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Import demand elasticities for farmed salmon in the European Union and United States.

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Mohsin Lodhi

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Abbreviations

AIDS	Almost Ideal Demand System
EU	European Union
FAO	Food and Agriculture Organization
FOB	Free on Board
LA/AIDS	Linear Approximation of Almost Ideal Demand System
MT	Metric ton
NSEC	Norwegian Seafood Export Council
ROW	Rest of the World
SUR	Seemingly unrelated regression
US	United States
USD	United States Dollar
WFE	Whole fish equivalent

Abstract

This research has been conducted to investigate the demand structure of farmed salmon in EU and US markets between 2002 and 2014, and moreover to find the impact of the financial crisis on the demand for farmed salmon. The analysis includes 155 monthly observations from January 2002 to November 2014 in respect of the quantity and value of farmed fresh and frozen salmon exported from Norway, Chile and the rest of the world (ROW) in the EU and US markets. Linear approximation of an Almost Ideal Demand system (LA/AIDS) has been used to estimate demand elasticities. The demand model is estimated by using seemingly unrelated regression (SUR). The five-equation demand system is estimated separately for the EU and the US. Moreover, then all ten equations are integrated and estimated together to demonstrate the difference between the two markets. Finally, the impact of the financial crisis is captured by estimating the demand model before and after the financial crisis in both markets. The results show that the fresh farmed salmon demand is price elastic whereas the frozen farmed salmon is price inelastic in the EU market. However, both fresh and frozen salmon demands are price inelastic in the US market during the same period. Moreover, research reported a clear difference in the market structure of both regions: the EU market is dominated by Norwegian fresh salmon while US consumers prefer salmon from Chile and the ROW. Furthermore, the impact of financial crisis on both salmon markets is quite significant, particularly in the US market. In the EU market, before the financial crisis, demand for Norwegian fresh, Chilean frozen and ROW fresh salmon was elastic with respect to their price but none of the products remained elastic after the financial crisis. So the EU salmon market is a stable market. On the other hand, demand elasticities were found to be more price elastic in the US market after the financial crisis in the US salmon market. The contribution of this study of salmon demand is that previous studies have not integrated the EU and US salmon markets in order to investigate demand elasticities. Moreover, the impact of the financial crisis has not been explored either in the earlier literature on salmon demand.

Keywords: salmon demand, financial crisis, EU and US salmon markets.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Seafood is of huge importance in the human diet, as it is healthy as well as nutritious (Claret et al 2014). According to the Food and Agriculture Organization of the United Nations, about 150 g of fish fulfils 50 to 60 per cent of the daily protein requirement of an adult (FAO 2014). In tandem with the rapid rise of the world fisheries, production was about 158 million tons in 2012. The utilization of fish increased globally from about 40 million tons to 136.2 million tons within the period from 1970 to 2012 (FAO 2014). The increase in the utilization of fish globally can be attributed to an increase in per capita consumption (from 10.9 kg/annum to 19.2 kg/annum) during these years (FAO 2014, Claret et al 2014).

Compared to other forms of fish, both the production and consumption of farmed salmon are increasing day by day. Salmon is the general name of several fish species in the family of Salmonidae (Marine Harvest 2014). Many of these species are available as farmed and wild species, but most of the Atlantic salmon is farmed (Handbook 2014). Over the last few decades, a revolution in aquaculture has led to a substantial increase in production (Asche and Bjørndal, 2011). Along with all other products of aquaculture, production of Atlantic salmon has increased substantially, and industrialization in aquaculture has led to a decrease in the risk factor (Asche and Bjørndal 2011, Marine Harvest 2014, Brækkan 2014). According to research, farmed salmon accounts for 60 per cent of the world's production of salmon and its production is expected to grow further because of its low production cost and ease of handling (Knapp et al., 2007, Nesse and Naess-Ulseth 2014, Marine Harvest 2014).

Salmon farming depends upon environmental and biological conditions (Nesse and Naess-Ulseth, 2014). The most suitable water temperature for the production of salmon is around 13 degrees Celsius (Thyholdt 2014). Salmon do not survive at a temperature above 13 degrees, while their growth rate slows down below this temperature. This limits the production area, and the salmon industry is established in some selected countries (Brækkan 2014). Salmon is produced mainly in Norway, Chile, Canada, Scotland, Ireland, and the Faroe Islands. However, Chile and Norway are the two leading producers, sharing 85 per cent of the total supply (Asche and Bjørndal 2011, Brækkan 2014). Farmed salmon is traded globally while the EU, USA, and the Japan are the three major traders in terms of value; accordingly they are the main consumers (Asche and Bjørndal 2011, Brækkan 2014).

1.2 Research issues and objectives

The continuous and steady progress of the farmed salmon industry in the last three decades has encouraged many researchers to investigate and report on the structure and growth in demand for salmon in the world markets. Researchers around the globe have investigated different issues regarding the production, consumption and growth of salmon including the impact of health information, price volatility, trade restrictions, and advertising on the supply of and demand for salmon (Asche et al., 2011, Klinger et al., 2013, Jensen et al., 2012, Xue et al., 2015, Friesen et al., 2015, Brækkan 2014, Asche 1997, Asche et al., 2014, Kinnucan and Myrland 2006, Anderson and Fong 1997, Xie 2008, Tveteras and Asche 2008, Yajie et al., 2011). Moreover, demand for salmon on the basis of form and origin has also been investigated by various policymakers (Asche 1997, Claret et al., 2014, Nguyen et al., 2015).

