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# The effect of Norwegian biomass on French import prices of salmon.

The relationship between Norwegian biomass of farmed salmon and import prices of different Atlantic salmon products.
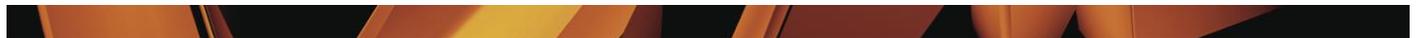
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Field of Study - Innovation, Organisation and Management (30 credits)

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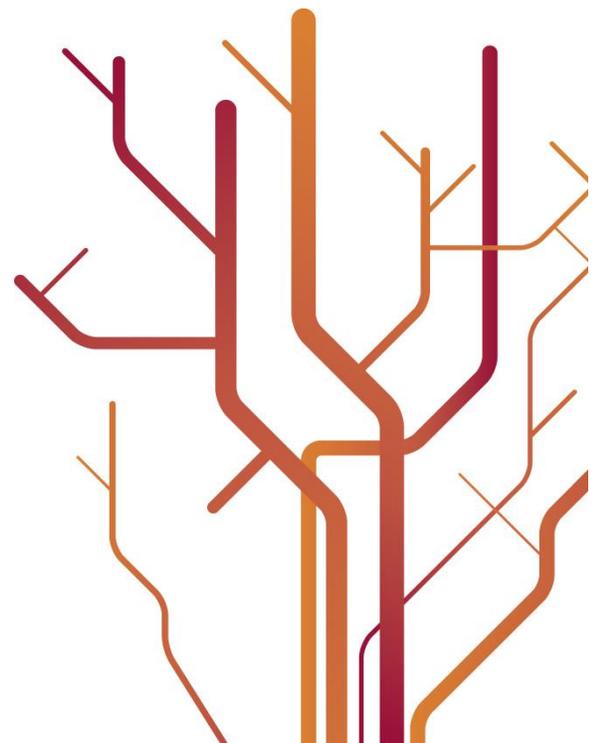
Acknowledgements

With this master thesis I am finishing my fishery candidate degree from the Norwegian College of Fishery Science, University of Tromsø. A somewhat long journey is about to end. I want to express great gratitude to those who made this thesis possible. To my co-advisor Jinghua Xie, for her guidance in programming and feedback throughout the process. To Professor Øystein Myrland, my advisor, for constructive feedback and new perspectives. For providing data and insight in the French salmon market I would like to thank my former colleague and good friend, Paul Aandahl, who is senior analyst at the Norwegian Seafood Council. To my good friend Stian Staven, customer service advisor at Ewos, for providing useful insights in salmon farming and the feed industry. Last, my good friend and former fellow student, Uladzimir Kamovich, for useful feedback.

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Tromsø, 15.05.2013

Tormod Viken Johannessen

Abstract

In this master thesis, I have investigated the relationship between the Norwegian biomass of farmed salmon and import prices of different salmon products in France. By using an Inverse Almost Ideal Demand System (IAIDS) model, imports and biomass data has been modeled. This is a new perspective in salmon price analysis, and has not been performed previously. Own- and cross-price flexibilities and scale flexibilities have been calculated for all the products. The effects on price of growth in biomass and import quantity have also been modeled and presented. The estimated flexibilities of the products are also a new, and few, if none, comparable studies of similar aggregated groups exist.

The results of the investigation permit to state that the strongest relationship between biomass and import prices is found in the fresh products. I have not been able to find significant and reliable results in the frozen and smoked category. The flexibilities are to some extent in accordance with the limited literature in the field. The effects of changes in import and biomass are the most sensitive for changes in import quantity. This is a result of limited significant and reliable biomass flexibilities, and that biomass is indirectly affecting import prices.

Keywords: IAIDS (Inverse Almost Ideal Demand System), Atlantic salmon, France, flexibilities, inverse demand, biomass, inventory,

Sammendrag

I denne oppgaven har jeg sett på sammenhengen mellom biomasse av oppdrettslaks i Norge og importpriser av forskjellige lakseprodukter i Frankrike. Dataene for biomasse og import er modellert med en invers AIDS modell. Dette er et nytt perspektiv i prisanalyse av laks, og har ikke blitt utført tidligere. Egen- og kryssprisfleksibiliteter og skalafleksibiliteter er kalkulert for alle produktene. I tillegg er effekten på pris av endringer i biomasse og import volum analysert. De estimerte fleksibilitetene er også ny, da få, eller ingen, sammenlignbare studier av tilsvarende produktaggregering eksisterer.

Resultatene konkluderer med at den sterkeste sammenhengen mellom norsk biomasse og importpriser er funnet i den ferske kategorien. Man har ikke vært i stand til å finne signifikante og reliable resultater i den fryste og røkte kategorien. Fleksibilitetene er i samsvar med den begrensete litteraturen som finnes på fagfeltet. Effekten av økt import viser seg å være mest prissensitiv. Kun et fåtall av biomassefleksibilitetene er signifikante og reliable. Effekten av endringer i biomasse er mindre enn effekten av endringer i import. Dette kommer som et resultat av at biomasse er en indirekte effekt, mens import er direkte.

Contents

1. Introduction

The global production of Atlantic salmon was nearly 2 million tons in 2012. Norway accounted for nearly 60% of the global supply. Even though the world trade has become globalized over the years, the most important market-region for Norwegian salmon is the EU. Nearly 70% of the salmon produced in Norway is consumed in EU, mainly as a fresh product. Within the EU, France is the most important salmon market (P.Aandahl 2013, pers.comm. 9th April). France is considered as a reference market in development, trends and market growth (Asche et al. 2011). In order to regulate the Norwegian production of farmed salmon, the Norwegian government imposed strict regulations to control the production of Atlantic salmon. One of the regulations imposed from 1. January 2005 is the amount of biomass allowed per license (Fiskeridirektoratet 2004). To ensure that farmers kept within the framework of the legislation, a mandatory reporting system was developed. The Norwegian Directorate of fisheries has at each given time data of the current biomass of every license released. If a farmer exceeds the Maximum Allowed Biomass (MAB), the biomass must be reduced by slaughtering in accordance of what is the most economic and biological profitable. The growth of salmon is mainly determined by light and temperature: the brighter and higher temperature (to a certain degree), the more rapid growth (S.Staven 2013, pers comm. 27th March). From an economic perspective, a smaller salmon is priced lower than larger salmon. Hence, reducing biomass in locations were the average size of the salmon is small is not considered profitable. Another economic and biological perspective is that salmon reach sexual maturity at a given time, and the value and growth will, then, rapidly decrease.

In order to analyze if there is a relationship between salmon prices in France and the Norwegian biomass, I consider the biomass as an inventory variable in an inverse demand system. Considering the biomass as an inventory variable in a demand system is to some extent a new direction in the field of price analysis of salmon. There are quite a few studies where inventory has been used in forecasting and demand models. In the literature, inventory is mainly considered as what is available to the market, in other words; what is stored in a warehouse. The uniqueness of considering the biomass as inventory is that the biomass is alive and growing. In addition, a fairly large proportion of the biomass is not available for sale. Salmon farming moves in cycles with varying growth. It is more profitable to utilize periods with high growth, than selling in

periods with low growth and higher prices (Guttormsen 2013). However, the biomass is limited by regulations and biological restrictions, which in turn limits the farming time of salmon and the weight of the biomass.

The most important products are; fresh fillet and whole, frozen fillet and whole, and smoked. The data of these products are present in our set. The product, fresh fillet and whole, is not possible to be held as an inventory in long terms, as opposed to frozen salmon, and to some extent, smoked salmon. Retail and HoReCa is therefore dependent on selling fresh products at a much higher pace, due to a limited shelf life.

In the literature, models often are estimate on larger aggregated groups, rather than a product level. Therefore, it is of interest to analyze the own- and cross-price flexibilities, and the scale flexibilities of the products. The estimate flexibilities will be used to analyze the effect on prices of volume changes in import and biomass. Then, we can see what leaves the largest impact on changes in price.

This thesis is divided into six chapters. The first chapter is background information about Norwegian salmon farming and the French salmon market. In addition, a description of the problem positioning and what is investigated throughout the thesis. In Chapter 2, the literature is reviewed, both with similar studies of inventory and demand studies of salmon. The data used in the thesis is presented in Chapter 3. The methodology and the derived econometric model are presented in Chapter 4. In Chapter 5 the results are presented. Last, a summary with concluding remarks is presented.

1.1 Problem positioning

In this thesis I want to determine how import prices of different Atlantic salmon products are affected by the current biomass in Norway. This relationship is not widely studied and has never been done before on salmon. By using an inverse demand model and lagging the biomass variable, I hope to get reliable and significant results. One can expect that there is a negative relationship between the biomass and price. However, I expect different relationship for the products used in the model. This is also consistent with expectations from the literature e.g. (Chiang et al. 2001). In my study I expect a better fit for the fresh products since they are more adaptable to price changes. As I will mention later, I can only increase the amount of lags to a certain degree to account for the cycles in salmon farming. Then, when dealing with the products that require more time to adjust their price to the biomass, it is expected that these products will show a less significant connection since the model have a given lag structure imposed.

In my study, the scale and price flexibilities both own- and cross price can be extracted. To my knowledge, there are no other studies that look at the scale and price flexibilities at the same aggregated level as in this thesis (besides smoked salmon). Normally, in other studies categories as total fresh and frozen, and even larger aggregated groups (e.g. medium value fresh fish where salmon is included) are used. The approach applied in the thesis is rather unique, and few, if any, similar studies exist. The assumptions of the flexibilities were limited as there is little literature with the same product aggregation as used in this thesis. However, I assume that smoked salmon would be more luxurious than other products. I will also determine how prices of the different products change in accordance with changes in both the biomass and import. It is expected that changes in import will yield larger changes than changes in the biomass. This is because the biomass is indirectly affecting the prices, while the import quantity is a direct effect.

