 2013). Most of the pangasius farms are situated around poor areas in the Mekong Delta province. The production of pangasius has provided over 16 million jobs connected to the industry, and it has contributed to improving the living standards in the Mekong Delta province. Hence, the pangasius industry has had a considerable and essential impact on the economic development in this area (Hanh, 2009).

Pangasius has alongside tilapia contributed to a new market dimension as they are produced at highly competitive prices and in huge quantities (Asche et al., 2009a). Figure 3 illustrates the development in imports of pangasius, both in terms of volume and value to the EU. During the period 2000 to 2010 the imports of pangasius to Europe increased substantially. In the EU mainland alone the volume increased from 67,008 tons in 2000 to a staggering 1,047,780 tons in 2010. The rapid growth in volumes has provoked discussions both in the EU and the U.S. Pangasius production has been criticised for its impact on the rural populations around the Mekong delta as well as the fish's environment and quality (Bush, Khiem, & Sinh, 2009; Little et al., 2011; SEAT, 2011). Nevertheless, the negative discussions surrounding pangasius does not seem to have had a permanent detrimental effect on the imports of the specie. Despite a decrease in imports after 2010, imports seem to have slowly started to increase again around 2013. Pangasius has become a part of several certification programs, such as that of Aquaculture Certification Council (ASC) and Marine Stewardship Council (MSC), in order to restore its reputation (Beukers, Van Duijn, & Van der Pijl, 2013). These certification programs may have contributed to the increase in pangasius imports around 2013.

Figure 3: Yearly development in value and volume of pangasius from 2000-2014



3. Literature Review

This chapter provides a brief overview of similar demand studies done with regards to the Whitefish market. Up until the mid 1980s demand studies for fish and seafood in general received very little attention (Asche, Bjørndal, & Gordon, 2005). However, from then and onwards there has been an explosion of demand studies both on product forms and on various markets. The market for salmon has perhaps been the most studied field, mainly due to the development in salmon aquaculture. Nowadays, the whitefish market has received more attention, due to the development in aquaculture of whitefish in the global markets. Though, there has not been conducted much research on the whitefish market in the European Union. According to Asche et al. (2005) several demand studies conducted on whitefish species suggest that demand elasticities are in general around -1 or more elastic, though they vary in magnitudes. The research done by Asche et al. (2005) do not focus much on cross-price elasticities. Still, they conclude that there are more substitutes for species with larger own-price elasticities.

Asche et al. (2009a) has written a discussion paper on the effects of new species entering the Whitefish market, including pangasius. Their findings suggest that the transformation that aquaculture species will have on global seafood markets has just started. The consumption levels of more traditional species such as Alaska Pollock, tuna, cod and flounder has dropped, whereas consumption of newly farmed species such as salmon, shrimp, pangasius and tilapia has and is still increasing. Thus, Asche et al. (2009a) conclude in their paper that the introduction of new species has changed and will continue to change the global seafood markets. Though, their findings do not give an indication of to what extent the introduction of new aquaculture species will have on the seafood markets.

In the paper by Asche et al. (2009a) they make a simplified assumption that the effect of an increase in the supply of fish products on prices varies across market sizes. An expansion in fish quotas and/or increased production of aquaculture products causes the supply of fish to increase. According to their simplified assumption, the aquaculture industry can face two main market structures in terms of market size. The first market structure is somewhat small and limited, as there are only a few products and other species that can win market shares. The second market is a larger market, where the producer only produces a miniscule share. Thus, in the smaller market an increase in fish production or an expansion in fish quotas has a larger effect on prices compared to the larger market. The whitefish market is one of the largest segments in the seafood market. Hence, one would perhaps not expect prices to change substantially due to an expansion in fish quotas or fish production, based on the simplified assumptions of Asche et al. (2009a). If pangasius belong in the whitefish market, it follows that the prices will not change substantially due to changes in supply.

There has unfortunately not been devoted much attention in the literature on potential structural changes in demand caused by new farmed species entering the whitefish markets. This proposition is supported by Asche, Bjørndal, and Young (2001). Their findings suggest that there is limited evidence on substitution between farmed and wild-caught species, apart from those species that are available as wild and farmed. Many farmed species are traded at such high quantities and there is accordingly a huge demand for these species. Hence, they must win market shares from some market segment. However, Asche et al. (2001) point out that it is challenging to locate where the aquaculture species win market shares. They partly form new market segments and they partly win parts of already existing market segments.

In an effort of testing structural changes caused by new species entering the market, Asche and Zhang (2013) applied the inverse almost ideal demand system approach to the U.S. whitefish import market. Their findings suggest that increasing quantities of new-farmed species like tilapia will cause the prices of wild caught species, such as cod, to decline in the U.S. Their results suggest that, a 1 percentage change in the volume of tilapia imported reduces the price of cod by as much as -0.51%. Due to the similarities between tilapia and pangasius it will therefore be interesting to see if the estimated elasticities in this master thesis can provide similar results but for pangasius in the EU market.

4. Theory

This master thesis is a demand analysis of the whitefish market in the EU. It is therefore essential to understand the theory behind demand, and apply some simple assumptions concerning the consumer. A fundamental concept for economists, is that the observed price and quantity is the result of an interaction between supply and demand (Thyholdt, 2015).

The basic law of demand states that when all other factors are being held constant, as the price of a good increases, consumers will demand less of that good and vice versa (Hildenbrand, 1983). This is a key assumption in demand theory. Hence, it is expected that as the price of one of the species in question increases, consumers will demand less of that good, unless it is a Giffen good. But to what extent demand is affected by a price-increase may vary across the different species. According to Spiegel (1994), a Giffen good is rather unlikely and it is therefore not expected to be the case in this master thesis. A Giffen good is a unique case of an inferior good in which the negative income effect caused by the price change is strong enough to overcome the substitution effect, which results in a positive relationship between price and demand.

A simple assumption regarding the consumer is as follows; when the consumer is faced with a limited budget he or she will always choose a bundle of goods that maximizes their utility. Given the price and budget situation, the theory further assumes that a unique bundle of goods exist that maximizes a consumers' utility. This assumption is also known as the Marshallian demand function (Thyholdt, 2015). The consumer is believed to be rational and will thereby choose the best option of bundles. It is also assumed that the consumer will spend its entire budget; this essentially means that a change in the price of good i will not have an effect on total expenditure. Hence, somewhat simplified it is assumed that the representative consumer is faced with a linear budget constraint, and is believed to have rational, continuous, strictly convex and non-satiated preferences (Thyholdt, 2015).

As the purpose of this research is to further investigate the impact pangasius, as a new specie, has had on the demand for imported whitefish species (cod, Alaska pollock, haddock and saithe) to the European Union, one must apply a demand model that can account for these effects.

During the last decade two demand systems have been vastly applied by both agriculture and aquaculture economists as the demand system of choice, namely the Rotterdam model and the Almost Ideal Demand system. These two models share several similarities and are both compatible with demand theory, though they often lead to different results (Alston & Chalfant, 1993).

According to Barnett and Seck (2008) economic theory does not give a clear answer as to which model that should be applied when estimating a demand function using a given dataset. Though, the Rotterdam model has not been applied as often as the AIDS model during the most recent years. Alston and Chalfant (1993) argue that the AIDS model has perhaps been chosen over the Rotterdam model due to the fact that the Rotterdam model is believed to be overly restrictive. Therefore, I shall apply the AIDS model for the purpose of this research.

This chapter shall proceed as follows: 1) Reasoning behind the choice of demand model, 2) description of the model and 3) description of Marshallian/Hicksian elasticities.

4.1. The LA/AIDS Model

The Almost Ideal Demand System (AIDS) of Deaton and Muellbauer has been selected for the purpose of this research due to its characteristics. It is also regarded as a more flexible model compared to the Rotterdam model (Alston & Chalfant, 1993). According to Deaton and Muellbauer (1980a) the model has several comparative advantages over its main competitor, the Rotterdam model, despite the several similarities. It satisfies many of the same properties that the Rotterdam model possesses. Though, the AIDS model unlike the Rotterdam model can possess these properties simultaneously.

Similar to the Rotterdam model the AIDS model can test for homogeneity and symmetry. It can also be applied to any demand system and has the ability to give an arbitrary first-order approximation of these demand systems; it satisfies exact aggregation across consumers; it assumes that consumers are behaving rationally; and its functional form satisfies household-budget data.

There are several arguments to why the AIDS model is one of the most commonly used models in demand analysis. According to Buse (1994), most importantly the AIDS model assumingly gives a well-structured analytical framework; accommodates certain types of aggregation; permits testing for standard restrictions of classical demand theory, as well as it is seemingly easy to estimate. Moschini (1995) points out in his research that the AIDS model is a "flexible" representation of an arbitrary demand system. Still, he focuses on the advantage that the translog price index (2) can be replaced by the stone price index in order to achieve a linear demand system.