Despite the massive research that has been done on various issues regarding salmon demand in the world, the demand structure of salmon in the EU and US markets has not yet been explored by incorporating both markets. Moreover, although the financial crisis of 2008 has badly affected the world economy, its impact on the salmon market has not been discussed in previous studies. The aim of this research is twofold: firstly to estimate and compare the market structure of farmed salmon in the EU and US markets over the period from 2002 to 2014; and secondly to estimate and compare the demand elasticity for farmed salmon before and after the emergence of the financial crisis in October 2008.

1.3 Structure of the thesis

Following the introduction in Chapter 1, which includes a statement about the research problem and objectives of the study, Chapter 2 presents a review of related literature, while the specifications of the model are presented in Chapter 3. Next, Chapter 4 provides information regarding the data and explains the methodology used in the thesis for estimation. The empirical results are reported in Chapter 5, and Chapter 6 discusses the salmon market structure and the impact of the financial crisis on the EU and US salmon markets. Finally, Chapter 7 summarizes and concludes the study with policy prescriptions.

CHAPTER 2

LITERATURE

A review of previous studies related to the demand structure of farmed salmon in different parts of the world has been summarized briefly in this section.

In order to describe the structure of demand for farmed salmon in Italy and Spain, Bjørndal and Salvanes (1994) reported the demand elasticity of farmed salmon in these countries by taking monthly data on the export value of fresh Norwegian salmon from January 1985 to December 1989. They specified the demand model by using Box-Cox transformation of variables and the endogeneity of price was determined by Hausman test. In both markets, own price elasticity estimates of demand were found to be unitary in the short run but showed significant price elasticity in the long run. The estimates also report the absence of substitutes for salmon in Spain and Italy in the short run, whereas cross-price elasticity exceeds the value of unity in the long run. While estimating income elasticity, the finding demonstrates that farmed salmon is considered a luxury commodity in these two markets both in the short run and in the long run.

Asche et al. (1998) projected the demand for salmon in the market of the European Union by taking into account the origin and form of the product, by using quarterly data on import value and quantity of fresh Atlantic salmon, frozen Atlantic salmon, and frozen Pacific salmon over a period from 1984 to 1992. The demand system was estimated by using the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980). The cross-price elasticity indicates that all three salmon types are substitutes for each other, as the demand for Atlantic frozen salmon depends on the prices of fresh Atlantic and also Pacific frozen salmon. In the case of expenditure elasticities, both fresh and frozen Atlantic salmon were found to be elastic and considered luxury commodities whereas frozen Pacific salmon was conveyed as inferior goods, having negative income elasticities. In another study, Asche et al. (2011) used an index approach to investigate the growth in demand for salmon in the EU and France. The study reported an average growth of 7.6% per year in the demand for salmon in the EU and it was 4.6% per year for France.

Fofana and Clayton (2003) worked on a paper entitled “Demand interaction between farmed salmon and wild caught fish in the United Kingdom” and they explored the relationships between salmon demand and other species of wild caught shellfish and white fish by using a single equation as well as the LA/AIDS model. The result of the study indicates the presence of a long-run market relationship between salmon and other species of white fish including monkfish, cod, whiting, saithe, and plaice. It also maintains a long-run relationship between species of shellfish such as mussels, scallops, shrimp, and nephrops. Research shows the importance of this group as they act as strong substitutes for salmon among consumers in the United Kingdom.

Xie (2008) estimated the effect of advertising conducted by the Norwegian Seafood Export Council in the EU Atlantic salmon market during 1998–2007 on Norwegian salmon demand. The results reveal that in the EU market Chilean and Norwegian salmon act as a substitute for UK salmon, as their cross-price elasticity is found to be greater than the own price elasticity of UK salmon. Moreover, the study found that the advertising of Norwegian salmon resulted in shifting the Norwegian salmon demand curve to the right and led to a shift in the ROW salmon demand curve to the left. The study highlighted the importance of the advertising effect on per unit benefit-cost ratio and producer surplus.

In another research conducted by Xie et al. (2009), the elasticity of demand for farmed salmon in the world market and the impact of advertising on the trade of Norwegian farmed salmon were examined. The demand system was estimated for fresh salmon from Norway, Chile, the United Kingdom, and the rest of the world (ROW) and frozen salmon globally over the period from 1998 to 2005. The results suggest that the global demand for farmed salmon is becoming less price elastic with the passage of time due to increases in production and technology. Moreover, the study found that the UK has to bear greater competition in the global market, whereas Chilean fresh salmon faces relatively less competition in world salmon trading. In the context of the NSEC promotion programme, it was concluded that the advertising had beneficial outcomes for fresh salmon at the cost of frozen salmon. Moreover, the global demand for farmed fresh and frozen salmon has become less price elastic in the world market.