1.2 The French salmon market

France has for a very long time period been the most important market for Norwegian salmon. 2012, was the first year when another country, Russia, nearly passed France both in value and volume of salmon. Nevertheless, France is still a very important salmon market, which is ranked first both in value and volume. France is considered as a reference market for both trends and development in consumption of salmon, and the products have a much larger product variety than found elsewhere (Asche et al. 2011). According to the senior analyst at the Norwegian Seafood Council (NSC), Paul Aandahl, there has never been consumed as much fresh salmon, both in volume and frequency as in France in 2012. Paul Aandahl, refers to consumer panel data from Europanel. From focus group research performed on French consumers, the preference for salmon is beyond any other seafood products, mainly because of the availability, taste, texture and a fair price in comparison with other sources of protein and seafood products (P.Aandahl 2013, pers.comm. 9th April).

In 2012, 44% of total salmon home consumption consisted of fresh salmon, where fillets constituted 84% of the volume and the remaining 16% were the fresh whole salmon. The share of whole fresh salmon sold for household consumption in France is fairly small in comparison with the import level. Conclusions made by Asche et al. (2011) state that a large proportion of the value-adding processes take place within the EU, and that this also applies to the French market for Atlantic salmon. However, the level of processing is decreasing in France, and other EU-countries are taking market shares (P.Aandahl 2013, pers.comm. 9th April). This decrease is also observed in the import statistics and discussed in the data section.

Smoked salmon accounted for 38% of total salmon home consumption in 2012; however at the import level, it only constituted 4% of the volume on average in the data set. Smoked salmon has a very strong position in the French market, and is the largest market for smoked salmon. (P.Aandahl 2013, pers.comm. 9th April). This is supported by Asche et al. (2011) who concluded that there still is a large smoking industry in France.

Frozen salmon had a market share of 15% of total salmon home consumption in 2012, where fillets constituted the majority of the volume (96%). The imported fillets are mainly sold for home consumption as finished products. These products are easy to prepare, and often marinated, breaded or seasoned. Frozen whole salmon is mainly used in food service and rarely sold for

home consumption (P.Aandahl 2013, pers.comm. 9th April). The market share of frozen fillets in home consumption is equal with the imported market share.

2. Literature review

Studies on the demand for salmon is a widely examined topic and has been of increased interest the last couple of years as salmon farming has advanced. Generally, the functional form of salmon demand can be divided into two categories: inverse and ordinary demand models. These sub-categories can be divided even further into new categories, but I will only present the most relevant literature for this thesis. Xie et al. (2008) studied how the export price of farmed salmon was affected by the exchange rates from the exporting countries. By using an inverse CBS model, they concluded that the changes in exchange rate was as important for changes in prices, as changes in volume exported. They also calculated the flexibilities of different salmon products, which is important as a basis for comparison in my study. Oglend and Sikveland (2008) studied the volatility in salmon prices. They concluded that the higher price, the more volatile the price is. In periods with large shocks, price- forecasting is a difficult task, because the market has to correct for large changes. Asche et al. (1999) studied product aggregation and market integration, and investigated the relationship between the prices of different products and species of salmon in a global perspective. They concluded that farmed Norwegian salmon competes in a global market and will be substituted with other salmon species as long as the price is in favor of the Pacific species. In addition, in a long-run perspective, the price of the different species and product categories (fresh and frozen) will move together. There are some studies that look into the willingness of paying more for origin and quality. Asche and Sebulonsen (1998) studied how Atlantic salmon from Norway and Scotland operated in the same markets. They concluded that consumers did not distinguish between the two producing countries, and that difference in price was as the result of a smaller supply of Scottish salmon rather than preference.

The demand of both farmed and wild caught salmon has been researched globally (DeVoretz and Salvanes 1993; Xie et al. 2009), in the EU region (Asche et al. 1997; Nielsen 1999; Chiang et al. 2001), and in France (Asche et al. 2011; Xie and Myrland 2011). By using different demand systems, they determined how the demand of salmon has moved through time and how salmon is positioned in the market among other seafood products. The usage of a higher aggregate product group (e.g. total fresh, total frozen) is a common trait of those studies, compared to this thesis, as I use lower aggregated product groups (e.g. fresh fillet, fresh whole).

In addition, there are a few studies that not necessarily are methodically relevant, but relevant in the sense of understanding how the market for farmed salmon is developing. Looking at the market structure, studies by using endogeneity (DeVoretz and Salvanes 1993) and cointegration test (Asche et al. 2005), one can determine how salmon behave in the market.

The Inverse Almost Ideal Demand System (IAIDS) model was first proposed by Eales and Unnevehr (1994) and has been used for a wide variety of studies of commodities: oranges (Brown et al. 1995); meat (Kesavan and Buhr 1995; Holt and Goodwin 1997); and different seafood products (Eales et al. 1997; Roth et al. 2001), where salmon is included. Roth et al. (2001) studied consumer preferences of quality graded fish, and salmon was one of them. However, they were not able to prove any differences in preference between two different quality grades of salmon. Eales et al. (1997) divided different products into categories of high-, medium-, and low-value fresh fish and studied the Japanese market for fish. By using different generalized models they studied such as the elasticities and flexibilities of the different categories.

There are many studies that look on the relationship between commodity inventory and price. One study explored the inventory to determine how future prices are affected when production and inventory costs increase or decrease (Tryfos 1974). Tryfos (1974) found that when production costs are low the inventory would increase, and livestock would be held back from the market. Brennan (1958) and Telser (1958) studied how future price are affected by changes in inventory. Brennan (1958) studied the demand of storage of agriculture commodities, while Telser (1958) included consumer demand of cotton and wheat. However, the results of both studies support that inventory have a close relationship with future prices.

Ye et al. (2002) used the inventory of crude oil from OECD countries to forecast the spot price. This study also supported that there are a close connection between inventory and future price.

However, there are very few studies where inventory is used as an explanatory variable to determine how it affects the price of easily perishable goods by using inverse demand models. Many studies used inverse demand models for easily perishing goods (Barten and Bettendorf 1989; Eales and Unnevehr 1994; Brown et al. 1995; Eales et al. 1997; Holt and Bishop 2002; Park et al. 2004; Wong and McLaren 2005; Xie et al. 2008) But none of the mentioned research

studies investigate the relationship between the biomass/inventory and price, except from (Chiang et al. 2001).

Chiang et al. (2001) studied the impact of inventory on tuna auction prices in Japan by using an inverse Rotterdam demand system. By using a scaling approach, they incorporated the inventory of tuna in the model. The data used in the analysis was monthly data of three different species in two product categories, fresh and frozen. The data was catch statistics from fishing vessels, and the price and quantity sold at wholesale fish markets. The authors found that auction prices were significantly affected by the inventory of tuna at the wholesale markets, and that there was a substitution between frozen tuna and a substitution of different products of the same species. Their results indicated that an inclusion of the inventory variables in the model increased its explanatory power. The scale effect was in accordance with their expectations, negative and statistically significant. This means that a proportional increase of the quantity of all products will decrease the price. The scale elasticities were lower for frozen tuna then fresh tuna, indicating that fresh tuna is more perishable; hence, fresh tuna is more susceptible to scale change.

3. Data

The data presented are quantitative monthly time series data, from 1. January 2002 through November 2012. The trade data is official French import statistics provided by the Norwegian Seafood Council. The biomass data is official Norwegian biomass statistics (Directorate of Fisheries 2013).

3.1 Trade data

Monthly French import data from 1. January 2002 through November 2012 is provided by the Norwegian Seafood Council (NSC). The data is aggregated to total import of fresh and frozen Atlantic salmon in the categories of whole, fillets, and smoked Atlantic salmon. The data is quantitative variables. The volume is given in amounts of tons in product weight and the value is given in 1000 Euros. The price is calculated by dividing the value on amount in tons. The unit price is given in CIF, which means that cost, insurance, and freight is included.

I separated the products to determine if the price structures are different in relation with the biomass in Norway. Xie and Myrland (2011) concluded that this was possible since salmon can be aggregated on product form, even though salmon products have been greatly differentiated in the French salmon market. It is reasonable to assume that value added products will need longer lag lengths to detect the link between price and biomass. The reasoning behind this assumption is that value added products tend to have stickiness in price movements (Guillotreau 2004).

Table 1: Average prices in Euros per kilo and product quantity in tons imported, maximum and minimum observations, and average market share

		Mean	Minimum	Maximum	Market share in Value and Volume
Price, Euro/ kilo	Fresh fillet	5.97	3.50	9.15	8%
	Fresh whole	3.84	2.62	5.77	64%
	Frozen fillet	5.20	3.80	7.47	17%
	Frozen whole	5.02	2.41	9.36	3%
	Smoked	9.64	7.19	12.37	9%
Volume, tons	Fresh fillet	605	70	2333	6%
	Fresh whole	7587	4315	13708	74%
	Frozen fillet	1435	714	2314	14%
	Frozen whole	268	42	819	3%
	Smoked	424	142	1353	4%

Fresh whole has the lowest mean price and the largest volume, with frozen fillets ranked as second largest in mean volume. A large proportion of fresh whole salmon is processed in France as smoked salmon. A very small proportion is sold to consumers as whole salmon, and often retailers slice the fish into useful sizes and portions.