When including the stone price index instead of the translog price, we have a linear model called the Linearized Almost Ideal Demand System (LA/AIDS). Deaton and Muellbauer (1980a) suggest that the stone price index is a good alternative to the translog price index. Though, there has been and there still is an extensive discussion of whether or not the stone price index is a good unit of measurement for the AIDS model. But they argue that in the case where prices are highly collinear, that is when P (price index) is approximately equal to P* (stone price index), then the stone price index is a good unit of measurement. However, the findings by Deaton and Muellbauer also suggest that the stone price index can make the parameter estimates inconsistent, as prices are never perfectly collinear.

Moschini (1995) has suggested several other price indices as alternatives to the stone price index using Monte Carlo studies. Nevertheless, most empirical applications still apply the stone price index that results in the LA/AIDS, in the hope that it provides a reasonable approximation for the true almost ideal demand system (Asche & Wessells, 1997; Green & Alston, 1991; Moschini, 1995). Hence, this paper shall proceed by implementing the stone price index in the AIDS model, which forms the LA/AIDS model.

4.2. Estimating the LA/AIDS Model

When estimating the LA/AIDS model I shall follow the approach by Deaton and Muellbauer (1980a).

The AIDS model is usually defined as follows:

(1) $R_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} ln\, p_j + \beta_i \ln\left(\frac{y}{P}\right)$

i = 1, 2, …n (1= cod, 2= saithe, 3= Alaska pollock, 4= haddock and 5= pangasius)

Where,

R_i = the budget share of the ith commodity

p_j= is the price of the jth commodity. p =value/quantity

y = total expenditure

$\ln(y / P)$ is the income effect parameter

Where P is defined by,

(2) $lnP = \alpha_o + \sum_{i=1}^{n} \alpha_i lnp_i + {}^{1}\!/_{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} lnp_i lnp_j$

lnP is the trans-log price index for the true AIDS model. However in order to achieve a linear demand system the trans-log price index is replaced by the stone price index, which is defined as following:

(3) $lnP^{*} = \sum_{k=1}^{n} R_i lnp_i$

After having adjusted for the problem of a non-linear demand system by replacing the trans-log price index by the stone price index we are left with the LA/AIDS model:

(4) $R_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} ln\, p_j + \beta_i \ln\left(\frac{y}{P*}\right)$

Where, $lnP*$ is the stone price index. The stone price is approximately proportional to the translog price index.

In order for the model to be consistent with demand theory, the restrictions of adding up, symmetry and homogeneity are being applied to the model.

The adding up conditions applies to the intercept a_j, price coefficient γ_{ij} and income coefficient β_i:

(5a) $\sum_i^n a_j = 1$

(5b) $\sum_i^n \gamma_{ij} = 0$

(5c) $\sum_i^n \beta_i = 0$

The adding up conditions implies a singular variance-covariance matrix for the disturbances (Buse, 1994); this is being dealt with by deleting the nth equation. The coefficients of the deleted equation are later on recovered by applying the adding up restrictions.

Homogeneity and symmetry are given by:

(6) Homogeneity $\sum_j^n \gamma_{ij} = 0$

(7) Symmetry $\gamma_{ij} = \gamma_{ji}$

If the restrictions of adding up, symmetry and homogeneity hold, equation (1) represents a system of demand functions that are homogenous of degree zero in prices and expenditures, add up to total expenditure (R_i =1) and satisfies Slutsky symmetry.

The homogeneity restriction with zero degree simply implies that the budget share remains constant, given that prices and income changes at the same rat. In other words the absence of money illusion (Thyholdt, 2015). Given that the restrictions of adding up, symmetry and homogeneity hold, the AIDS model can simply be interpreted as:

"in the absence of changes in relative prices and "real" expenditure (x/P) the budget shares are constant and this is the natural starting point for predictions using the model"(Deaton & Muellbauer, 1980a, p.314)

4.3. LA/AIDS: Elasticities

The Marshallian elasticities, also known as uncompensated elasticities, are accounted for in the LA/AIDS model. They show the total effect, both price and income effects on demand. Alston and Chalfant (1993) suggest that the AIDS model is identical to LA/AIDS model at one point, which is when all prices are approximately proportional. If this is assumingly correct then the elasticities can be found as following:

4.3.1. The Own-Price Elasticity

The own-price elasticity is accounted for by deriving R_i with respect to p_i.

(8) $E_{ii} = \frac{dlnR_i}{dlnp_i} - 1 = \frac{dR_i}{dlnp_i}\frac{1}{R_i} - 1,$

Where $\frac{dR_i}{dlnp_i}$ is equal to $\gamma_{ii} - \beta_i R_i,$

Thus, the own-price elasticity can be written as:

(9a) $E_{ii} = \frac{\gamma_{ii}}{R_i} - \beta_i - 1$

If $E_{ii} < 1$, the good is price inelastic.
If $E_{ii} = -1$, the good is unit elastic.
If $E_{ii} = 0$, the good is perfectly inelastic.
If $-\infty < E_{ii} < -1$, the good is elastic or relatively elastic.

4.3.2. The Income Elasticity

The income elasticity, A_i, is derived by first considering the following equation:

(1) $R_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} ln\, p_j + \beta_i \ln\left(\frac{y}{P^*}\right)$

Where, $R_i = q_i \frac{p_i}{c(p,u)} = \frac{p_i q_i}{Y}$

The general expression for A_i is as follows:

(10) $A_i = \frac{dlnq_i}{dlnY} = 1 + \frac{dR_i}{dlnY}\frac{1}{R_i}$

Where, $\frac{dR_i}{dlnY}$ can be written as β_i. The income elasticity can therefore be expressed as:

(9b) $A_i = \frac{\beta_i}{R_i} + 1$

If $A_i > 1$, then i'th commodity is a luxury good.
If $A_i > 0$, then ith commodity is a normal good.
If $A_i < 1$, then ith commodity is a necessity good.
If $A_i < 0$, then ith commodity is a inferior good.

4.3.3. The Cross-Price Elasticity

The cross price elasticities are found by deriving R_i with respect to p_j.

$R_i = \frac{p_i q_i}{Y}$, derived by p_j gives the following equation

(11) $E_{ij} = \frac{dlnR_i}{dlnp_j} = \frac{dR_i}{dlnp_j}\frac{1}{R_i}$,

Where, $\frac{dR_i}{dlnp_j}$ can be written as $\gamma_{ij} - \beta_i R_j$.

Substituting $\gamma_{ij} - \beta_i R_j$ in for $\frac{dR_i}{dlnp_j}$ we end up with the following cross-price elasticity:

(9c) $E_{ij} = \frac{\gamma_{ij} - R_j \beta_i}{R_i}$

If $E_{ij} > 0$, the goods are substitutes.

If $E_{ij} < 0$, the goods are compliments.

If $E_{ij} = 0$, the goods are independent.

4.3.4. The Hicksian Elasticities

The LA/AIDS model only directly presents the Marshallian elasticities (uncompensated elasticities). However, by applying the Slutsky equation the Hicksian elasticities (compensated elasticities) can also be accounted for. While the uncompensated elasticities capture the net effect of both the substitution and income effect, the compensated elasticities give a further insight into the relative strength of the substitution effects by isolating the income effect. As Hicksian isolates the income effect, we expect its own-price elasticities to be less elastic than Marshallian own-price elasticities for normal goods.

The Slutsky equation:

(12) $E_{ij}^{*} = E_{ij} + R_j A_i$

Where, E_{ij}^* is the Hicksian elasticity, E_{ij} is the Marshallian elasticity, A_i is the Marshallian income elasticity and R_j is the mean of the budget share for good i.

Given that A_i (9b) and E_{ij} (9c) is the Marshallian elasticities we can rearrange (12) in order to find the Hicksian own-price and cross-price elasticities.