CHAPTER 3

MODEL

3.1 The model

The demand equation was presented by Richard Stone in the early 1950s (Deaton and Muellbauer 1980). Since then, various models have been put forward to analyse the behaviour of the consumer, and prominent among them are the Rotterdam Model, translog models and the Almost Ideal Demand System (Taljaard et al., 2004). The Rotterdam and translog models have been widely used in literature to analyse the system of demand equations, yet they do not possess all the desirable restrictions and properties used in the AIDS model (Deaton and Muellbauer 1980).

In the AIDS model, the budget shares of the different commodities are linearly related to the logarithms of the relative prices and the logarithm of the real total expenditure. AIDS will become linear by replacing the translog price index with the Stone price index. The Linear Approximation of Almost Ideal Demand System (LA/AIDS) model is preferred due to the aggregation over consumers (Taljaard et al., 2004). Equation 1 presents the general form of AIDS:

$$R_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{Y}{P}\right) \quad (1)$$

Notations represent:

R_i is the ith good share in the budget

p_j is the price of good j

α_i is the intercept that shows trend effect

γ_{ij} and β_i are the parameters of relative prices and real expenditures, respectively

P is the price index for the selection

Y is the total expenditures spent on all commodities in this demanding group

$\ln\left(\frac{Y}{P}\right)$= lnY – lnP that gives real total expenditure

lnP is the translog price index that is defined as

$$\ln P = \alpha_0 + \sum_i \alpha_i \ln(p_i) + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln(p_i)\ln(p_j) \quad (2)$$

This translog price index represented in equation (2) creates a non-linear model, which makes econometric estimation more complex (Taljaard et al., 2004). The Stone price index is used in place of the translog price index to make the model linear and also to avoid evaluation problems. The Stone price index is defined as

$$\ln P = \sum_{i=1}^{n} R_i \, lnp_i$$

The restrictions of AIDS are adding up, homogeneity and symmetry in the demand system of equations as follows:

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

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

$$\gamma_{ij} = \gamma_{ji} \;\; \forall \; i \neq j \qquad \text{(symmetry)}$$

Homogeneity restriction means that the sum of all the price parameters in each demand equation should be equal to zero. This indicates that if all the prices change by the same percentage amount simultaneously the expenditure share of that commodity will only change when the real income changes. So homogeneity means that consumers' decisions will be motivated by real income with price changes remaining constant.

Symmetry restriction means that the cross-price effect on quantity demanded should remain the same for all commodities in the whole system of equations. The requirement for system parameters to be symmetric reveals that change in demand for good j due to change in price of good i remain the same within the system and vice versa (Fofana and Clayton 2003).

Holding these theoretical restrictions, the equation demand system would be homogeneous of degree zero in prices and income.

As we are interested in comparing demand elasticities in the EU and US markets, the following models R_i^{EU} and R_i^{US} represent budget share equations in the EU and US market, respectively:

$$R_i^{\mathrm{EU}} = \alpha_i + \sum_{\mathrm{j}} \gamma_{i\mathrm{j}} \ln \mathrm{p}_j + \beta_i \ln\left(\frac{\mathrm{Y}^{\mathrm{EU}}}{\mathrm{P}}\right) \quad (3)$$

$$(\mathrm{i} = 1,2,3,4,5) \text{ and } (\mathrm{j} = 1,2,3,4,5) \text{ for EU salmon demand equations}$$

$$R_i^{\mathrm{US}} = \alpha_i + \sum_{\mathrm{j}} \gamma_{ij} \ln \mathrm{p}_j + \beta_i \ln\left(\frac{\mathrm{Y}^{\mathrm{US}}}{\mathrm{P}}\right) \quad (4)$$

$$(\mathrm{i} = 6,7,8,9,10) \text{ and } (\mathrm{j} = 6,7,8,9,10) \text{ for US salmon demand equations}$$

Equation 3 represents the budget shares in the EU salmon market, which shows that the budget shares for each equation depend on all product prices and the real income also in LA/AIDS. Moreover, equation 4 shows the US salmon budget shares for all five equations. When we integrate both markets, we obtain all products' budget share from the LA/AIDS models. It is quite obvious that both markets have different total expenditures, relative prices, and budget shares also. For EU salmon demand elasticities $(i = 1,2,3,4,5)$ and $(j = 1,2,3,4,5)$ while for US salmon demand elasticities $(i = 6,7,8,9,10)$ and $(j = 6,7,8,9,10)$, so R_1 and A_1 are the budget share and income elasticity of Norwegian fresh salmon in the EU market whereas R_6 and A_6 represent the budget share and expenditure elasticity of Norwegian fresh salmon in the US market. So in total, we have ten equations; the first five belong to the EU market and the next five to the US market.