Norway is the largest supplier of both fresh whole salmon and fresh fillets. The import of fresh whole salmon has nearly doubled from Norway from the year 2002 to 2012. Relatively speaking, the import of fresh fillets has increased over 1800% from Norway in the same time frame. Other Atlantic salmon producing countries like Faroe Islands, Great Britain, Ireland and Chile are present in the import statistics, but have, in comparison with Norway, a fairly small market share. The European producers have almost 100% market share of fresh salmon; however, when speaking of frozen salmon it is rather the opposite. The explanation is transportation costs and shelf life of fresh salmon. Chile is mainly exporting frozen salmon, and, on average, has the largest market share. Worth mentioning is the increase in import of frozen fillets from China[1].

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[1] The import of Atlantic salmon from China is a mix between Pacific salmon and Atlantic salmon. Due to difficulties separating them, and as a simplification, in this thesis the quantity is considered as Atlantic salmon.

The import of frozen fillets from China has increased from 830 tons in 2002 to 8165 tons in 2011, which makes them greater than Chile in 2011. China is not a producer of Atlantic salmon. It is assumed that salmon is re-exported from the growing processing industry in China. The origin is more uncertain, and it is most likely a melting pot consisting of different producing countries like Norway and Chile.
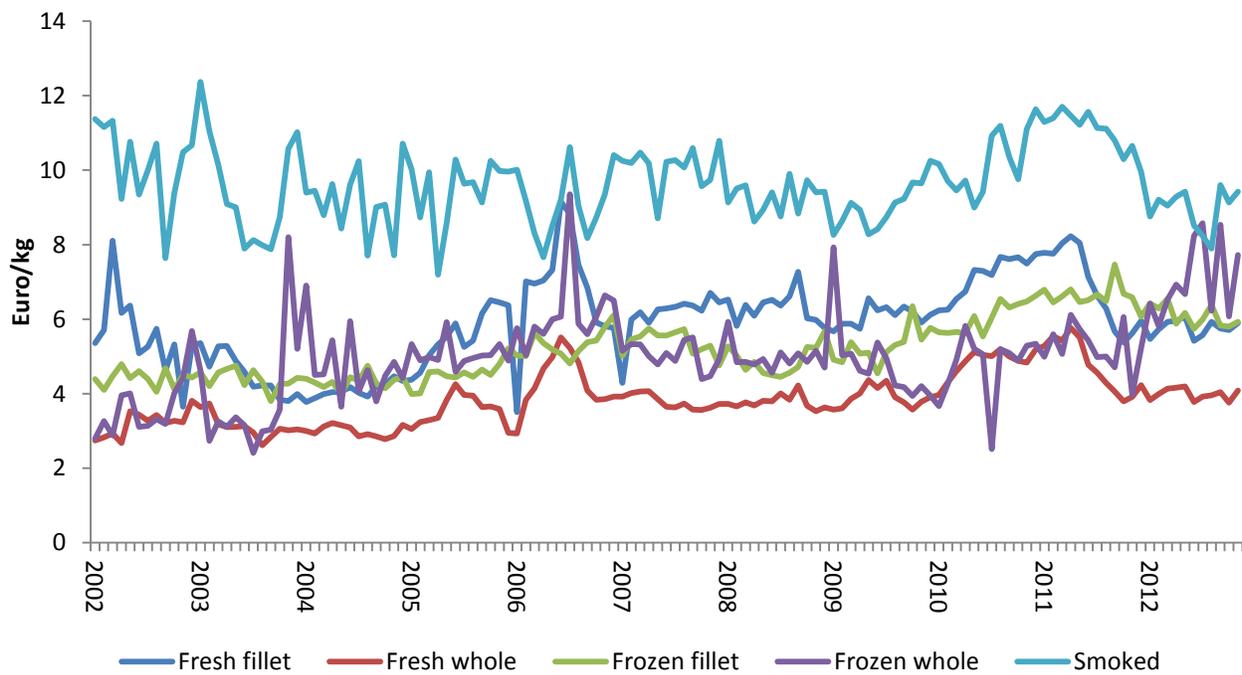
Figure 1: **Monthly average prices of products imported to France from January 2002 to November 2012**

From Figure 1, we can see that smoked salmon is in the highest price range, while fresh whole is in the lowest price range. This is reasonable due to level of value adding. Smoked salmon is considered as a more exclusive product in comparison with fresh salmon.
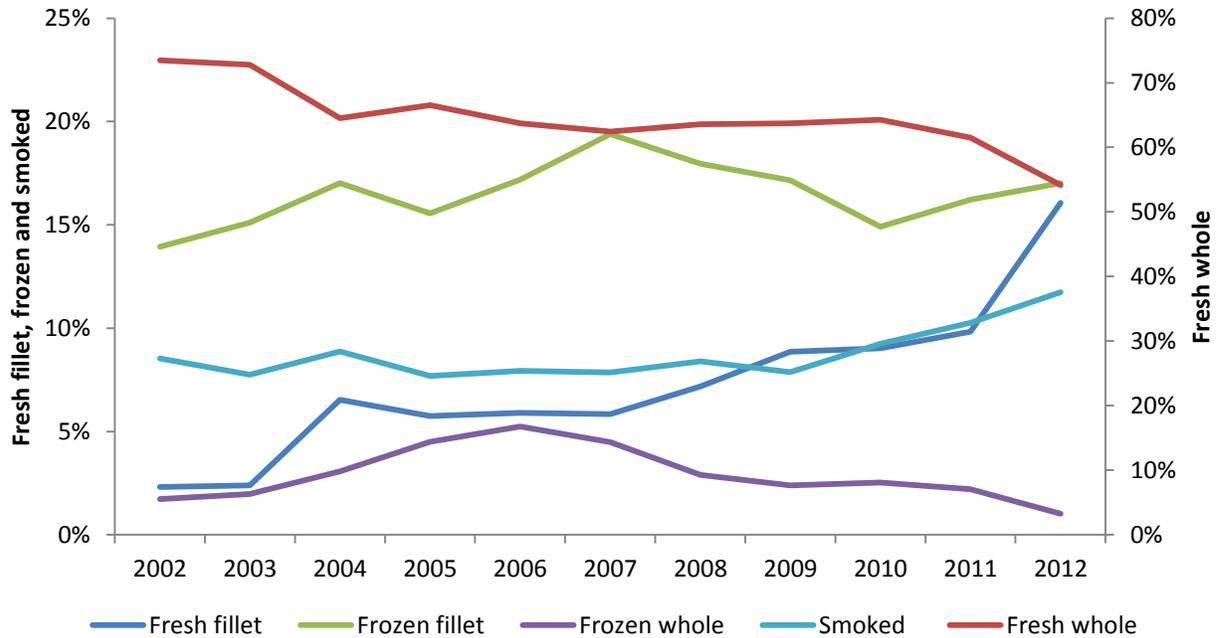
In Figure 2 the market share of value is plotted for each product. The average market shares of value and volume is provided in Table 1. Fresh whole salmon has decreased from 73% market share in 2002 to 54% in 2012. As mentioned the value-adding processes of salmon has decreased in France. Fresh whole salmon is often used for value-adding processes; this also applies to some extent for frozen whole salmon, while fresh fillets are not suitable for value-adding due to higher prices. The import of fresh fillets has increased from 2% market share in 2002, to 16% in 2012. Smoked salmon has increased its market share with 3% from 2002 to 2012. This is mainly driven by the development of a value adding industry in Poland. The import of smoked salmon from Poland was zero in 2002 and above 6000 tons in 2012. There is still a smoked salmon industry in France. Therefore, the demand for fresh salmon at an import level, is an aggregated demand for both smoked and fresh salmon (Xie and Myrland 2011).

The import share of whole salmon from Norway has been decreasing since Poland entered the smoked salmon industry. An explanation for this development could be that Norway has increased their export to Poland for value adding, and the smoked salmon is re-exported to France. The majority of salmon used for smoking in Poland has mainly a Norwegian origin, but other origins occur like, for example, Great Britain and Faroe Islands, etc. Another explanation

could be changes in preference towards more convenient products. When whole salmon is imported it requires processing, as whole salmon rarely is sold towards customers as whole salmon. Retailers often buy whole salmon and cut it into more convenient pieces, and sell it as fillets.