Starting with the cross-price elasticity we substitute in for the Marshallian elasticities, which results in the following equation:

(13) $E_{ij}^* = \frac{\gamma_{ij} - R_j\beta_i}{R_i} + R_j\left(\frac{\beta_i}{R_i} + 1\right)$

By simplifying the equation we end up with the following equation:

Hicksian cross-price elasticity: (14) $E_{ij}^* = \frac{\gamma_{ij}}{R_i} + R_j, \ (i \neq j)$

By following the same procedure as for the cross-price elasticity we can also find the own-price elasticity. Instead of using the Marshallian cross-price elasticity (9c) in the Slutsky equation (12) we use the Marshallian own-price elasticity (9a), which gives the following equation:

Hicksian own-price elasticity: (15) $E_{ii}^* = \frac{\gamma_{ii}}{R_i} + R_i - 1$

To summarize, the LA/AIDS is the model of choice for the purpose of this research:

(4) $R_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} ln\, p_j + \beta_i \ln\left(\frac{y}{P^*}\right)$

In order for the model to be consistent with demand theory the following restrictions must be applied:

The adding up restrictions:

(5a) $\sum_i^n a_j = 1$

(5b) $\sum_{i}^{n} \gamma_{ij} = 0$

(5c) $\sum_{i}^{n} \beta_{i} = 0$

(6) Homogeneity $\sum_{j}^{n} \gamma_{ij} = 0$

(7) Symmetry $\gamma_{ij} = \gamma_{ji}$

The elasticities of the AIDS/LAIDS model are the following equations.

Marshallian (uncompensated elasticities):

(9a) Own-price elasticities: $E_{ii} = \frac{\gamma_{ii}}{R_i} - \beta_i - 1$

(9b) Income elasticities: $A_i = \frac{\beta_i}{R_i} + 1$

(9c) Cross-price elasticities: $E_{ij} = \frac{\gamma_{ij} - R_j \beta_i}{R_i}, (i \neq j)$

Hicksian (compensated elasticities):

(14) Hicksian cross-price elasticity: $E_{ij}^{*} = \frac{\gamma_{ij}}{R_i} + R_j, (i \neq j)$

(15) Hicksian own-price elasticity: $E_{ii}^{*} = \frac{\gamma_{ii}}{R_i} + R_i - 1$

5. Data Description

The data set is provided by Capia and contains secondary import data on the quantity and value of haddock, saithe, cod, Alaska Pollock and pangasius, from January 1988 including December 2014. Finding data on pangasius has been rather challenging. The solution to this problem has been to collect total fish export data from Vietnam to the EU. The reason why I have chosen to collect total fish export data from Vietnam is that it stands for around 90% of the world's export of pangasius, and most of the country's fish export stems from the pangasius industry (Wright, 2012).

When using trade data it is vital to keep in mind that the fish, which is being traded across boarders, will go through several domestic channels or be used in other production processes before entering the consumer market. Hence, the fish will be viewed as an intermediate good and not as a final consumption good. Even though, the fish is not physically altered, there will be extra costs added to the final good from processes such as insurance, repackaging, storing and so on (Washington & Kilmer, 2002). This results in extra value added to the final good. As the EU has introduced an exemption from duty on several Norwegian fish species such as, haddock, cod and saithe (E.U.D.N, 2015), the differences in prices between low-cost species, such as pangasius, and high-cost species, like cod, may be smaller when they have reached the consumer market. As Norway is the largest supplier of cod to the EU, one should keep this concern in mind when assessing the results.

The data has been aggregated according to the model specification. Unit prices were obtained by dividing the value by quantity for each of the species. The quantity or as in this case the weight of various product forms, such as filet, frozen and fresh, are not directly comparable. Thus, the quantity is converted to live weight equivalents, which is a common unit for the different product forms. When referring to the quantity throughout this paper I am considering the live weight equivalents, and I do not separate between product forms. Live weight is the wet weight of whole fish (Miyake, 2010). Capia AS has been helpful with converting the quantities into live weight equivalents.

Table 2 list the average prices, average monthly quantities and market shares for export of cod, saithe, Alaska Pollack, haddock and pangasius to the EU, for the period January 1988 including December 2014. As shown in the table, cod has a substantially larger market share

(60%) compared to the other species in the whitefish market while haddock has the lowest market share (2%). Haddock is often taken with cod as a by-catch, which might explain its low market share (Krag, Holst, Madsen, Hansen, & Frandsen, 2010). In addition to having the highest market share cod also has the highest price (2.16 euro), whereas pangasius has the lowest price (1.13). Hence, the data confirms the general assumption that pangasius is a low-cost specie while cod is a high cost-specie.

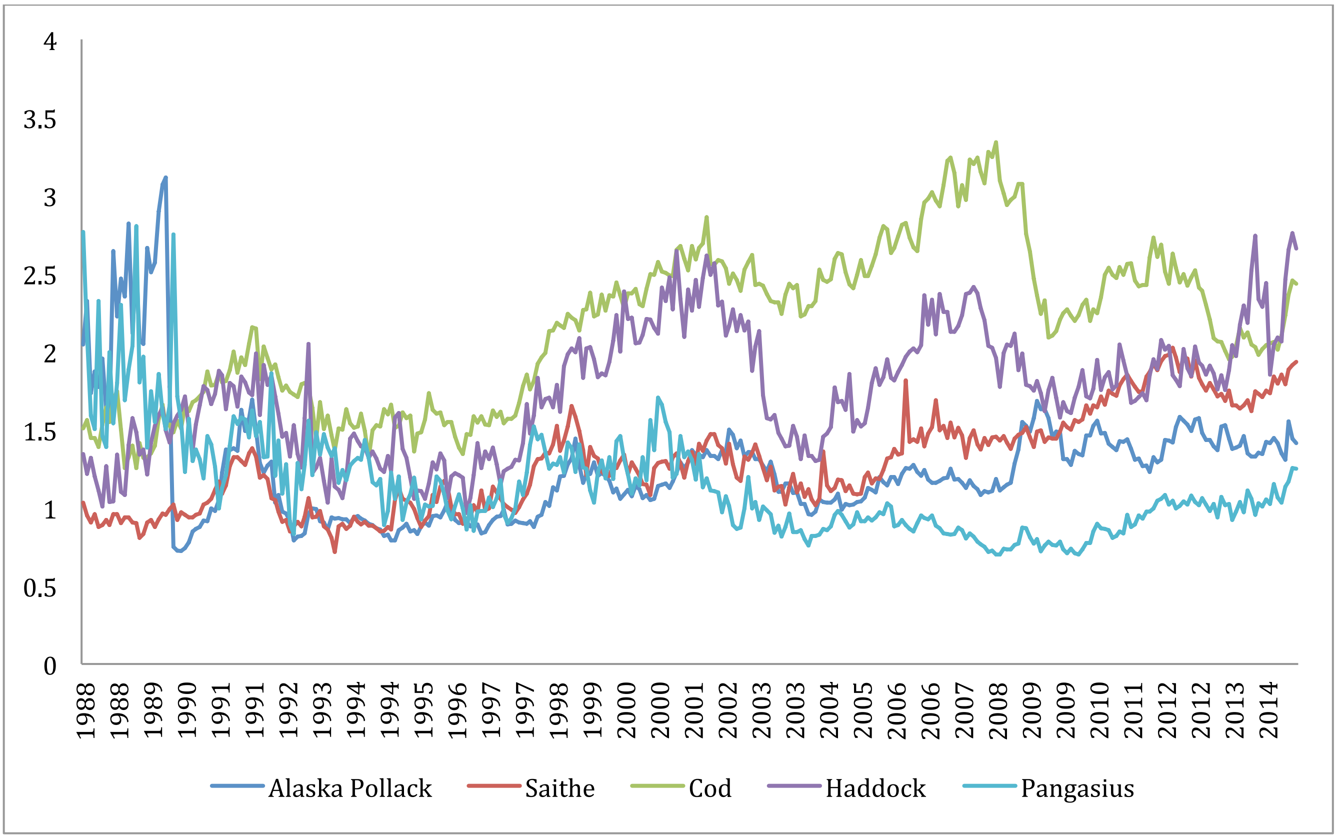
Figure 4 illustrates the variation in prices of cod, haddock, Alaska Pollack, pangasius and saithe. There is seemingly a relationship between the fluctuations in the price of cod and its market share. The price of cod started to increase approximately around 2004, which is around the same period where it started to loose market shares. From around 2008-2009 there was a huge drop in the price of cod, which is roughly around the same period where its market share started to grow again. One can also see a similar pattern for the other species. From figure 4 the prices also appear to follow a common trend. This suggests that the species operate in the same market. Though the price levels differs with the perceived quality of the five species.

Table 2: Average quantity, price and market share.

	Round weight	**Average price**	**Market share**
Cod	124395.8	2.16	60%
Saithe	29275.27	1.29	9%
Alaska Pollack	75819.67	1.26	17%
Haddock	6039.06	1.75	2%
Pangasius	85095.92	1.13	12%

Figure 4 illustrates the variation in prices of cod, haddock, Alaska Pollack, pangasius and saithe. There is seemingly a relationship between the fluctuations in the price of cod and its market share. The price of cod started to increase approximately around 2004, which is around the same period where it started to loose market shares. From around 2008-2009 there was a huge drop in the price of cod, which is roughly around the same period where its market share started to grow again. We can also see a similar pattern for the other species. From figure 4 the prices also appear to follow a common trend, which suggest that the species operate in the same market. Though the price levels differs with the perceived quality of the five species.