3.2 Elasticities

The elasticities that we obtained from the LA/AIDS model are known as Marshallian elasticities. Marshallian own price, cross price, and expenditure elasticities are as follows:

$$\text{Marshallian own price elasticities:} \qquad e_{ii} = \frac{\gamma_{ii}}{R_i} - \beta_i - 1 \quad (5)$$

Own price elasticity shows how the price of the goods affects their demand. It is rational that when the price of a normal good increases the demand for its product will decrease, so we expect that the Marshallian own price elasticities should have negative signs.

$$\text{Marshallian cross} - \text{price elasticities:} \qquad e_{ij} = \frac{\gamma_{\, ij - R_j \, \beta_i}}{R_i} \tag{6}$$

For a 1% increase in the price of good 'j', how much the quantity demanded of good 'i' will change is known as the cross-price elasticity holding all other variables constant. For complementary goods it should be negative whereas for substitute goods it should be positive. If the price of one good does not affect the quantity demanded of other goods it means that both goods are independent.

$$\text{Marshallian expenditure elasticities:} \qquad A_i = \frac{\beta_i}{R_i} + 1 \tag{7}$$

The expenditure elasticity states how much the quantity demanded of a commodity changes when the real income changes by 1%. For normal goods, when the income increases the quantity demanded of that good will also increase but income elasticity for inferior goods is negative.

CHAPTER 4
DATA AND ESTIMATION PROCEDURES

4.1 Data

The data set contains 155 monthly observations from January 2002 to November 2014 in respect of the quantity and FOB value of farmed fresh and frozen salmon exported to the EU and US markets. The amounts of whole fish equivalent (WFE) were in metric tons, and the values were measured in 1000 USD. The source of the data set is the NSEC (2015). Eurostat and other national statistics are the primary sources for collecting data in the NSEC. The monthly prices were obtained by dividing values into their corresponding quantities. The leading exporters of salmon in the EU and US markets are Norway and Chile. The remaining exporters such as Australia, the United Kingdom, Canada, and the Faroe Islands combined into one category representing the rest of the world (ROW). Table 1 indicates quantities of fresh and frozen salmon and market shares exported to the EU market in the years 2002 and 2014.

Table 1: Trade volume and market share of farmed salmon, 2002 versus 2014 in EU market

Exporter	2002 volume metric tons			2014 volume metric tons		
	Fresh	Frozen	Both	Fresh	Frozen	Both
Norway	269301	26206	295507	784573	34401	818975
Chile	__	34774	34774	__	46983	46983
ROW	72246	8401	80647	63155	25839	88994
All	341547	69381	410928	847729	107223	954952
	2002 market share in EU			2014 market share in EU		
Norway	0.79	0.38	0.71	0.92	0.32	0.86
Chile	__	0.50	0.09	__	0.44	0.05
ROW	0.21	0.12	0.20	0.08	0.24	0.09

Source: NSEC (2015).

The trade volume of exported salmon to the EU market increased by 132 per cent from 2002 to 2014. The fresh salmon market share for Norway increased from 79 to 92 per cent whereas it decreased from 21 to 8 per cent for ROW. Norway dominates in the export of fresh salmon in the EU market. Fresh salmon from Chile was combined into the ROW fresh category. In 2002, the Chilean frozen salmon market share was 50 per cent whereas Norway had only 38 per cent, while in 2014 the market share reduced from 38 to 32 per cent and from 50 to 44 per cent for Norway and Chile, respectively. Overall, the core beneficiary was Norway, which captured an 86 per cent market share of farmed fresh and frozen salmon in the EU salmon market while 5 and 9 per cent belonged to Chile and ROW respectively in 2014.

Consider the average volume and market share of each region over the period of 13 years. Norwegian fresh salmon still leads with the highest mean quantity of 42,704 MT exported to the EU market from 2002 to 2014, sharing almost 75 per cent of the total budget on average (Table A1). ROW frozen salmon contributed the least to the budget share of the EU market with only 2 per cent, with a mean quantity of only 1202 MT during the same period. Figure 1 represents the prices of salmon in the EU market from 2002 to 2014.

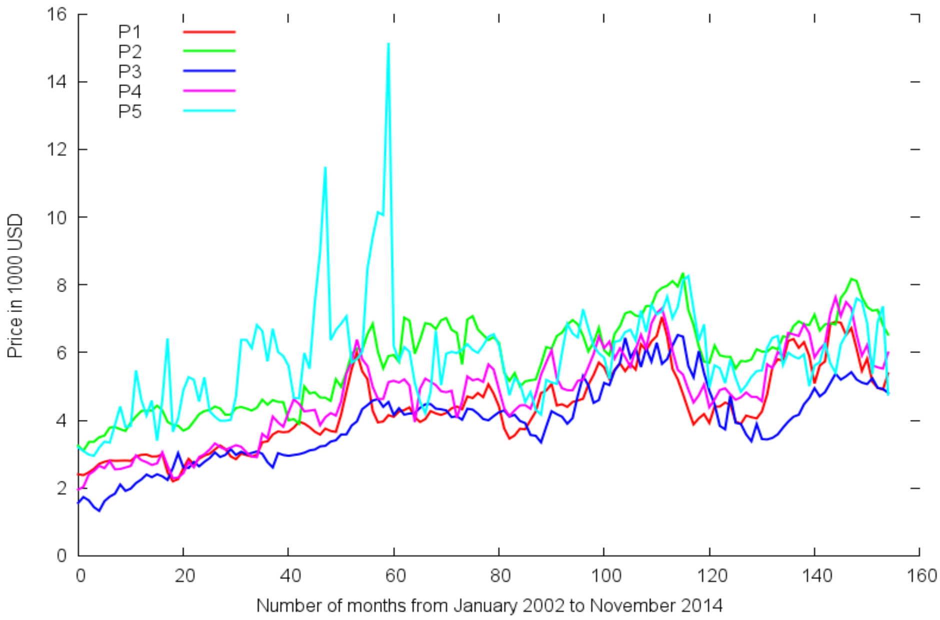

Figure 1: Prices of farmed salmon in EU market (2002–2014).