3.2 The Biomass variable

The biomass statistics is collected from the Norwegian Directorate of Fisheries online statistical portal. The data is aggregated to show the current status of the Norwegian biomass of farmed Atlantic salmon. The biomass is estimated by a mandatory reporting system that all farmers are obligated to follow. The biomass is given in amount of fish and average weight in each county in Norway. To calculate the biomass, we first multiply the amount of fish with the average weight in each county. Then, the biomasses in each county are added to each other, and we have the biomass in Norway. The data can be separated into different cohorts that are currently farmed; however, I have chosen to aggregate the data to total biomass. I have chosen this method because the cohort, who is due to slaughtering, constitutes a large proportion of the total biomass. Therefore, a separation of the cohorts is not necessary.
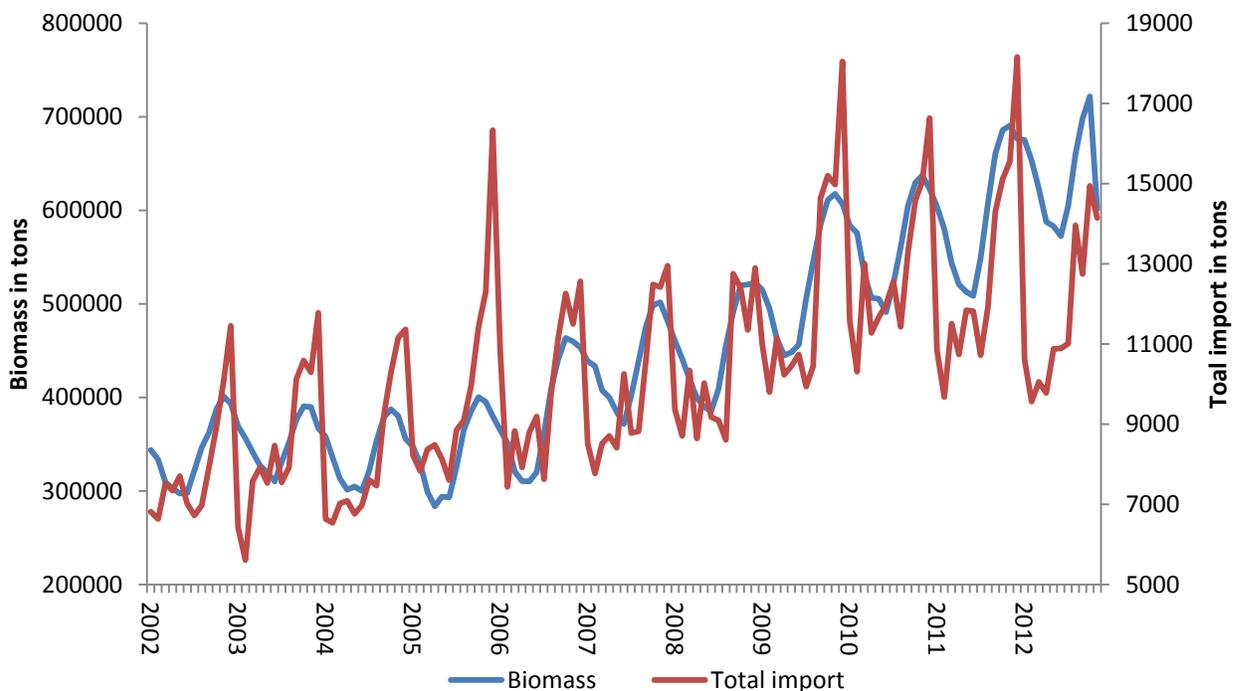
Figure 3: Monthly plot of total French import of Atlantic salmon and biomass of Atlantic salmon in Norway

The biomass has a limited inventory due to existing MAB regulation, and that fish reach sexual maturity (Oglend and Sikveland 2008). From Figure 3, we can see that the biomass drops rapidly each year around October/November. There is a specific reason for the fall. As initially mentioned, the farmers have to make both economic and biological decisions. The winter in Norway is dark and cold; hence; reduced growth. The growth of the salmon is what generates the profit in salmon farming. The plot of the biomass can resemble the growth of salmon, with low growth during the winter and rapid growth from August till October. Salmon farmers therefore reduce their biomass before the winter. Another reason is the sexual maturity. In general, if the fish has gone through two winters, the indications of sexual maturity among the fish will occur around February (S. Staven 2013, pers comm. 27th March). But, according to Oglend and Sikveland (2008), salmon has the highest probability of reaching sexual maturity around August-September. Farmers will maximize their production till around October and slaughter the fish before periods with low growth and when sexual maturity occurs. From the figure we note that when spring (around May) arrives the biomass increases rapidly. This is because the light and temperature increase, and new fish are set out into the pens.

Even though prices fluctuate during the year, farmers are willing to extract the growth during the fall and sell the fish then, rather than selling salmon during spring when prices in general are higher. The additional growth salmon have during the fall is more profitable than the higher prices the farmers get during the spring (Guttormsen 2013).

One could expect that farmers would hold back salmon when feed prices are fairly low and the market prices are low. Oglend and Sikveland (2008) argues that some sell salmon at a later moment, even though salmon has reached sellable size due to low prices. Even though feed costs constitute the majority of production cost, the feed prices are quite stable in comparison with salmon prices. According to Stian Staven (2013), very few producers hold back biomass when feed prices are "low". Many of the large companies do not have the option to hold back biomass when salmon prices are low. Large companies want to keep constant delivery to their customers. However, many of the smaller companies tend to hold back biomass when prices are low to maximize their profit as long as MAB and sexual maturity is within their limits.

From Figure 3 we note that the biomass and quantity imported move in the same cycles. This is natural because the biomass is a measure of what eventually will be available to the market, and

as the biomass increases the amount available increases. The French market has been one of the driving markets while the production in Norway has increased. The development in France comes clear when we see that as the biomass increase, the import also increases. From the plot we also can see that there are quite large seasonal variations both in the biomass and imported quantity. The seasonality will be discussed later in Chapter 4.3.
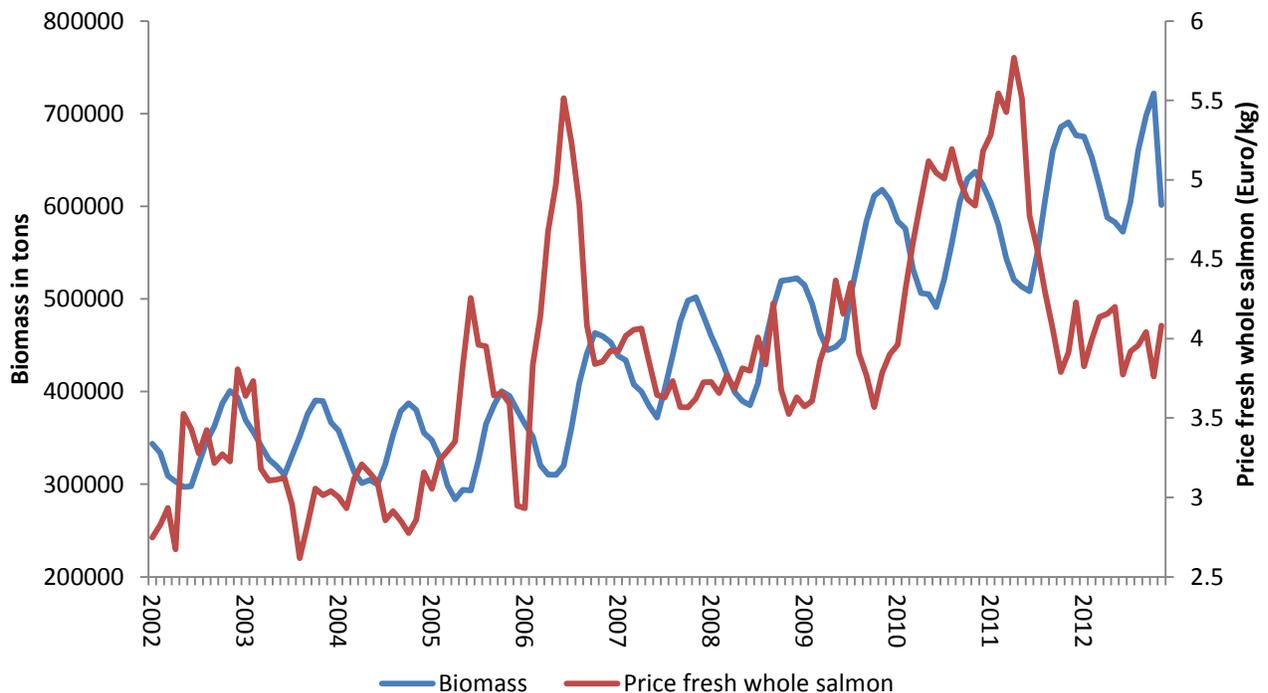
Figure 4: **Plot of biomass and import price of fresh whole salmon**

By studying the figure and the data set, we can determine the appropriate amount of lags to use in the model. I have chosen to compare the price of fresh whole salmon and biomass, since fresh whole is the largest category and considered the most dynamic product. We note that the two lines tend to correlate negatively and follow ordinary theory of supply and demand. By studying the figure we can count the amount of months from a bottom in the biomass till a peak in price, and vice versa. Then, we can determine the appropriate lag-structure to impose in the model.

From Figure 3 and 4, we see that the price, biomass, and import volume have a few peaks that deviate from the average movements. In econometric theory these are called structure breaks. The first import peak occurring in Figure 3 is in late 2005. This was a result of a period with high prices followed by a period with low prices. In periods with high prices, which are then followed

by low prices, the market reacts with a vacuum with very high consumption. When prices are low, many stores are willing to promote salmon and increase the consumption even more. In early 2006, the sea temperature was unusually low during the winter and this affected the production with lower volumes than expected. The vacuum in the market was so strong, that, as a result of lower supply, the price increased rapidly, as noted from Figure 4 (P.Aandahl 2013, pers.comm. 9th April).

Another example of a structure break came some years later in 2009. The period from 2007 to 2009 had very stable prices with "ordinary deviations". When the salmon disease, ISA, broke out in Chile, a large supplier of salmon to the global market almost disappeared. The Norwegian salmon was substituted into other markets, and especially the American and Japanese market. The Norwegian export to these markets increased rapidly, as the competition from Chilean salmon was heavily reduced. As the global supply of salmon decreased, the price increased steadily from late 2009 till early 2011. Then, when Chile started to produce significant volumes again, and the Norwegian production increased, the price plummeted after Easter in 2011 (P.Aandahl 2013, pers.comm. 9th April). In late 2011 the price stabilized at a level that has been kept throughout our data set.

4. The model and methodology

The choice of model has to be in accordance with what we want to study. We want to determine the relationship between the biomass and price, and estimate the scale and price flexibilities of different salmon products. Therefore, we need an inverse demand model. The usage of inverse demands models is also recommended by the literature. Eales et al. (1997) studied Japanese demand of fish, and they concluded that using inverse demand models gave the best applicable results when comparing price flexibilities and elasticities.