Figure 4: Yearly development in prices for period 1988-2014.



From figure 1 on p.5, it is shown that the level of the market share of haddock is very small. Hence, I have chosen to omit haddock during the empirical testing, as one would not expect the specie to have a significant impact on the other species in question. Another data adjustment I have chosen to make during the estimation process is to limit the data, so that it focuses on the period from 2000 to 2014. Due to the species entering the market at different periods since the 80s, including the entire dataset from 1988-2014 may lead to ambiguous estimation results. Still there is enough data in order to perform the estimation.

As the objective of this master thesis is to investigate the effect the introduction of pangasius has had on the other species in question, I will consider the period before the introduction of pangasius and after. In a report by Asche (2014), it is believed that pangasius entered the market fully around 2005. This is also confirmed by the sup-Wald statistic test carried out in chapter 6.

Table 3 and 4 lists the average market shares, average prices and average round weight for both periods. As seen in table 3, period 2000-2005, the market share of cod is a staggering 62.6%, while the market shares for the other species ranges from 6.7% to 23.8%. During the second period, which is shown in table 4, cod has lost a considerable share of the market compared to period 2000-2005. Cod went from having 62.6% of the market in the first period, to as low as 45.1% in the second period. The market shares of saithe and Alaska Pollock have remained somewhat unchanged. But the market share of pangasius has reached a staggering 27.4% during the second period. This may suggest that pangasius has taken over market shares from cod, but it has had little effect on the other species in question. However, the elasticities will provide a more thorough understanding of this relationship.

Table 3: Average quantity, price and market share for period 2000-2005.

	Round weight	**Average price**	**Market share**
Cod	121294.9	2.47	62.6%
Saithe	26577.9	1.23	6.9%
Alaska Pollack	96119.5	1.18	23.8%
Pangasius	31215.2	1.07	6.7%

Table 4: Average quantity, price and market share for period 2005-2014.

	Round weight	Average price	Market share
Cod	125973.2	2.55	45.1%
Saithe	29003.4	1.61	6.7%
Alaska Pollack	107795.7	1.34	20.7%
Pangasius	213738.3	0.91	27.4%

6. The Estimation Procedure

For the purpose of estimating the LA/AIDS model, the SUR (seemingly unrelated regression) method is applied. The SUR method is a popular choice in applied econometrics due to several features. According to Fiebig (2001), the most important feature is its applicability to large classes of modelling and testing problems, which is why this method has been selected for this master thesis.

Before the model can be estimated one must test and account for issues that may arise during the estimation procedure. It is important to undergo these tests to ensure that the time series data used in the estimation do not cause spurious regression results.

There are mainly three tests that shall be conducted, to ensure that the time series data applied in the estimation provide useful estimates. Firstly, the Augmented Dickey-Fuller test is carried out in order to test the statistical properties of the data, that is, the price variables will be tested for stationarity to ensure that the common trend is removed from the data series (Van Schalkwyk, 2003). Secondly, the sup-Wald statistic test will be carried out to test for possible structural breaks at an unknown break date. Finally, the Likelihood ratio test will be applied in order to test if symmetry and homogeneity restrictions are compatible with the data or not.

6.1 Testing for Non-Stationarity

Non-stationarity can be a symptom of an incorrect functional form and it can influence the properties and the behaviour of the model. If the time series variables are found to be non-stationary, it is necessary to transformer the variables by differencing the series. For instance if the price variable is non-stationary it may be made stationary by estimating $\Delta P_t = (P_t - P_{t-1})$ and apply ΔP_t to the model of equations. In the case where the time series variable is non-stationary it is important to decide how many times the variable must be differenced in order to attain a stationary variable (Taljaard, Alemu, & Van Schalkwyk, 2004). In order to test for stationarity the Augmented Dickey-Fuller (ADF) test is often applied in applied econometrics. If the results show that the variables are non-stationary then they will have to be excluded from the model. The null and the alternative hypothesis are as follows (Hill, Lim, & Griffiths, 2012):

$$H_o = non\ stationary$$
$$H_1 = stationary$$

If the absolute value of the test statistics is greater than the critical values then the null hypothesis is rejected. Table 5, shows that none of the price variables are stationary prior to being written in first differenced form. However, the results from the test show that in the case where the variables are written in first difference form then they are stationary. From Table 6, it is shown that the absolute value of the test statistic is greater than the critical values. Hence, it is necessary to reject the null hypothesis of non-stationarity at all significance levels.

Table 5: Augmented Dickey-Fuller test for the LA/AIDS model

Z(t)	Test-statistic	1% Critical Value	5% Critical value	10% Critical value	Stationary/non-stationary
P1	-2.273	-4.014	-3.440	-3.140	Non-stationary
P2	-2.881	-4.014	-3.440	-3.140	Non-stationary
P3	-2.674	-4.014	-3.440	-3.140	Non-stationary
P4	-1.603	-4.014	-3.440	-3.140	Non-stationary

Table 6: Augmented Dickey-Fuller test for the LA/AIDS model in first difference form

Z(t)	Test-statistic	1% Critical Value	5% Critical value	10% Critical value	Stationary/non-stationary
dlnp1	-9.158	-4.014	-3.440	-3.140	Stationary
dlnp2	-13.576	-4.014	-3.440	-3.140	Stationary
dlnp3	-10.460	-4.014	-3.440	-3.140	Stationary
dlnp4	-11.233	-4.014	-3.440	-3.140	Stationary

The results from the ADF test, shows that prices in first difference form needs to be incorporated into the model, i.e. when prices are integrated of order 1, I(1). Though regardless of the test results, Okrent and Alston (2011) point out that it is in general better to work with first difference models rather than level-data models. They argue that the consequences of differencing a model when it is not necessary is less severe than not running the model in first difference form when it is needed.

6.2 Structural Breaks

From figure 1, it is clearly shown that pangasius has a large variation in the market share. From being close to zero to a sudden increase around 2000-2005. Reporting average results for period 1988-2014 may be misleading in this case, as there have clearly been changes throughout this period. Hence, it is plausible to test for structural breaks. Failure of accounting for structural breaks in the data series will lead to ambiguous estimation results (Van Schalkwyk, 2003).

In order to account for a structural break a dummy variable will be incorporated into the model. From figure 1, it is suspected that the structural break happened somewhere between 2003 and 2006. The modified Chow test; also know as the Quandt likelihood ratio (QLR) statistic or the sup-Wald statistic, is applied in order to test for a break at an unknown break date.

STATA can unfortunately not test for unknown structural breaks in SUR (seemingly unrelated regressions). Hence, I started off by running an OLS (ordinary least squares) of the pangasius equation followed up by the command estat sbsingle, which is the command for the sup-Wald test. The result from the test is presented in table 8. The null hypothesis, that there is no structural break, is rejected at a 1% level. The results show that the estimated break date is June 2005. This result is consistent with findings by Asche (2014), who reported that pangasius achieved a higher market share in the EU market in 2005.

Table 7: Sup-Wald statistic: Test for structural break: Unknown break date

Number of observations		323
Full sample		1988m2-2014m12
Trimmed sample:		1992m3-2010m12
Estimated break date		**2005m6**
H0:		No structural break
Test	**Statistic**	**p-value**
swald	284.525	0.00

6.3 Homogeneity and Symmetry

Before running the model, it is also need to test if the symmetry-and homogeneity restrictions are compatible with the data or not. The Likelihood Ratio Test (LRT) is applied in order to decide whether to run a restricted or an unrestricted model. The null hypothesis states that the restricted model is compatible with the data. When performing the likelihood ratio test, both the unrestricted and the restricted model must be fit (StataCorp, 2013). There are three cases of restrictions that one need to test: 1st test is for homogeneity only, 2nd test is for symmetry only and the 3rd test is for both symmetry and homogeneity. The null hypothesis is rejected at a 5% significance level when $LR \geq \chi^2$. From table 7, it is shown that none of the three tests can be rejected at a 5% significance level. In all of the three cases the likelihood ratio is smaller than the critical value, this means that the null hypothesis cannot be rejected in any of these cases. I therefore choose to impose both symmetry and homogeneity to the model for it to be in accordance with demand theory.