In the above Figure 1, P1, P2, P3, P4, and P5 represent the prices of Norwegian fresh, Norwegian frozen, Chilean frozen, ROW fresh and ROW frozen salmon, respectively. In brief, from 2002 to 2014, ROW frozen salmon (P5) was the most expensive with a mean price of 5.8757 in terms of thousand USD. Moreover, Chilean frozen salmon (P3) was the cheapest, having an average price of 3.9510 (in 1000 USD) during the stated period in the EU salmon market (Table A1).

Table 2 reports the quantities and market share of fresh and frozen salmon imported into the US in the years 2002 and 2014.

Table 2. Trade volume and market share of farmed salmon, 2002 versus 2014 in US market

Exporter	2002 volume metric tons			2014 volume metric tons		
	Fresh	Frozen	Both	Fresh	Frozen	Both
Norway	5944	6653	12596	23809	21974	45783
Chile	__	40043	40043	__	69227	69227
ROW	233824	367	234191	285523	5246	290769
All	239768	47063	286831	309332	96447	405779
2002 market share in US				2014 market share in US		
Norway	0.02	0.14	0.04	0.08	0.23	0.11
Chile	__	0.85	0.14	__	0.71	0.17
ROW	0.98	0.01	0.82	0.92	0.06	0.72

Source: NSEC (2015).

The trade volume of salmon increased from 286,831 metric tons to 405,779 metric tons over the period from 2002 to 2014 in the US market. The increase in the quantity of salmon exported to the US market was only 41 per cent, which is quite small compared to the increase in trade volume of the EU during the same period, which was 132 per cent. The US market growth rate of importing salmon is quite small compared to the EU market growth of trade volume from same regions Norway, Chile, and ROW.

The Norwegian fresh salmon market share increased from 2 to 8 per cent whereas the ROW market share of fresh salmon dropped from 98 to 92 per cent in the US salmon market from 2002 to 2014. The main reason for why a larger share belongs to ROW fresh salmon is due to Chilean fresh salmon. Around half of the trade volume in ROW fresh salmon is Chilean fresh salmon. The market share of Chilean frozen salmon in the US market dropped from 85 to 71 per cent, whereas it increased from 14 to 23 per cent for Norwegian frozen salmon from 2002 to 2014. So combining fresh and frozen salmon together, the Norwegian salmon market share increased from 4 to 11 per cent, while the Chilean salmon market share also increased from 14 to 17 per cent, although the market share belonging to ROW decreased from 82 to 72 per cent. So the main exporters of salmon to the US are Chile and ROW; together they captured 89 per cent of the salmon market share. The volume share of fresh salmon in ROW fresh salmon from Chile, Canada, and the United Kingdom was 50%, 36%, and 10% respectively in the US market. The main exporters in ROW fresh salmon are Chile, Canada, and United

Kingdom. The share of frozen salmon in ROW frozen salmon from Canada, the United Kingdom, and the Faroe Islands was 53%, 33%, and 14% respectively exported to the US market.

On average, ROW fresh salmon captured almost 74 per cent of the total budget share of the US salmon market over the period from 2002 to 2014, by exporting a mean quantity of 19,093 MT. Meanwhile, the lowest share went to ROW frozen salmon, at only 1 per cent, with an average quantity of 165 MT during these 13 years (Table A2). Figure 2 represents the prices of salmon in the US market from 2002 to 2014.