The supply of agriculture and fish products that easily perish tends to be very inelastic in the short run and the price takers are the producers of the goods. The link between price taking consumers and price taking producers are traders that buy goods at a price that is expected to clear the market. In reality the traders offer a price for the fixed quantity supplied at a given time. Then, a margin is included, and which is within the price range that appeals to the consumers. Opposed to an ordinary demand system, where quantity is a function of price, the traders use the price as a function of quantity, an inverse demand system. In the inverse demand system only quantity, price and total expenditure for each respective product of Atlantic salmon is taken into consideration (Barten and Bettendorf 1989).

By following theory of inverse demand models, the approach is to relate the price of different products of Atlantic salmon, to its quantity on import level, and the total imported volume of Atlantic salmon (Barten and Bettendorf 1989). In addition, a biomass variable will be included as an independent variable, to explain the changes in import price. The level of production in quantity is determined by the production at the market level, hence; the models applicability to agriculture and fish products that easily perish (Barten and Bettendorf 1989; Park et al. 2004). The relation between substitution and complementarity of the quantity is modeled in the inverse demand system (Barten and Bettendorf 1989).

In the early stages of this thesis, an inverse CBS model was used. The results were not as good as anticipated and we replaced it with an IAIDS model. The results became better and more reliable, and we concluded that the IAIDS model was more applicable. This is perhaps due to the fact that the AIDS model has a more flexible functional form compared to the CBS model.

4.1 The IAIDS model

The Almost Ideal Demand System (AIDS) was first proposed by Deaton and Muellbauer (1980a). It shares many of the properties of the Rotterdam model and translog models. The AIDS model has properties that simultaneously can be estimated as opposed to the other demand systems mentioned above, which gives the system prominent advantages. The AIDS model is derived from a PIGLOG cost function, which is an exact aggregation of rational consumer decisions (Deaton and Muellbauer 1980a). One of the advantages with inverse models is that price flexibilities easily can be extracted, both compensated and scaled (Eales et al. 1997).

When deriving the LA/IAIDS model, I use Eales and Unnevehr (1994) line of reasoning. The AIDS model can be derived by specifying a suiting distance function. The distance function is characterized as a proportional change in all quantities consumed to derive a level of utility. The proportional "distance" is along a ray through an indifference surface that has the origin from change in quantity. The definition of the distance function is $U\{q/D(u,q)\} = u$. The distance function carries the same properties as a cost function. The AIDS model can be derived from a logarithmic distance function:

$$\ln D(U,q) = (1 - U)\ln a(q) + U\ln b(q) \tag{1}$$

Where *D* express the distance function, *u* denotes the utility, and *a(q)* and *b(q)* are homogenous functions (Kesavan and Buhr 1995). The price is a substitution for quantities, since the requirements for the distance function is equal to the cost function according to duality theory. To meet this requirement, the ln *a(q)* and ln *b(q)*, an employment of a specification in an analogous manner to the AIDS development (Eales and Unnevehr 1994):

$$\ln a(q) = \alpha_0 + \sum \alpha_j lnq_j + 0.5\sum_i\sum_j \gamma_{ij}^* lnq_i lnq_j , \tag{2}$$

$$\ln b(q) = \beta_0 \prod_j q_j^{-\beta_j} + lna(q)$$

can now put this into (1):

$$\ln D(U,q) = \alpha_0 + \sum \alpha_j lnq_j + 0.5\sum_i\sum_j \gamma_{ij}^* lnq_i lnq_j + U\beta_0 \prod_j q_j^{-\beta_j} \tag{3}$$

The compensated inverse demand is derived from the derivative of the distance function in relation with the quantity of any good in the system. The property of the derivative of the

distance function is $\frac{\partial D(U,q)}{\partial q_i} = \pi_i$, the normalized prices (π_i) of expenditure of all goods in the system, p_i/x, where p_i is the price of good i and x is the total expenditure. The compensated inverse demand is possible to manipulate by multiplying both sides by $q_i/D(U,q)$, we can get the compensated inverse demand in share form when u(q)=U then D(U,q)=1: $(\frac{\partial D(U,q)}{\partial q_i})(\frac{q_i}{D(U,q)}) = \frac{\partial lnD(U,q)}{\partial lnq_i} = \frac{p_iq_i}{x} = w_i$. The system is now rewritten where the budget share of good i, w_i,is related to the quantity of all goods, qs, and utility, U, in the system:

$$\frac{\partial lnD}{\partial lnq_i} = w_i = \alpha_i + \sum_j \gamma_{ij}lnq_j - \beta_i U\beta_0 \prod_j q_j^{-\beta_j}, \tag{4}$$

Where $\gamma_{ij} = 0.5(\gamma_{ji}^* + \gamma_{ij}^*)$.

The direct utility function is found by inversing the distance function at the optimum, and be used in the inverse demands for uncompensation.

$$U(q) = -lna(q)/\{lnb(q) - lna(q)\} \tag{5}$$

This will yield the IAIDS:

$$w_i = \alpha_i + \sum_j \gamma_{ij}lnq_j + \beta_i lnQ \tag{6}$$

Where w_i denotes the budget share of the commodity i and q is the quantity demanded. The quantity scale index, Q, is given as:

$$lnQ = \alpha_0 + \sum_j \alpha_j lnq_j + 0.5\sum_i\sum_j \gamma_{ij}lnq_i lnq_j \tag{7}$$

The restrictions hold for the IAIDS model, and like the AIDS model they only apply for the fixed unknown coefficients. The restrictions are as follows:

$$\sum_i \alpha_i = 1, \ \sum_i \gamma_{ij} = 0, \ \sum_i \beta_i = 0 \qquad \text{(adding up)} \tag{8}$$

$$\sum_j \gamma_{ij} = 0 \qquad \text{(homogeneity)} \tag{9}$$

$$\gamma_{ij} = \gamma_{ji} \qquad \text{(symmetry)} \tag{10}$$

To calculate equation (6), nonlinear estimation is necessary since (7) is nonlinear in parameters, (7) is replaced by a linear approximation of the index:

$$lnQ = \sum_i w_i lnq_i \qquad (11)$$

The Stone`s quantity index (11) would be problematic if used in an AIDS model as prices of similar products in time-series data tend to be collinear. This does not apply for the LA/IAIDS, as quantities are not collinear (Eales et al. 1997).

4.2 Flexibilities

When dealing with inverse demand models, the price flexibilities can be easily extracted from the estimated demand model.

4.2.1 Uncompensated own and cross price flexibility

The flexibilities from the LA/IAIDS are derived from equation (6) and is in line of reasoning of Eales and Unnevehr (1994).

$$w_i = \alpha_1 + \sum_j \gamma_{ij} \ln q_j + \beta_i \ln Q$$

Then the log of q_j is differentiated:

$$\frac{\partial w_i}{\partial l q_j} = \gamma_{ij} + \beta_i \left(\frac{\partial \ln Q}{\partial \ln q_j} \right) = \gamma_{ij} + \beta_i (\alpha_j + \sum_k \gamma_{kj} \ln q_j) = \gamma_{ij} + \beta_i (w_j - \beta_j \ln Q) \qquad (12)$$

where $w_i = \frac{p_i q_i}{x}$ then,

$$\frac{\partial w_i}{\partial l q_j} = \frac{\partial \left(\frac{p_i q_i}{x} \right)}{\partial \ln q_j} = \frac{\partial p_i}{\partial \ln q_j \left(\frac{q_i}{x} \right)} = \frac{\partial \ln p_i}{\partial \ln q_j \left(\frac{p_i q_i}{x} \right)} = f_{ij} w_i \qquad (13)$$

This implies for *i≠j*:

$$f_{ij} = \{\gamma_{ij} + \beta_i (w_j - \beta_j \ln Q)\} / w_i \qquad (14)$$

There is a second term for the own price flexibility which is from $\left(\frac{\partial q_i}{\partial \ln q_i} \right) \left(\frac{p_i}{x} \right) = (\partial q_i / \partial q_i) w_j$, then we get:

$$f_{ii} = -1 + \{\gamma_{ij} + \beta_i (w_i - \beta_i \ln Q)\} / w_i \qquad (15)$$

The flexibilities can be interpreted in a similar manner as elasticities. When a 1% increase in consumption of a commodity leads to a 1% decrease of the marginal value of the same commodity in consumption, the demand of the commodity is inflexible. If the cross price flexibility is negative the commodities are substitutes, and if positive, they are complements (Eales and Unnevehr 1994).

4.2.2 Scale flexibility

From the homogeneity restriction, the scale flexibility is derived (Eales and Unnevehr 1994); $f_i = \partial lnp_i(\lambda q^*)/\partial ln\lambda$ for any scalar, λ, and a reference vector, q*, which is the sum over j of the f_{ij}:

$$f_i = \sum_j f_{ij} = \sum_j \left[-\delta_{ij} + \{\gamma_{ij} + \beta_i(w_j - \beta_j lnQ)\}/w_i \right] \tag{16}$$

$$= \sum_j -\delta_{ij} + \frac{\{\sum_j \gamma_{ij} + \beta_i \sum_j w_j - \beta_i lnQ \sum_j \beta_j\}}{w_i} = -1 + \beta_i/w_i$$

δ_{ij} is the Kronecker delta by the adding up restriction (8); $\sum_i w_i = 1$ and $\sum_i \beta_i = 0$, and the homogeneity restriction (9) $\sum_j \gamma_{ij} = 0$.

4.3 The empirical model

The IAIDS model (equation 6 in Chapter 4) is a classical basic inverse AIDS. In our empirical model, all the variables are log-differentiated to cope with plausible stationarity, since we are using monthly data. The biomass variable is appropriately lagged in accordance with the empirical observations in part 3. The appropriate amount of lags is a maximum of three periods.