Table 8: The Likelihood Ratio Test

Restrictions	Degrees of freedom	LR	Critical value χ^2 At 5% significance level
Homogeneity	6	4.37	12.592
Symmetry	6	3.92	12.592
Homogeneity and symmetry	12	6.63	21.026

7. The Theoretical Model

The extended LA/AIDS model is based on the standard LA/AIDS model developed by Deaton and Muellbauer as described in chapter 4.

$$R_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} ln\, p_{jt} + \beta_i \ln\left(\frac{y_t}{p_t^*}\right) + \varepsilon_{it} \qquad \text{(Model 1)}$$

The explanatory variable, R_{it}, is the expenditure share in period t for the *ith* commodity, where *i=1,2,3,4 is* cod, saithe, Alaska Pollack and pangasius respectively. The global whitefish market determines the prices and they are therefore considered as exogenous variables. The parameters that shall be estimated are as follows: the constant, α_i, for equation *i*; γ_{ij}, which represents the change in the demand for specie *i* when there is a change in price of specie *j,* given that all else is being held constant; β_i, shows the change in the demand for specie *i* with a change in income when the other variables are being held constant.

As fisheries are often subject to seasonal variations, it is important that this is being dealt with in the LA/AIDS model (Asche & Zhang, 2013). To capture seasonal shifts, 11 dummy variables D_m are incorporated into model 1. This change gives rise to the following model specification:

$$R_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} ln\, p_{jt} + \beta_i \ln\left(\frac{y_t}{p_t^*}\right) + \sum_{s}^{12} \delta_{is} D_{st} + \varepsilon_{it} \qquad \text{(Model 2)}$$

In order to prevent falling into the dummy variable trap it is necessary to drop one of the seasonal dummy variables. For the purpose of this estimation, the dummy variable for January has been dropped.

For the sake of accounting for the structural break of pangasius in period June 2005, one must incorporate a dummy variable, h_t, which captures that break. The dummy variable, h_t, illustrates the impact the introduction of pangasius has had on the other species where, $h_t = 0$ before the structural break and $h_t = 1$ after the structural break. One also needs to adjust for non-stationarity and run the model in first difference form. After having corrected for these issues, the result is the final extended version of the LA/AIDS model. The parameter estimates obtained from the extended LA/AIDS model will be applied in order to estimate the compensated and uncompensated elasticities of cod, saithe, Alaska Pollack and pangasius.

$$dR_{it} = \alpha_i + \phi_i h_t + \sum_{j=1}^{n}(\gamma_{ij} + \lambda_{ij} h_t) dln\, p_{jt} + (\beta_i + \xi_i h_t) d \ln\left(\frac{y_t}{p_t^*}\right) + \sum_s^{12} \delta_{is} D_{st} + \varepsilon_{it} \qquad \text{(Model 3)}$$

$$h_t \begin{cases} = 0 & for\ t < June\ 2005 \\ = 1 & for\ t \geq June\ 2005 \end{cases}$$

The extended version (model 3) of the LA/AIDS model satisfies the adding up restrictions, homogeneity- and symmetry restrictions. However, one must also impose symmetry and homogeneity restrictions on the coefficients of the dummy variables to ensure that the model is consistent with demand theory:

(16) $\sum_i \phi_i = 0, \sum_i \xi_i = 0,$ (Homogeneity)

(17) $\lambda_{ij} = \lambda_{ji}$ (Symmetry)

After having included the dummy variable, h_t, the elasticities are now given by the following equations.

Before the structural break, that is when $h_t = 0$:

(18) Own-price elasticity: $E_{ii} = \frac{\gamma_{ii}}{R_i} - \beta_i - 1$

(19) Income elasticity: $A_i = \frac{\beta_i}{R_i} + 1$

(20) Cross price elasticity: $E_{ij} = \frac{\gamma_{ij} - R_j \beta_i}{R_i}$

After the structural break, that is when $h_t = 1$:

(21) Own-price elasticity: $E_{ii} = \frac{(\gamma_{ii} + \lambda_{ii} * h_t)}{R_i} - (\beta_i + \xi_i * h_t) - 1$

(22) Income elasticity: $A_i = \frac{(\beta_i + \xi_i * h_t)}{R_i} + 1$

(23) Cross price elasticity: $E_{ij} = \frac{(\gamma_{ij} + \lambda_{ij} * h_t) - R_j(\beta_i + \xi_i * h_t)}{R_i}$

The elasticities for both before and after the structural break are found by using the average market shares for the respective periods. That is, before the structural break the market share prior to June 2005 is used, while after the structural break the average market share after June 2005 is used.

8. Results

The LA/AIDS model was estimated in accordance to the extended version, model 3, where homogeneity and symmetry restrictions were imposed. Seemingly unrelated regression (SUR) estimates were found with the computer software program STATA. The equation for pangasius was dropped from the regression in order to avoid singularity of the error covariance matrix and was later recovered by applying the adding up condition.

Table 9 represents the parameter values that were found by estimating the model with the SUR method (seemingly unrelated regression). The table shows that the value for R^2 ranges between 0.365 (saithe) and 0.582 (cod). This suggests that the model does not explain changes in the dependent variables very well for both saithe (0.365) and Alaska Pollack (0.396). However, changes in the dependent variable cod is relatively well explained.

Among the 16 price parameters, only 4 are statistically significant at a 10% level, while none of them are statistically significant at a 5% significance level. This suggests that perhaps the demand for each of the species is not highly affected by a change in the price of the other species. However, the elasticities will give a further insight into this relationship.

The interaction parameters, λ_{ij}, are the price parameters after the structural break. From the table we can see that 9 out of the 16 interaction parameters are statistical significant at a 5% significance level. This indicates that there might be a relationship among the price parameters after the introduction of pangasius. However, the interaction parameter of income in the period after the structural break,ξ_i, tells a different story. During the period after the structural break only the income parameter of pangasius is statistically significant. Though, before the structural break 3 out of 4 income parameters, β_i, were statistically significant.

Among the parameters in table 9 the dummy variable, ϕ_i, is perhaps the most interesting as it provides an insight to whether or not the introduction of pangasius has had an impact on the budget share of the respective species. None of them are statistically significant, which suggest that the introduction of pangasius has not had an impact on the budget shares. The estimates from the model are per se not of huge economic significance, hence it is plausible to focus more on the elasticities (Xie & Myrland, 2010).

Table 9: SUR estimates for period 2000-2014

		Cod	Saithe	Alaska Pollack	Pangasius
Constant	α_i	0.033** (0.009)	0.010** (0.002)	-0.014* (0.008)	-0.029** (0.005)
Prices	γ_{1j}	-0.111 (0.096)	0.037* (0.021)	0.030 (0.077)	0.0433 (0.036)
	γ_{2j}	0.037* (0.021)	-0.009 (0.012)	-0.038* (0.020)	0.010 (0.009)
	γ_{3j}	0.030 (0.077)	-0.038* (0.020)	0.035 (0.075)	-0.028 (0.029)
	γ_{4j}	0.043 (0.036)	0.010 (0.009)	-0.028 (0.029)	-0.025 (0.024)
Income	β_i	-0.051 (0.032)	-0.047** (0.008)	0.064** (0.027)	0.034* (0.018)
Monthly dummy	δ_2	0.012 (0.012)	-0.014** (0.003)	-0.007 (0.010)	0.008 (0.007)
	δ_3	0.017 (0.011)	-0.005** (0.003)	-0.025** (0.010)	0.014** (0.007)
	δ_4	-0.075** (0.012)	-0.018** (0.003)	0.024** (0.010)	0.069** (0.007)
	δ_5	-0.053** (0.012)	-0.010** (0.003)	0.028** (0.010)	0.035** (0.007)
	δ_6	-0.060** (0.012)	-0.008** (0.003)	0.025** (0.010)	0.043** (0.007)
	δ_7	-0.047** (0.012)	-0.011** (0.003)	0.005 (0.010)	0.053** (0.007)
	δ_8	-0.060** (0.012)	-0.012** (0.003)	0.027** (0.010)	0.045** (0.007)
	δ_9	0.025** (0.012)	-0.001 (0.003)	-0.013 (0.010)	-0.011 (0.007)
	δ_{10}	-0.016 (0.012)	-0.013** (0.003)	0.007 (0.010)	0.022** (0.007)
	δ_{11}	-0.050** (0.012)	-0.009** (0.003)	0.014 (0.010)	0.043** (0.007)
	δ_{12}	-0.086** (0.013)	-0.018** (0.003)	0.061** (0.010)	0.043** (0.008)
Dummy	ϕ_i	-0.001 (0.005)	-0.0002 (0.001)	0.001 (0.004)	0.0003 (0.003)
	λ_{1j}	0.268**	-0.080**	-0.030	-0.158**