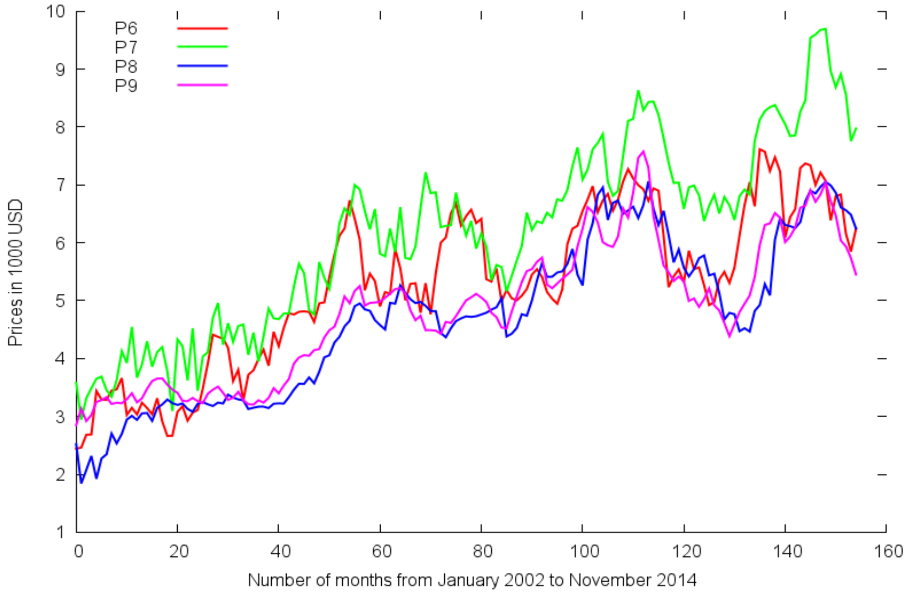

Figure 2: Prices of farmed salmon in US market (2002–2014).

In the above Figure 2, P6, P7, P8, P9, and P10 represent the prices of Norwegian fresh, Norwegian frozen, Chilean frozen, ROW fresh, and ROW frozen salmon, respectively. Norwegian frozen salmon remained expensive (P7) throughout the study period, but ROW frozen salmon was the most expensive (P10), which, due to very high price values, was not included in the graphical representation. Chilean frozen salmon (P8) was the least costly salmon product in the US salmon market. In brief, from 2002 to 2014, ROW frozen salmon was the most expensive with a mean price of 54.989 in terms of 1000 USD per MT. Moreover, Chilean frozen salmon was the cheapest, having an average price of 4.7058 (in 1000 USD) during the stated period in the US salmon market (Table A2).

4.2 Estimation procedure

The demand elasticities of farmed salmon were estimated by the LA/AIDS model for the EU market using the econometric software Shazam. The demand model estimated five equations from 1 to 5, Norway (fresh), Norway (frozen), Chile (frozen), ROW (fresh), and ROW (frozen) salmon exported to the EU market. Seemingly unrelated regression (SUR) was used to estimate the demand model. Then the theoretical restrictions homogeneity and symmetry were imposed because elasticity estimations that are consistent with theory would be preferable. During the estimation process, due to the singularity problem in the covariance matrix the equation of ROW (frozen) was not included in the system. The coefficients of the omitted equation were recovered by using the adding-up restriction.

Secondly, the demand elasticities of farmed salmon were estimated for the US market by applying the LA/AIDS model. The demand model has five equations from 6 to 10, Norway (fresh), Norway (frozen), Chile (frozen), ROW (fresh), and ROW (frozen) salmon exported to the US market. The theoretical restrictions homogeneity and symmetry were applied to attain the consistent elasticities. Due to the singularity problem in the variance-covariance matrix the equation of ROW (frozen) was not included in the system during the estimation process. The coefficients of the deleted equation were recovered by using the adding-up restriction.

Finally, the demand elasticities of farmed salmon for both the EU and US markets were estimated together by applying the theoretical restrictions on all ten equations so that we can make a good comparison between these two markets. Seemingly unrelated regression (SUR) was used to estimate the demand model. Homogeneity and symmetry were also imposed while estimating the demand elasticities and parameters of the LA/AIDS model. The equations of ROW (frozen) to the EU and ROW (frozen) to the US were not included during the estimation process, due to the singularity problem, and then the parameters were recovered by adding-up restrictions. Moreover, the same demand elasticities of farmed salmon in the EU and US markets were estimated by dividing the whole period into two samples. The first sample includes the period from January 2002 to October 2008 and represents from sample 1 to 82 during estimation; this period was described as being before the financial crisis. The second sample period goes from November 2008 to November 2014 and represents from sample 83 to 155; this period was described as being after the financial crisis. We divided the whole period into two samples because we are interested in seeing how the demand elasticities of farmed salmon change in these EU and US markets before and after the financial crisis.

CHAPTER 5

RESULTS AND ANALYSIS

The theoretical restrictions homogeneity and symmetry were tested separately and together in the EU and US markets but were rejected as having a lower p-value than the level of significance of 5 per cent, as indicated in Table 3.

Table 3: Theoretical restrictions test in LA/AIDS model

Restriction	P-value	Test result
Homogeneity and symmetry in EU market	0.0000	Rejected
Homogeneity and symmetry in US market	0.0000	Rejected
Homogeneity and symmetry in EU and US market	0.0000	Rejected

However, elasticity estimations that are consistent with theory would be preferable, so we choose to keep the restrictions imposed during estimation.

5.1 EU salmon market

The estimated coefficients of all these five equations are presented in Table 4, and p-values are included in parentheses for the EU salmon market.