The complete empirical econometric model (LA/AIDS) yields:

$$dw_{i,t} = \alpha_i + \sum_j \gamma_{ij} dlnq_{j,t} + \beta_i dlnQ_t + \sum_l \omega_l dlnBio_{t-l} \qquad (17)$$

The dependent variable dw_i describes the change in budget share for each product i, they are fresh fillet, fresh whole, frozen fillet, frozen whole, and smoked salmon, respectively. $dlnq_j$ is the log-differentiated of quantity imported of each product j. The quantity scale index which is necessary in order to calculate the linear estimation is expressed by $dlnQ$. The biomass is expressed by $\omega_l dlnBio_{t-l}$, and is log-differentiated with the first differences. When the first difference is taken, the variable is already lagged once, it is, therefore, lagged respectively l=0, 1, 2 and ω_l represent the coefficient of the different lags.

Recalling Figure 3, we saw quite large seasonal variations in the import and biomass. We assumed that a seasonal adjustment would be necessary in order to have reliable results. In the early stages of this thesis, both Almon lags and dummy variables were used to incorporate seasonality. Even though there is seasonality in the biomass and import quantity, the same strong seasonality is not found in price. When incorporating the seasonality, it has to be incorporated to all of the variables. When seasonality is imposed on both price and volume, the adjustment is diluted. The incorporation of seasonality in the model was without success, and therefore, excluded.

4.3.1 Uncompensated biomass flexibility
We take the base of (13) when calculating the biomass flexibilities. The coefficients of the biomass are summarized as a simplification in order to compare the results. This will yield:

$$(\sum \omega_l)/w_i \qquad (18)$$

where l=*0,1,2* and *i* is the different products.

5. Results

The model is estimated by a SUR (Seemingly Unrelated Regression) estimator by using the econometric software Shazam version 11. The SUR estimate is a generalized least square estimation, which accounts for the difference of the variance in the error term for the equations and the contemporaneous correlation between the products (Hill et al. 2012). Four of the equations are estimated jointly and the fifth is excluded, which is smoked salmon. The parameter estimate from smoked was recovered by using the restrictions on the model.

Table 2: Test of theoretical restrictions

	Degrees of freedom	LR=$2(lnL_U - lnL_R)$	Critical χ^2 at 5% level of significance.	Null-hypothesis
Homogeneity	3	79.8	7.815	Rejected
Symmetry	5	97.34	11.070	Rejected
Homogeneity and symmetry	8	105.94	15.507	Rejected

A likelihood ratio test was used to test if the theoretical restrictions are in accordance with our data. The theoretical restrictions, homogeneity, and symmetry were first tested separately. Then both were tested jointly. As the results in Table 2 state, the LR-value is larger than χ^2 distribution, and we reject the null hypothesis. There may be multiple reasons for rejecting the null hypothesis, including errors in the functional form, the aggregated data, or the model that do not capture the dynamic nature of consumer behavior (Deaton and Muellbauer 1980b).

The model was estimated both with and without restrictions. The model with the restrictions jointly imposed gave the best results. Therefore, the estimated results presented, apply for the model with both homogeneity and symmetry jointly imposed.

Table 3: SUR Estimated coefficients (1=Fresh fillet, 2=Fresh whole, 3=Frozen fillet, 4=Frozen whole, 5=Smoked)

		Fresh fillet	Fresh whole	Frozen fillet	Frozen whole	Smoked
Constant	α_i	0.000123 (0.00087)	0.00081 (0.0016)	-0.00049 (0.0011)	0.00004 (0.00063)	-0.00048* (0.00085)
Quantity	γ_{i1}	0.047* (0.0027)	-0.038* (0.0038)	-0.0051* (0.0024)	-0.00079 (0.0014)	-0.004** (0.0021)
	γ_{i2}	-0.038* (0.0038)	0.206* (0.0095)	-0.104* (0.0053)	-0.014* (0.0027)	-0.051* (0.0044)
	γ_{i3}	-0.0051* (0.0024)	-0.104* (0.0053)	0.123* (0.0044)	-0.0027 (0.0018)	-0.014* (0.0026)
	γ_{i4}	-0.0008 (0.0014)	-0.014* (0.0027)	-0.0027 (0.0018)	0.019* (0.0014)	-0.002 (0.0015)
	γ_{i5}	-0.004** (0.0021)	-0.051* (0.0044)	-0.014* (0.0026)	-0.002 (0.0015)	0.071* (0.0033)
Quantity index (dlQ)	β_i	0.0086 (0.0062)	-0.011 (0.012)	0.0015 (0.0086)	-0.0071 (0.0045)	0.008 (0.0061)
Biomass	ω_0	0.0423** (0.022)	-0.084* (0.039)	0.056** (0.029)	0.00014 (0.016)	-0.015 (0.021)
	ω_1	-0.081* (0.031)	0.0557 (0.055)	-0.037 (0.041)	0.023 (0.022)	0.034 (0.030)
	ω_2	0.023 (0.024)	-0.084* (0.043)	0.064* (0.032)	-0.018 (0.017)	0.016 (0.023)
R^2		0.72	0.84	0.89	0.61	0.79

Standard errors in parentheses; *significant at 5% critical level; **significant at 10% critical level.

The estimated model appears to have the best results with the most significant quantity effects and fairly high R^2 for fresh whole. This is not surprising due to the fact that fresh whole is the largest product imported by France.

The parameters of interest in Table 3 are the estimated coefficients of the biomass. We expect a negative relationship between biomass and price. This means that an increase in biomass will have a negative impact on the prices. This is in accordance with what Chiang et al. (2001) observed with tuna prices. In our estimated results, the strongest relationship is found in the fresh category. As previously mentioned, the majority of the fresh salmon supplied to the French market has a Norwegian origin; and therefore, we observe the strongest relationship between fresh products and the Norwegian biomass. The frozen salmon is mainly imported from Chile and China.

Asche et al. (1999) concluded that both fresh and frozen salmon prices move together, but short-run deviation might occur. According to Paul Aandahl at the NSC, it can take as much as a year from a large price-decrease of fresh whole salmon till the price of frozen, and especially smoked salmon, is notably reduced at a consumer level. Another important explanation is storage time. Frozen and smoked salmon can be stored for longer time periods than fresh, which has to be consumed within a rather short period of time. Processed products tend to be price-sticky and price alternations rarely occur at the same pace as fresh products (Guillotreau 2004). We are dealing with rather short-run lags in our model. This might be one of the reasons why the frozen and smoked products do not show any, or less, significant results. However, if the lag-lengths are increased, we might have a better fit for frozen and smoked salmon. But since the biomass moves in cycles, fresh products might be compared to a subsequent cycle and the results will be misleading.

If we look at those coefficients that are significant, we find that, when biomass is not lagged and lagged one period (month), there is both a negative and a positive relationship between the biomass and the fresh fillets. However, the variable, which is negative, shows a more significant result, and is more reasonable than the variable which is positive. Fresh whole salmon has two lag-lengths with negative and significant results, which yields the same coefficient value (-0.084). This is in accordance with the expectation since the fresh whole salmon is considered as the most dynamic product. From the standard error we can see that the lag-length has a higher level of significance with zero lag periods. This indicates that the market adjusts quite fast to the changes in biomass. Also, it supports the fact that import and biomass has a close relation. One could expect that two lag-periods would give a more significant result. Since the biomass is a variable

that measures what is currently farmed in Norway, but not necessarily in the market. The fact that fresh whole salmon gives the most significant results at zero lag-length and fresh fillets at one, could be an indication that there are higher transmission costs for fresh fillets. This would be natural as fresh fillets have a higher level of value-adding, and that there might be several parties involved in the import and production of fresh fillet[2]. The market information on biomass is quite efficiently communicated before the fish is harvested. The salmon farming industry is rather transparent, and buyers of salmon are aware of future quantities, which will be available.

Frozen fillets have two significant lag periods (zero and two), but they are both positive. An explanation for this could be the adding-up restriction that is used when modeling the system. The adding-up restriction restricts the sum of each coefficient in each equation to be equal to zero. When this applies, all the products cannot have a negative relation to the biomass, hence at least one of them has to be positive. Another aspect is that frozen fillets are mainly supplied by Chile and China, and not necessary directly affected by the Norwegian biomass in a relatively short time.

Both origin of salmon and dynamics of processing are the explanation for not having significant results on frozen and smoked products.

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[2] Since the first difference is taken from the variable the actual lag-length is plus one. In order words: the lag-length of fresh whole is one period and fresh fillet two periods.

5.1 Price and biomass flexibilities

Table 4: Estimated scale and price flexibilities. (1=Fresh fillet, 2=Fresh whole, 3=frozen fillet, 4=frozen whole, 5=Smoked, 6=biomass)

	Uncompensated						
	f_i	f_{i1}	f_{i2}	f_{i3}	f_{i4}	f_{i5}	f_{i6}
1	-0.88* (-0.085)	-0.34* (-0.039)	-0.059* (-0.0064)	-0.29** (-0.015)	-0.044 (-0.049)	-0.04 (-0.026)	-0.22 (-0.279)
2	-1.02* (-0.0018)	-0.44* (-0.062)	-0.69* (-0.014)	-0.65* (-0.035)	-0.63* (-0.112)	-0.53* (-0.059)	-0.174* (-0.056)
3	-0.99* (-0.051)	-0.049 (-0.041)	-0.16* (-0.0099)	-0.25* (-0.031)	-0.13** (-0.073)	-0.15* (-0.037)	0.497* (-0.162)
4	-1.24* (-0.15)	-0.0073 (-0.019)	-0.022* (-0.0043)	-0.016 (-0.011)	-0.35* (-0.049)	-0.021 (-0.017)	0.356 (-0.481)
5	-0.73* (-0.20)	-0.045 (-0.029)	-0.79* (-0.0072)	-0.083* (-0.016)	-0.089** (-0.052)	-0.16* (-0.038)	0.407** (-0.234)

Standard errors in parentheses; *significant at 5% critical level; **significant at 10% critical level.