		(0.113)	(0.026)	(0.089)	(0.049)
	λ_{2j}	-0.080** (0.026)	0.048** (0.017)	0.048** (0.023)	-0.017 (0.016)
	λ_{3j}	-0.030 (0.089)	0.049** (0.023)	0.031 (0.086)	-0.049 (0.041)
	λ_{4j}	-0.158** (0.049)	-0.017 (0.016)	-0.049 (0.041)	0.224** (0.042)
	ξ_i	-0.021 (0.041)	0.015 (0.010)	0.051 (0.035)	-0.044* (0.024)
R^2		0.582	0.365	0.396	-

**,* indicates significance at the 5% and 10% level respectively.
Numbers in parenthesis are standard errors.

Table 10: Estimated Marshallian Elasticities

	Cod	Saithe	Alaska Pollack	Pangasius	Income
Before Structural Break					
Cod	**-1.126**** (0.160)	0.065* (0.034)	0.068 (0.122)	0.075 (0.057)	0.918** (0.051)
Saithe	0.972** (0.327)	**-1.087**** (0.169)	-0.390 (0.282)	0.188 (0.135)	0.317** (0.111)
Alaska Pollack	-0.041 (0.347)	-0.178** (0.083)	**-0.915**** (0.309)	-0.135 (0.125)	1.269** (0.114)
Pangasius	0.326 (0.564)	0.111 (0.138)	-0.538 (0.430)	**-1.413**** (0.368)	1.514** (0.277)
After Structural Break					
Cod	**-0.581**** (0.144)	-0.083** (0.037)	0.034 (0.110)	-0.209** (0.083)	0.839** (0.079)
Saithe	-0.420* (0.241)	**-0.388**** (0.189)	0.257 (0.208)	0.027 (0.197)	0.523** (0.125)
Alaska Pollack	-0.248 (0.233)	-0.986** (0.067)	**0.204** (0.237)	-0.522** (0.151)	1.551** (0.142)
Pangasius	-0.400** (0.128)	-0.023 (0.047)	-0.273** (0.111)	**-0.267**** (0.131)	0.963** (0.075)

**,* indicates significance at the 5% and 10% level respectively.
Numbers in parenthesis are standard errors.

Table 11: Hicksian elasticities (compensated elasticities)

	Cod	Saithe	Alaska Pollack	Pangasius	
Before Structural Break					
Cod	-0.551** (0.153)	0.128** (0.034)	0.286** (0.124)	0.136** (0.057)	-
Saithe	1.171** (0.312)	-1.066** (0.169)	-0.315 (0.287)	0.210 (0.133)	-
Alaska Pollack	0.754** (0.326)	-0.107 (0.090)	-0.613* (0.316)	-0.050 (0.123)	-
Pangasius	1.275** (0.534)	0.215 (0.137)	-0.178 (0.437)	-1.312** (0.363)	-
After Structural Break					
Cod	-0.202 (0.145)	-0.027 (0.036)	0.208* (0.107)	0.021 (0.078)	-
Saithe	-0.456 (0.343)	-0.393** (0.194)	0.241 (0.244)	0.004 (0.256)	-
Alaska Pollack	0.452** (0.233)	0.118* (0.066)	-0.474** (0.233)	-0.097 (0.144)	-
Pangasius	-0.185 (0.661)	-0.140 (0.581)	-0.053 (0.566)	-0.504 (0.592)	-

**,* indicates significance at the 5% and 10% level respectively.
Numbers in parenthesis are standard errors.

The estimated Marshallian elasticities are presented in table 10 while the estimated Hicksian elasticities are presented in table 11. The two tables present the elasticities for both before and after the structural break. The elasticities were found by using the average expenditure shares for the respective periods. In order to find the Hicksian elasticities, the Slutsky equation is applied.

8.1 Own-Price Elasticities

According to Asche et al. (2005) a own-price elasticity of -1 is a focal point. Goods with no substitutes and constant budget share will have an elasticity of -1. The paper by Asche et al. (2005) also point out that for goods that are more elastic one would expect greater substitution possibilities and greater competition. Both Alaska Pollock and saithe are fairly close to the focal point in the period before the structural break. Thus, one might not expect them to be subject to much competition from other species during this period. Among the Marshallian own-price elasticities, 4 out of 4 are negative and statistically significant before the structural break. Where pangasius has the largest own-price elasticity in absolute value (-1.413) closely followed up by cod (-1.126), saithe (-1.087) and Alaska Pollock (-0.915). As the own-price elasticities are negative, they are consistent with theory.

After the structural break the own-price elasticities have changed significantly. During this period 3 out of 4 are negative and statistically significant. The own-price elasticities of cod (-0.581), saithe (-0.388) and pangasius (-0.267) have dropped significantly in absolute terms. Their own-price elasticities have gone from being elastic to inelastic. This indicates that cod, saithe and pangasius have become necessities after the structural break. According to FAO (2014) demand for fish products has in general increased, which might have contributed to these species becoming necessities. Pangasius has the lowest price compared to the other species; hence demand for pangasius might perhaps not change substantially with a small increase in the price. An other reason for why pangasius may be seen as a necessity is that it has become a regular addition on hotel-and restaurant menus due to a steady production/supply of the specie (Asche et al., 2009b). Changing menus might be more costly for hotels and restaurants compared to a small change in the price of pangasius.

8.2 Cross-Price Elasticities

During the first period only 3 out of the 12 uncompensated elasticities are statistically significant. However, during the period after the structural break 7 out of the 12 uncompensated cross-price elasticities are statistically significant. Though, Deaton and Muellbauer (1980b) criticizes the cross-price elasticities for being rather difficult to calculate with great precision, hence it is important to interpret them with care. Despite that only a few of the cross-price elasticities are statistically significant during the period before the structural break it is worthwhile briefly commenting the elasticities that are statistically significant. Still, it is necessary to be cautious when interpreting the results of the cross-price elasticities due to the difficulties of computing them with great precision. Among the cross-price elasticities that are statistically significant most of them carry a negative sign suggesting that certain species are regarded as compliments to one another while the rest of them are regarded as substitutes.

8.2.1 Cod

There is a positive relationship between cod and saithe (0.065) during the first period, suggesting that as the price of saithe increases, demand for cod will increase. This indicates that cod and saithe are weakly substitutes. However, during the second period we see that this relationship has changed as the cross-price elasticity has become negative suggesting that cod and saithe have become compliments (-0.083). Though, the cross-price elasticities in both periods suggest that a change in the price of saithe only has a insignificant effect on cod as they are fairly close to zero.

During the period after the structural break, we see that pangasius has an effect on cod. The cross-price elasticity between cod and pangasius is negative, which is a surprising result, as we would perhaps not expect them to be complimentary to one another.

8.2.2 Saithe

During the period before the structural break, the cross-price elasticity between cod and saithe (0.972) is close to one and positive, which suggest that they are close substitutes. Though, it is interesting to see that a change in the price of cod has a stronger affect on saithe than vice versa. During the period after the structural break the cross-price elasticity between saithe and cod (-0.420) becomes negative. It is somewhat surprising that cod and saithe becomes complimentary in the second period due to their strong positive relationship during the first period. However, the relationship in the second period is not as strong as in the first period.

8.2.3 Alaska Pollock

The cross-price elasticity between Alaska Pollock and saithe (-0.178) during the first period is negative but somewhat small indicating that they are weakly complimentary goods. The cross-price elasticity between the two species remains negative during the second period but the magnitude of the cross-price elasticity has increased in absolute value from -0.178 to -0.986. During the period after the structural break, the cross-price elasticity between Alaska Pollock and pangasius (-0.522) is also statistically significant and negative suggesting that they are compliments.

8.2.4 Pangasius

During the period before the structural break none of the cross-price elasticities between pangasius and the other species are statistically negative. However, this is not a surprising result, as pangasius had not entered the market to a significant extent at this stage. Though after the structural break, it is shown that 2 out of the 3 cross-price elasticities are negative and statistically significant. The result reveals that cod and Alaska Pollock are compliments to pangasius. Hence, as the price of either cod or Alaska Pollock increases then the consumers will demand less of pangasius. Asche et al. (2009a), state that pangasius is often used in processed food due to its low price and the subtle flavour. Alaska Pollock is in addition to pangasius also often used in fish sticks and other breaded and battered fish products, hence it is perhaps not a surprising result that pangasius and Alaska Pollock are regarded as compliments. It might be that demand for these product forms have changed due to other factors.