Table 4: Estimates parameters for LA/AIDS model in the EU salmon market (2002-2014)

Independent variable	Norway (fresh)	Norway (frozen)	Chile (frozen)	ROW (fresh)	ROW (frozen)
$\ln p_1$	0.018	-0.052**	-0.037**	0.095**	-0.025**
	(0.63)	(0.00)	(0.04)	(0.00)	(0.00)
$\ln p_2$	-0.052**	0.034**	0.003	0.000	0.014**
	(0.00)	(0.00)	(0.79)	(0.98)	(0.00)
$\ln p_3$	-0.037**	0.002	-0.010	0.043**	0.001
	(0.04)	(0.79)	(0.58)	(0.00)	(0.76)
$\ln p_4$	0.095**	0.460**	0.043**	-0.143**	0.004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.48)
$\ln p_5$	-0.025**	0.014**	0.001	0.004	0.005*
	(0.00)	(0.00)	(0.76)	(0.48)	(0.05)
$\ln Y_{EU}P_{EU}$	0.168**	-0.038**	-0.050**	-0.081**	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.66)
Intercept	-1.067**	0.461**	0.604**	0.993**	-0.056*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)
R^2	0.71	0.44	0.21	0.61	0.20
DW	0.60	0.45	0.38	0.76	1.40

Note: Numbers in parentheses are p-values. * and ** represent significance at the 10 per cent and 5 per cent level of significance, respectively.

The Durbin-Watson and R^2 statistics are reported. The R^2 ranges from 0.20 to 0.71. The ROW (frozen) salmon equation shows the least explanatory power whereas the Norway (fresh) salmon equation shows the most explanatory power. The Durbin-Watson result for all equations lies in between 0.38 and 1.40. All equations have significant intercepts at the 10% significance level. Sixteen price parameters out of 25 are significant at the 10% significance level. The estimated results for the coefficients have little economic importance and interpretation will rather be left to the estimated elasticities because they have more economic significance. The Marshallian price and income elasticities are presented in Table 5.

Table 5: Marshallian price and expenditure elasticities for EU salmon market (2002-2014)

Quantity Demanded from	e_{i1}	e_{i2}	e_{i3}	e_{i4}	e_{i5}	A_i
	SUR estimates					
Norway (fresh)	-1.144**	-0.083**	-0.063**	0.104**	-0.040**	1.225**
	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
Norway (frozen)	-0.382	-0.396**	0.081	0.071	0.251**	0.375**
	(0.16)	(0.03)	(0.62)	(0.75)	(0.00)	(0.00)
Chile (frozen)	0.017	0.094	-1.115**	0.789**	0.047	0.169
	(0.96)	(0.56)	(0.00)	(0.00)	(0.53)	(0.29)
ROW (fresh)	1.503**	0.051	0.460**	-2.300**	0.064	0.222**
	(0.00)	(0.70)	(0.00)	(0.00)	(0.278)	(0.00)
ROW (frozen)	-0.932**	0.504**	0.048	0.152	-0.811**	1.040**
	(0.00)	(0.00)	(0.77)	(0.49)	(0.00)	(0.00)

Note: Numbers in parentheses are p-values. * and ** represent significance at the 10 per cent and 5 per cent level of significance, respectively.

The Marshallian elasticities are estimated at mean budget or market shares. Norwegian fresh salmon has a 75 per cent mean market share in the EU salmon market whereas ROW (fresh) has only 10 per cent. Moreover, the remaining 15 per cent of market shares belong to the frozen salmon from Norway, Chile and ROW at 6, 6 and 3 per cent, respectively.

All the own price elasticities have expected negative signs and are significant at the 5 per cent significance level. That shows that when the price of a product increases the quantity demanded of that product will decrease, but the sensitiveness to its price depends on the magnitude of the elasticity value. The demands for Norwegian fresh, Chilean frozen and ROW fresh salmon in the EU salmon market are elastic to their prices at -1.14, -1.11, and -2.29, respectively. The demand for ROW (fresh) salmon in the EU market is more sensitive to its price than for fresh salmon from Norway and Chile. The demand elasticities of Norwegian and ROW frozen salmon in the EU markets are price inelastic at -0.39 and -0.81, respectively. The demand for Norwegian frozen salmon is the least sensitive to its price whereas ROW (fresh) salmon is the most sensitive in the EU salmon market.

All the expenditure elasticities have the expected positive sign and all are significant except for Chilean frozen salmon. Chilean frozen salmon has a small and relatively unstable market share, which might lead to it being insensitive to changes in total expenditure. Positive expenditure elasticity means that when the income of EU consumers increases, the demand for all products will also increase, but the strength depends on the magnitude of the expenditure elasticity. The expenditure elasticity of Norwegian fresh salmon is an elastic 1.22, which indicates that Norwegian fresh salmon is considered to be the luxury product among the consumers of the EU within their salmon budget share. Norwegian fresh salmon benefits the most from increased expenditure (1.22) while ROW (fresh) benefits the least, having an income elasticity of 0.22. On the other hand, this also means that Norwegian fresh salmon would experience the most harm from a reduction in EU expenditures or income. Norwegian frozen and ROW fresh salmon are considered as necessary goods among EU consumers, having inelastic income elasticities, whereas ROW frozen salmon has unitary income elasticity.