5.2 Uncompensated price and biomass flexibility

From Table 4, we can extract both the uncompensated cross- and own-price flexibilities of the different commodities. The estimates of the uncompensated own-price flexibilities are significant at a 5% critical level. The uncompensated own-price flexibilities are also smaller than 0 and larger than -1 which makes them inflexible. This is also supported by Asche et al. (1997). They found that both frozen and fresh salmon is own-price elastic and substitutes. They used an ordinary demand system, where the values are the opposite from an inverse. The uncompensated cross-price flexibilities, are all negative, which indicates that they are all substitutes, however, not all of them are significant.

Fresh fillet

Uncompensated own price flexibility of fresh fillets are -0.34, meaning that an increase of 1% quantity imported, the price will decrease with 0.34%. The cross-price flexibility between fresh fillet and frozen fillets is -0.29, indicating that there is a substitution effect between them. But the other way around it is different. One can assume that this is because fresh salmon has limited shelf life and it therefore is a limited inventory for stores and wholesalers. Frozen salmon can be

kept as an inventory for longer time periods without reducing the quality. Roth et al. (2001) reported the own price flexibility of -0.38 for Grade A salmon, which is close to what we observe for fresh fillets. However, they also reported the own price flexibility of -0.95 for Grade E salmon, which is graded more exclusive but in the flexibility context is less exclusive. They argue that the results are due to the fact that prices are formed in joint markets.

Fresh whole

Fresh whole salmon has an own-price flexibility of -0.69. This indicates that it is more of a necessity than the other products. We note that there is a strong connection between smoked salmon and fresh whole. As noted previously, some of the fresh whole salmon which is imported in France, is smoked there, and that the demand for fresh whole salmon is an aggregated demand for both fresh whole salmon and smoked salmon (Xie and Myrland 2011). What is interesting is that the increased import of fresh whole salmon has large influence on the price of all commodities, but the other way around the influence is much smaller. This is because fresh whole salmon constitutes such a large proportion of the total quantity imported (ref. Figure 2). The smaller market share a product has, the smaller is the influence it has on the price of other products. Eales et al. (1997) reported an uncompensated own-price flexibility of -0.52 for medium-value fresh fish with salmon included. This is close to both fresh fillets and fresh whole, and could be even closer if fresh salmon was aggregated to a total category. However, we have to keep in mind that Eales et al. (1997) studied Japanese demand for fish, and that the medium-value category is an aggregated group, where fresh salmon is included among other fish species.

Frozen fillet

Frozen fillets has an own price flexibility of -0.25, which is larger than fresh fillet and indicates that it is more luxurious. This is surprising since frozen fillets are mainly supplied by Chile and China, and has a lower mean price than fresh fillets. Paul Andahl argues that frozen fillet is sold as a finished product and fresh fillets as raw material. However, an increase in the supplied quantity of frozen fillets leaves no significant change in price of fresh fillets. But the other way around, we have significant results that show an increase of fresh fillets will reduce the price of frozen fillets.

Frozen whole

Increasing volume of frozen whole salmon does little influence on the price on other commodities. From Figure 2, we see that frozen whole salmon constitutes a small proportion of the total import, hence little influence. This is also noted when we see that the frozen whole salmon has only significant relations with fresh whole, and a significant own-price flexibility. Xie and Myrland (2011) found that the frozen salmon was complentary to the smoked salmon on a household level in France. However, we do not have significant results to support this.

Smoked

Smoked salmon has an own-price flexibility of -0.16; and, therefore, the lowest estimate among the other products. This indicates that it is more inflexible than the other commodities and more luxurious. An increase of 1% in quantity only decreases the price by 0.16%, which is far less than the other commodities. We note that the increase in smoked quantity reduces the price of the fresh whole salmon significantly. This supports the findings that Xie and Myrland (2011) made when they concluded that smoked and fresh salmon substitute each other strongly on a household level in France. It is reasonable to assume that when import of smoked salmon increase, the production of smoked salmon within France is reduced and the import of fresh whole salmon is therefore also reduced.

Biomass flexibility

There are only three products that have a significant relation to the biomass: fresh whole, frozen fillets and smoked. However, only fresh whole salmon has the expected negative sign, while frozen fillets and smoked are positive. There are several explanations why we do not have the expected results. First of all the lag-structure of processed products are longer than modeled. Second, as previously noted, the adding up restriction imposed in the model restricts the sum of the coefficients to be equal to zero. This was clearly the case with the coefficients of the biomass in relation to frozen fillets. Thirdly, both frozen fillets and smoked salmon consist of a melting pot of multiple countries of origin, and then when compared against Norwegian biomass it is clear that one can expect results which is not representative. Last, the market share of smoked is only 4% of the average volume. When calculating the flexibilities, the real expenditure is included, and the smaller market share, the less impact it makes.

5.3 Scale flexibility

All of the scale flexibilities are statistically significant at a 5% critical level and negative, as expected.

Fresh fillet

Fresh fillet has a scale flexibility which is less than one unity in absolute value, which means that fresh fillet, at the import level, is scale inflexible. If the quantity of all imported goods increases by 1%, the marginal value of fresh fillets will decrease by 0.88%. Because it is scale inflexible it is also considered as a luxury product. In comparison with fresh whole salmon, the scale flexibility is larger, which is expected because the fresh fillet is priced higher and has a higher degree of value adding.

Fresh whole

Fresh whole has a scale flexibility close to -1, which makes it neutral flexible. As mentioned, some of the fresh whole salmon is used for smoking in France, and the demand for fresh whole salmon is an aggregated demand for both fresh and smoked salmon. If one could exclude the fresh whole salmon used for smoking in France, one could expect that the scale flexibility of fresh whole would be bigger. Since smoked salmon is a luxurious products, and fresh salmon is a necessity (Xie and Myrland 2011).

Eales et al. (1997) reported a scale flexibility of -1.05 for medium-value fresh fish with salmon included. This is very close to what we observe for the fresh whole salmon. In addition, Roth et al. (2001) reported a scale flexibility of -1.06 for salmon of the highest quality (Grade E), and -1.46 for the second best quality (Grade A) salmon landed in Denmark between 1993 and 1998. The scale flexibility of the highest quality is close to what we observe for fresh whole salmon.

Frozen fillet

Frozen fillet has a scale flexibility which is also close to -1. The flexibility of frozen fillet is -0.99, and strictly it is a luxury product. The explanation is that frozen fillet is imported as a finished product. Fresh fillet has lower scale flexibility than frozen fillet, which indicates that the fresh fillet is considered more luxurious than frozen fillets. As mentioned, the imported fresh fillet is mainly from the European producers, and the frozen fillet is mainly imported from Chile and China.

Frozen whole

Frozen whole salmon has a flexibility of -1.24 and is a necessity product. Even though it is priced higher than te fresh whole, it is more of a necessity than the fresh whole. This is because frozen whole salmon is considered as a less exclusive product. The frozen whole is priced higher than the fresh whole due to the production costs (e.g. freezing, storage etc). According to Paul Aandahl, frozen whole salmon, is to a large extent, used in foodservice. Rather small volumes of frozen whole is sold at grocery stores. As mentioned, Roth et al. (2001) reported a scale flexibility of the salmon (grading A) of -1.46, which is close to the frozen whole salmon. Since the group Roth et al. (2001) studied was an aggregated group, one can assume that salmon with lower quality often is frozen as whole salmon.

Smoked

Smoked salmon has a scale flexibility of -0.73. This is not surprising due to the fact that the smoked salmon is considered as the most exclusive salmon product among all the products, and that it is priced the highest. The results is supported by Xie and Myrland (2011), which concludes that smoked salmon is a luxurious commodity.

The estimated flexibilities are, to some extent, in compliance with the literature. However, one should take care when comparing my results with the literature. As mentioned, my product aggregation is rather unique, and will deviate from other studies. My time series is from 2002 to 2012, and in the literature there is a wide variety of time frames used. Last, my flexibilities are estimate on French import data. In the literature, other nations export, import, and consumer panel data are used.

From a Norwegian perspective, where fresh products are the most important, and indirectly smoked salmon, we note that the frozen whole salmon is greatest affected by increased imported volumes. Smoked salmon is the least affected due to the scale flexibility of -0.73, and, next in line, fresh fillet with a scale flexibility of -0.88. The largest and most important product, fresh whole, will have the greatest negative effect, in comparison with the "Norwegian" products. However, the scale flexibility is rather close to -1. If one should give any advices to the Norwegian exporters, it would be: to increase the level of export of fresh fillets, because it is seemingly less affected by the changes in quantity.

5.4 Effects of growth in biomass and import

From Table 5 (the table continues on the following page) we can extract the annual percentage change in biomass, volume, and percentage effects. The effects of changes in volume on prices are calculated by multiplying yearly increase of total imported volume by the scale flexibility of each respective product. The effects of biomass growth are calculated by multiplying the cross-biomass flexibility of each product by the yearly percentage change in biomass. From Table 4 we note that all of the scale flexibilities are significant, and from the biomass flexibilities only fresh whole, frozen fillet and smoked are significant.