8.3 Expenditure Elasticities

The expenditure elasticity or income elasticity measures the responsiveness of a change in expenditure on demand of a good, where expenditure is a proxy for income. The expenditure elasticities are important among fishermen and producers of fish products in terms of forecasting and planning purposes (Haque, 2006). For normal goods we expect the expenditure elasticities to be positive, which they are in this case. The estimated income elasticities are all statistically significant at a 5% level and positive in both periods although the magnitude of the elasticities differs across species.

When comparing both periods it is shown that Alaska Pollock is the most sensitive specie to a change in income, closely followed up by pangasius, cod and saithe. The results suggest that Alaska Pollock is regarded as the most exclusive specie, while the remaining species are considered as necessities. The fact that Alaska Pollock turn out to be a luxury good is not as expected due to the fact that it is considered as a low-cost specie. The same argument applies to pangasius, which is also considered as being a-low-cost specie. During the first period the results suggest that pangasius is a luxury good, however during this period pangasius had not entered the market to a significant extent hence we do not take the income elasticity of pangasius in the first period into much consideration. In the second period pangasius is in fact considered as a necessity but its elasticity is fairly close to one.

It is perhaps not surprising that cod is considered as being a necessity ($A_i < 1$). Cod has the highest market share compared to the other species throughout both periods, which indicates that it stands for a greater part of peoples consumption habits compared to Alaska Pollock, saithe and pangasius. Hence, increases in income will not necessarily generate a much higher consumption level of cod as it is already consumed to a great extent.

As all of the income elasticities are statistically significant and positive each specie will gain from income-induced increases in market size (Xie, Kinnucan, & Myrland, 2009). Though the distribution of the benefit varies among the species, where Alaska Pollock gains the most, closely followed up by pangasius, cod and saithe. A decrease in the income of consumers in the EU will therefore harm producers and fishermen of Alaska Pollock the most.

8.4 Hicksian Elasticities

The Hicksian elasticities, also known as compensated elasticities, are computed in order to gain further insight into the relative strength of both the substitution effect and the price effects (Xie & Myrland, 2010). The compensated elasticities compensate for the income effect and is therefore often smaller in absolute value compared to the Marshallian elasticities, which we can see from table 11 that it is also the case here.

Before the structural break all 4 own-price elasticities are negative and statistically significant. Similar to the uncompensated elasticities the own-price elasticity of pangasius (-1.312) is the most elastic in the first period followed up by saithe (-1.066), Alaska Pollock (-0.613) and cod (-0.551). Though, as earlier mentioned pangasius had not entered the market to a significant degree in the first period, hence we do not take the magnitude of the own-price elasticity of pangasius as given during this period. The own-price elasticities of both cod and Alaska Pollock suggest that they are both relatively inelastic while the elasticity of saithe suggests that saithe is elastic. This suggests that cod and Alaska Pollock are not as responsive to a change in their own price as saithe is.

During the second period only the own-price elasticities of saithe and Alaska Pollock are statistically significant at a 5% level. The magnitudes of their elasticities have dropped compared to the first period. The elasticity of Alaska Pollock has not dropped considerably and it still remains relatively inelastic to a change in its own price. However, the same does not apply for saithe that has gone from being elastic to relatively inelastic.

Among the estimated compensated elasticities, 6 out of 12 cross-price elasticities are statistically significant in the period before the structural break, while 3 out of 12 are statistically significant after the structural break. As illustrated in table 11 the strongest substitutes in the first period in a ranked order are as follows: Pangasius-cod (1.275), saithe-cod (1.171), Alaska Pollock-cod (0.754), cod-Alaska Pollock (0.286), cod-pangasius (0.136) and cod-saithe (0.128). An interesting result is that an increase in the price of cod has a larger effect on pangasius, saithe and Alaska Pollock than vice versa. This essentially means that cod has a stronger substitution effect on these species than the other way around, which is perhaps not a surprising result considering that cod has the highest market share.

As cod is more costly compared to the other species it is also plausible that when the price of cod increases even further, consumption will shift towards one of the other species if they are regarded as close substitutes. If the price of less costly species such as Alaska Pollock, pangasius or saithe increases, the effect is likely to be less than in the case where the price of cod increases.

During the second period the species that conveys the strongest substitution effects are as follows: Alaska Pollock-cod (0.452), Cod-Alaska Pollock (0.208) and Alaska Pollock-saithe (0.118). The results show that after the structural break the substitution effects are not as strong as in the case before the structural break. The cross-price elasticity between Alaska-Pollock and cod has decreased from 0.754 in the first period to 0.452 in the second period. It is also interesting to see that during the second period none of the cross-price elasticities between pangasius and the other species are statistically significant.

The fact that the Hicksian elasticities do not display significant relationships for pangasius may suggest that pangasius do not operate in the same market as cod, Alaska Pollock and saithe. However the Marshallian cross-price elasticities suggest otherwise. Hence it is somewhat unclear if pangasius do operate in the whitefish market.

9. Concluding Remarks

Despite the vast changes that has occurred in the global seafood markets during the last couple of decades, there has not been conducted many demand studies on the whitefish market. Important factors that have contributed to these changes are the expansion in aquaculture production, and the reduction in catch of wild fish. Aquaculture species play an important role in changing the global seafood markets. Given globalization and trade, we see new species entering already existing markets, such as the whitefish market (Asche et al., 2009b). As there has not been conducted much research on demand relations in the whitefish market, this master thesis will contribute to fill this gap in the literature. The objective of this thesis has been to investigate the demand structure in the European Union's whitefish market, given the entry of low-cost species such as pangasius. By applying the LA/AIDS model, the demand elasticities for cod, saithe, Alaska Pollock and pangasius were estimated. These estimates were based on monthly trade data provided by Capia. I have made some adjustment to the LA/AIDS model in order to avoid spurious estimation results. Still, it is important to interpret the estimation results with care.

Given that the species in question did not enter the market during the same time period, one must take this into account in order to avoid spurious estimation results. It is challenging to evaluate the impact of new species, unless one accounts for structural breaks (Asche & Zhang, 2013). Accounting for structural breaks for each of the species can be rather challenging. Hence the solution has been to limit the dataset up until the point where all of the species had entered the market; namely the period from January 2000 including December 2014. As the aim of this research is to review the effect the increase in pangasius imports has had on the market, I chose to include a dummy variable in the model that accounts for this increase. By doing so, I could compare the period before the large increase in pangasius imports, and after, to see if the species have had an effect on EU's whitefish market. The Sup-Wald statistics revealed that there was a structural break for pangasius in June 2005.

Cod has dominated the whitefish market since the 1980s. However, as shown in figure 1, its market share started to stagnate given the entry of new species. When comparing the average market shares for the period before and after the structural break, one can see that the market share of cod has dropped the most among the species in question; from a staggering 62.6% to 45.1%, while the market share of pangasius increased from 6.7% to 27.4%. This may suggest that pangasius has taken over market shares from cod, as the market shares for the other species have remained somewhat stable. However, the parameter that accounts for the structural break of pangasius is not statistically significant. This indicates that the increase in pangasius imports has not had a significant impact on the demand for the other species in question. Still, the demand elasticities found for the period before the entry of pangasius differs from those found for the period after.

The degree of the substitution effects varies across species, while the expenditure elasticities are all close to 1 and positive (apart from that of saithe) during both periods. According to Asche et al. (2005) a focal point for the own-price elasticities is -1. During the first period, cod, Alaska pollock and saithe have own-price elasticities fairly close to -1. This basically tells us that they are not likely to face much competition from other species. However, during the period after the structural break, the own-price elasticity of cod, pangasius and saithe dropped considerably in absolute terms, making them necessities. One factor that may have contributed to these species becoming necessities, other than the increase in pangasius imports, is the increasing demand for fish products in general. Though, there might be other factors that have contributed to changing the demand elasticities for the given periods that the model fails to account for.

The Marshallian cross-price elasticity suggests that pangasius and cod are in fact weakly complimentary goods. This is an unexpected result, as it does not coincide with the findings of Asche and Zhang (2013). They show that there is seemingly a substitution effect between tilapia and cod in the U.S market. Due to the fact that pangasius and tilapia share similar characteristics, one would have expected a similar result to that of Asche and Zhang (2013). Though, the fact that it is challenging to compute cross-price elasticities with great precision, one cannot rely on cross-price elasticities with utmost certainty.

Considering the continuous development in aquaculture, it is expected that this area will receive more attention in the future. New species might enter the whitefish market, and lead to further structural changes. This master thesis has focused on the European Union. However, there might be differences across countries within the EU that the model does not capture. It would therefore be interesting to conduct further research on the whitefish market by applying the model to different countries within the EU. By doing so, noteworthy differences across countries could be revealed. Huge differences across countries may have caused ambiguous estimation results during this research.