Table 5: **Effects and percentage annual change of growth in biomass and import (effects in percentage)**

		Effects of import growth on price				
	% Change import volume	Fresh fillet	Fresh whole	Frozen fillet	frozen whole	Smoked
02/03	7.0	-6.2	-7.1	-6.9	-8.7	-5.1
03/04	-3.6	3.2	3.7	3.6	4.5	2.6
04/05	18.8	-16.6	-19.2	-18.6	-23.3	-13.7
05/06	1.1	-1.0	-1.2	-1.1	-1.4	-0.8
06/07	0.2	-0.2	-0.2	-0.2	-0.3	-0.2
07/08	4.3	-3.8	-4.4	-4.3	-5.4	-3.2
08/09	18.9	-16.6	-19.3	-18.7	-23.4	-13.8
09/10	4.6	-4.1	-4.7	-4.6	-5.7	-3.4
10/11	-0.8	0.7	0.8	0.8	1.0	0.6

		Effects of biomass growth on price				
	% Change biomass volume	Fresh fillet	Fresh whole	Frozen fillet	frozen whole	Smoked
02/03	3.2	-0.7	-0.6	1.6	1.2	1.3
03/04	-3.3	0.7	0.6	-1.6	-1.2	-1.3
04/05	0.2	0.0	0.0	0.1	0.1	0.1
05/06	11.5	-2.5	-2.0	5.7	4.1	4.7
06/07	14.6	-3.2	-2.5	7.3	5.2	6.0
07/08	3.4	-0.8	-0.6	1.7	1.2	1.4
08/09	16.2	-3.6	-2.8	8.1	5.8	6.6
09/10	7.6	-1.7	-1.3	3.8	2.7	3.1
10/11	5.4	-1.2	-0.9	2.7	1.9	2.2

%Change		Combined effects				
	%Change	Fresh fillet	Fresh whole	Frozen fillet	frozen whole	Smoked
02/03	10.2	-6.9	-7.7	-5.3	-7.5	-3.8
03/04	-6.9	3.9	4.2	1.9	3.3	1.3
04/05	19.0	-16.6	-19.2	-18.5	-23.3	-13.7
05/06	12.6	-3.5	-3.2	4.6	2.7	3.8
06/07	14.9	-3.4	-2.8	7.0	4.9	5.8
07/08	7.7	-4.6	-5.0	-2.6	-4.1	-1.8
08/09	35.1	-20.2	-22.1	-10.6	-17.6	-7.2
09/10	12.2	-5.7	-6.0	-0.8	-3.0	-0.3
10/11	4.6	-0.5	-0.1	3.5	2.9	2.8

As noted previously, the biomass flexibility of frozen fillets and smoked is not reliable, even though they are significant. Therefore, the most interesting product to discuss is fresh whole, which is the most important imported Norwegian product. The effect of increased biomass is positive, when it increases for both smoked and frozen fillet as a result of positive biomass flexibility. As mentioned, one should take care when analyzing the biomass flexibility of the given products due to the adding-up restriction which makes them positive. The largest negative effect of increased biomass on price of fresh whole salmon is -2.8%. This was the result of the increase of 16.2% in the biomass.

There is a stronger impact on increased imported volume than from increased biomass. This is the result of a stronger direct connection between prices and imported quantities, compared with the relationship between prices and increased biomass in Norway. For example, fresh whole and frozen fillet has almost a one-to-one relation to the increased import as a result of the scale flexibilities are close to -1, while the biomass flexibility is -0.174 for fresh whole. This is the result of import is a direct effect, while the biomass is an indirect effect. There are several countries that supply the French market with Atlantic salmon, while the biomass here is only recorded in Norway. In addition, the salmon, produced in Norway is sold to the global market and not only to France. The biomass in Norway has increased by 74% from 2002 to 2011, and the imported quantity in France has increased by 60% the same period. Indeed, the French market has grown, to some extent, in line with the Norwegian production, but new important markets have developed as well, taking shares of the production. Some speculate that Russia soon will be a more important market than France.

There are some deviations between the percentage change in biomass and volume imported. The years that deviate are 2005/2006 and 2006/2007 when the biomass has increased notably, but the import has been kept stable. This underlines that the biomass was an indirect influence on prices, and import was a direct influence, and that increased biomass does not necessarily always lead to increased import. As stated in section 4.1, we have two structure breaks in our data set. The increase of import in 2005 and 2009, that we can see notably the effect of in Table 5. From 2004 to 2005 the import increased by 18.8%, the effect of this increase is a price reduction of fresh whole salmon of 19.2%. We also note that frozen whole has the largest decrease in price, and smoked has the smallest. This is in line with what has been discussed previously in regards of luxury and necessity goods. From 2008 to 2009, there was an increase of 18.9% in imported quantity, and we see the same effect on price as in 2005. The year 2009 stands out from the other years, as there was both strong increase in biomass and import, compared to 2008. If we look at the combined effects at the bottom of Table 5, we see that the combined effects are the largest from 2008 till 2009. The combined effect on price of fresh whole in 2008/2009 is a price decrease of 22.1%, where the biomass accounted for nearly 13% of the negative change. So, even though the biomass is considered an indirect effect, it accounts for a rather large proportion of the changes in price.

From Table 5 we see a negative trend in the price both for changes in biomass and import. This is due to the increased supply. Asche et al. (1999) concluded that decreasing prices of farmed salmon was driven by increasing production. This trend will most likely continue, unless the demand significantly shifts. In their study, they found that it both applied for farmed salmon and wild caught salmon. Their analysis also concluded that the products form, fresh, and frozen will follow the same price pattern over time, although short term deviations occur (Asche et al. 1999). My study is to some extent supported by their conclusion. The biomass indirectly affects the imported quantity, and especially in the French market where import and biomass are highly correlated. The effects of changes in biomass have, however, a smaller influence on prices than changes in import. My study can only support that increasing production decreases price of fresh whole salmon. Oglend and Sikveland (2008) argues that decreasing unit cost prices of salmon also is the reason for decreasing prices. However, I have not studied the profitability of salmon farming and cannot support their findings.

6. Summary and concluding remarks

There are three things I wanted to investigate in this thesis. First, I wanted to study the relationship between Norwegian biomass of Atlantic salmon and French import prices of different Atlantic salmon products. Second, study the scale, own- and cross-price flexibilities and biomass flexibility of different product categories. Finally, I analyzed the effects of changes in biomass, import quantity, and the combined effects. This was done by using an LA/IAIDS model with French import statistics provided by the NSC and biomass statistics from the Norwegian Directorate of Fisheries.

The estimated model gives best results for fresh whole, which is not surprising, as the fresh whole constitute the majority of the market share. The strongest relationship between biomass and import price is found in the fresh category. With zero lag-length, fresh whole salmon yields the most significant result, and the same applies for fresh fillet at one lag-length. This indicates that the fresh fillet has higher transmission costs and a higher degree of value-adding than the fresh whole. Also, my assumption that fresh whole is the most price-dynamic, holds. I am not able to show significant and reliable relation of the frozen and smoked category. There are multiple reasons for this: 1) theoretical restrictions; 2) lag-lengths; and the market structure for smoked and frozen salmon.

The uncompensated cross-price flexibilities show that quantity changes of fresh whole yields the largest impact on the other products. This can be explained by the dominant market share that fresh whole has in the French market. We also note that the cross flexibilities are negative, indicating that they are all substitutes. Worth mentioning is that frozen fillets are often "finished products", opposed to fresh fillet and whole that are raw material. So, even though they are substitutes, they do not necessarily compete in the same market segment. The same can be mentioned about frozen whole salmon, which is mainly used in food service. The uncompensated biomass flexibilities only give significant and reliable results for fresh whole.

I also estimated the scale flexibilities of the different products. Smoked salmon can be labeled as the most luxurious product at an import level. Smoked salmon has a relatively higher price than the other products and a very strong position in the French salmon market. Changes in imported quantity lead to smaller changes in price, in comparison with the other salmon products. Fresh whole salmon has a scale flexibility that is close to neutral flexible.

From the effects of changes in biomass and import, we see that the changes in import yield larger effects, opposed to the changes in biomass. This is because import has a direct effect, while biomass has an indirect effect. Increased biomass does not necessarily lead to increased import, even though they are highly correlated in the French market. 2009, was the only year in our data set where there was both a strong increase in import and biomass. The biomass flexibilities yielded reliable results for fresh whole, while all of the scale flexibilities are significant and reliable. Also, the absolute value of the scale flexibilities are larger than the biomass flexibilities; hence, larger impact when volume changes. However, one shall not neglect the relationship between prices and biomass. The effect of change in biomass in 2008/2009, accounted for nearly 13% decrease of the combined effect on price of fresh whole. Which is quite a large proportion, considering that biomass is an indirect effect.

Biomass will affect the price of salmon in a long run, since it affects the supply. Salmon, which is currently farmed, and constitutes the biomass, will eventually be sold to the market. The price of salmon is determined in the market. However, farmers determine on their own when they will slaughter the salmon, as long as they are within the MAB. Still, the biomass and import follow a specific pattern, where there are peaks at certain periods throughout the year. These peaks are rather predictable. The farming industry is, to a wide extent, transparent, and buyers are aware of the current and future prospect of the supply of salmon. This is also reflected in the model, where the strongest relationship is found for fresh products. For frozen and smoked products, we cannot with certainty claim the same.

According to our analysis, Norwegian biomass has a negative relationship with the salmon prices at an import level in France. However, this only applies for the fresh products in a short run, and one could expect that there is a relationship with smoked products in the long run. It is more uncertain if there is a negative relationship with frozen products, since these are mainly supplied by Chile. However, salmon prices are cointegrated in the long run, and there might be a long run relationship as the result of this (Asche et al. 1999). We can conclude that biomass has a negative relationship with import prices of fresh products in France, in a short run.

Yet, little research has been done in this field, and further research is necessary to fully understand the relationship between biomass and prices. An interesting perspective would be to look at the entire EU market, instead of studying isolated the French market. The EU market is

the most important market region, but Russia has become a more important salmon market lately; thus including Russia could give more explanatory power to the model.

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