With this master thesis I have contributed to further knowledge regarding the effect pangasius has on already established wild-fish species in the whitefish market. The results suggest that the increase in pangasius imports has not had a significant effect on the demand for cod, saithe nor Alaska pollock. This study shows that pangasius is perhaps not a threat for already established species in the whitefish market.

References

Alston, J., & Chalfant, J. (1993). The Silence of the Lambdas- A Test of the Almost Ideal and Rotterdam Models. *Am. J. Agr. Econ., 75*(2), 304-313.

Anderson, J. L. (2002). Aquaculture and the Future: Why Fisheries Economists Should Care. *Marine resource economics, 17*(2), 133-151. doi: 10.2307/42629357

Asche, F. (2014). EU-markedet for fisk (og norsk torskeeksport). University of Stavanger.

Asche, F., Bjørndal, T., & Gordon, D. V. (2005). Demand structure for fish: SNF.

Asche, F., Bjørndal, T., & Young, J. (2001). Market interactions for aquaculture products. *Aquaculture Economics & Management, 5*(5-6), 303-318. doi: 10.1080/13657300109380296

Asche, F., Roll, K. H., & Trollvik, T. (2009a). New aquaculture species—The whitefish market. *Aquaculture Economics & Management, 13*(2), 76-93. doi: 10.1080/13657300902881641

Asche, F., Roll, K. H., & Trollvik, T. (2009b). New aquaculture species. Entering the whitefish market. 1-29.

Asche, F., & Wessells, C. R. (1997). On price indices in the almost ideal demand system. *Am. J. Agr. Econ., 79*(4), 1182-1185.

Asche, F., & Zhang, D. (2013). Testing structural changes in the U.S whitefish import market: An inverse demand system approach. *Agricultural and Resource Economics Review, 42*(3), 453-470.

Balata, F., Devlin, S., Esteban, A., & Crilly, R. (2014). Fish dependence-2014 update. neweconomics.org.

Barnett, W. A., & Seck, O. (2008). Rotterdam model versus almost ideal demand system: will the best specification please stand up? *Journal of Applied Econometrics, 23*(6), 795-824. doi: 10.1002/jae.1009

Beukers, R., Van Duijn, A. P., & Van der Pijl, W. (2013). Pangasius in the EU market. Netherlands.

Bostock, J., McAndrew, B., Richards, R., Jauncey, K., Telfer, T., Lorenzen, K., . . . Corner, R. (2010). Aquaculture: global status and trends. *Philosophical Transactions of the Royal Society B, 365*(1554), 2897-2912. doi: 10.1098/rstb.2010.0170

Buse, A. (1994). Evaluating the linearized almost ideal demand system. *American journal of agricultural economics, 76*(4), 781-793.

Bush, S., Khiem, N. T., & Sinh, L. X. (2009). Govering the Environmental and Social Dimensions of Pangasius Production in Vietnam: A Review. *Aquaculture Economics & Management, 13*(4), 271-293. doi: 10.1080/13657300903351594

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

Deaton, A., & Muellbauer, J. (1980b). *Economics and consumer behavior*: Cambridge university press.

E.U.D.N. (2015). Trade relations EU-Norway. Oslo: European Union Delegation to Norway.

Eriksen, M., & Martinsen, G. (2008). Utenlandsk fisk populært. *NRK*. Retrieved from http://www.nrk.no/nordland/utenlandsk-fisk-populaert-1.5357520

FAO. (2014). The State of World Fisheries and Aquaculture 2014. Rome: FAO.

Fiebig, D. G. (2001). Seemingly unrelated regression. *A companion to theoretical econometrics*, 101-121.

Green, R., & Alston, J. (1991). ELASTICITIES IN AIDS MODELS - A CLARIFICATION AND EXTENSION. *Am. J. Agr. Econ., 73*(3), 874-875.

Hanh, B. L. T. (2009). Impact of financial variables on the production efficiency of Pangasius farms in An Giang province, Vietnam. Tromsø: University of Tromsø.
Haque, M. O. (2006). *Income Elasticity and Economic Development: Methods and Applications*: Springer US.
Hildenbrand, W. (1983). On the "Law of Demand". *Econometrica, 51*(4), 997-1019. doi: 10.2307/1912048
Hill, R. C., Lim, G. C., & Griffiths, W. E. (2012). *Principles of econometrics* (4th ed. ed.). Hoboken, N.J: Wiley.
Krag, L. A., Holst, R., Madsen, N., Hansen, K., & Frandsen, R. P. (2010). Selective haddock (Melanogrammus aeglefinus) trawling: Avoiding cod (Gadus morhua) bycatch. *Fisheries Research, 101*(1–2), 20-26. doi: http://dx.doi.org/10.1016/j.fishres.2009.09.001
Little, D. C., Bush, S. R., Belton, B., Thanh Phuong, N., Young, J. A., & Murray, F. J. (2011). Whitefish wars: Pangasius, politics and consumer confusion in Europe. *Marine Policy, 36*(3), 738-745. doi: 10.1016/j.marpol.2011.10.006
Lysvold, S. (2009). Torskens verste fiender. *2015*(15 October). http://www.nrk.no/nordland/torskens-verste-fiender-1.6472351
Miyake, M. P. (2010). *Recent developments in the tuna industry : stocks, fisheries, management, processing, trade and markets*. Rome: Food and Agriculture Organization of the United Nations.
Moschini, G. (1995). Units of measurement and the stone index in demand system estimation. *American journal of agricultural economics, 77*(1), 63-68.
Muir, J. F., & Young, J. A. (1999). Strategic issues in new species development for aquaculture. *Elsevier Biofutures Series*(XXXIII International Symposium on New Species for Mediterranean Aquaculture), 85-96.
NOFIMA. (2015). Whitefish Report Summary (pp. 1-3). CORDIS.
Okrent, A. M., & Alston, J. M. (2011). *Demand for Food in the United States: A Review of Literature, Evaluation of Previous Estimates, and Presentation of New Estimates of Demand*. Richmond: University of California.
SEAT. (2011). Struan Stevenson Learns About Pangasius From SEAT. http://seatglobal.eu/2011/04/struan-stevenson-learns-about-pangasius-from-seat/ - .VSt_vmaYnV1
Spiegel, U. (1994). The case of a “Giffen good”. *The Journal of Economic Education, 25*(2), 137-147.
StataCorp. (2013). lrtest-Likelihood-ratio test after estimation. College Station: StataCorp LP.
Statista. (2012). *Top 10 importers of fish and fishery products worldwide in 2012 (in million U.S. dollars)*. Retrieved from: http://www.statista.com/statistics/268266/top-importers-of-fish-and-fishery-products/
Subasinghe, R. (2005-2015). State of World Aquaculture. FAO: FAO.
Taljaard, P., Alemu, Z., & Van Schalkwyk, H. D. (2004). THE DEMAND FOR MEAT IN SOUTH AFRICA: AN ALMOST IDEAL ESTIMATION. *Agricultural Economics Research, Policy and Practice in Southern Africa, 43*(4), 430-443. doi: 10.1080/03031853.2004.9523659
Thyholdt, S. B. (2015). *Just like putting scissors to a market : investigation supply and demand relations of farmed Atlantic salmon.* UiT The Arctic University of Norway, Faculty of Biosciences, Fisheries and Economics, School of Business and Economics, Tromsø.

Valdimarsson, G. (2007). *Challenges for the global seafood industry.* Paper presented at the Sixth World Congress on Seafood Safety, Quality and Trade: 14-16 September 2005, Sydney, Australia.
Van Schalkwyk, H. P. (2003). DEMAND RELATIONS OF OILSEED PRODUCTS IN SOUTH AFRICA: AgEcon Search.
Washington, A. A., & Kilmer, R. L. (2002). The production theory approach to import demand analysis: A comparison of the Rotterdam model and the differential production approach. *Journal of Agricultural and Applied Economics, 34*(3), 431-444.
Wright, J. (2012). ASC recognizes Vietnam's pangasius 'pioneers'. http://www.seafoodsource.com/news/aquaculture/13602-asc-recognizes-vietnam-s-pangasius-pioneers
WWF. (2013). Moving forward to a sustainable pangasius industry. panda.org: World Wildlife Fund.
Xie, J., Kinnucan, H. W., & Myrland, Ø. (2009). Demand elasticities for farmed salmon in world trade. *European Review of Agricultural Economics, 36*(3), 425-445. doi: 10.1093/erae/jbp028
Xie, J., & Myrland, Ø. (2010). Modeling market structure of the Spanish salted fish market. *Acta Agriculturae Scandinavica, Section C — Food Economics, 7*(2-4), 119-127. doi: 10.1080/16507541.2010.531942