Ten of the 20 cross-price elasticities are significant at the 5 per cent level of significance. None of the other salmon prices affected the demand for Norwegian fresh salmon strongly; only ROW fresh salmon has a small substitution effect, but that is almost negligible. The prices of other products of salmon except ROW (fresh) have little gross complement effect on the demand for Norwegian fresh salmon. The cross-price effects between Norwegian and ROW frozen salmon are e_{25}=0.25 and e_{52}=0.50, which shows that the Norwegian frozen salmon price has a stronger effect on the demand for ROW frozen salmon than the price of ROW frozen salmon on the demand for Norwegian frozen salmon. The strongest substitution effect in the EU market is e_{41}=1.5, which suggests that a decline in the Norwegian fresh salmon price brings down the ROW fresh salmon demand to a greater extent, whereas e_{14}=0.10 indicates that the ROW fresh price has little effect on the demand for Norwegian fresh salmon. Norwegian fresh salmon has a 75 per cent market share whereas only a 10 per cent market share belongs to ROW fresh salmon, so the Norwegian fresh salmon price has a greater influence on the quantity demanded of ROW fresh salmon. ROW frozen salmon and Chilean frozen salmon have some substitute effect among them. The negative cross-price elasticity indicates that these products are complements. e_{51}=-0.93 shows that when the price of Norwegian fresh salmon declines the demand for ROW frozen salmon increases and vice versa.

5.2 US salmon market

Theoretical restrictions in the LA/AIDS model such as homogeneity and symmetry were tested individually and together but did not sit well with the data set for the US salmon market. However, the elasticities estimated with these restrictions would be preferable. The estimated coefficients of all five equations from 6 to 10 are reported in Table 6 and the numbers in parentheses represent the p-values.

Table 6: Parameter estimates of LA/AIDS model in the US salmon market (2002-2014)

Independent variable	Norway (fresh))	Norway (frozen)	Chile (frozen)	ROW (fresh)	ROW (frozen)
$\ln p_6$	-0.032	-0.023*	0.026	0.040	-0.011**
	(0.14)	(0.08)	(0.13)	(0.12)	(0.00)
$\ln p_7$	-0.023*	-0.029*	0.097**	-0.036**	-0.008**
	(0.08)	(0.09)	(0.00)	(0.03)	(0.00)
$\ln p_8$	0.026	0.097**	0.095**	-0.233**	0.016**
	(0.13)	(0.00)	(0.00)	(0.00)	(0.00)
$\ln p_9$	0.040	-0.036**	-0.233**	0.226**	0.004
	(0.12)	(0.03)	(0.00)	(0.00)	(0.12)
$\ln p_{10}$	-0.011**	-0.009**	0.016**	0.004	0.000
	(0.00)	(0.00)	(0.00)	(0.12)	(0.91)
$\ln Y_{US} P_{US}$	-0.086**	-0.017	0.059**	0.033	0.010**
	(0.00)	(0.17)	(0.00)	(0.20)	(0.01)
Intercept	0.934**	0.246*	-0.488**	0.393	0.019
	(0.00)	(0.05)	(0.01)	(0.14)	(0.63)
R^2	0.32	0.48	0.34	0.36	0.21
DW	0.37	0.71	0.82	0.63	1.14

Note: Numbers in parentheses are p-values. * and ** represent significance at the 10 per cent and 5 per cent level of significance, respectively.

The R^2 ranges from 0.21 to 0.48. The ROW frozen equation shows the least explanatory power while the Norway (frozen) equation shows the most explanatory power. The Durbin-Watson statistic ranges in between 0.37 and 1.14. The Norway (fresh) and Chile (frozen) equations have significant intercept at the 5 per cent significance level, which shows that trend effects are significant for these equations. In LA/AIDS, estimated results for the coefficients are of little economic importance and interpretation will rather be significant for the estimated elasticities. The Marshallian price and income elasticities are reported in Table 7; these elasticities are estimated at mean market share in the US salmon market.

Table 7: Estimated price and expenditure elasticities in the US market (2002-2014)

Quantity Demanded from	e_{i6}	e_{i7}	e_{i8}	e_{i9}	e_{i10}	A_i
	SUR estimates					
Norway (fresh)	-1.678**	-0.435**	0.930**	0.469**	-0.243**	-1.043**
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.02)
Norway (frozen)	-0.437*	-1.580**	1.998**	-0.476	-0.167**	0.661**
	(0.09)	(0.00)	(0.00)	(0.15)	(0.00)	(0.01)
Chile (frozen)	0.1514	0.612**	-0.445**	-1.799**	0.097**	1.384**
	(0.17)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
ROW (fresh)	0.053	-0.051**	-0.322**	-0.729**	0.005	1.045**
	(0.14)	(0.03)	(0.00)	(0.00)	(0.15)	(0.00)
ROW (frozen)	-0.979**	-0.761**	1.181**	-0.284	-1.005**	1.848**
	(0.00)	(0.00)	(0.00)	(0.36)	(0.00)	(0.00)

Note: Numbers in parentheses are p-values. * and ** represent significance at the 10 per cent and 5 per cent level of significance, respectively.

In the US salmon market, ROW and Chile together have a 91 per cent salmon market share for fresh and frozen salmon. Moreover, the remaining 9 per cent salmon market share belongs to Norwegian salmon in the total imported salmon in the US market. All Marshallian own price elasticities are significant at 5 per cent and have the expected negative sign. The Marshallian own price elasticities of Norway (fresh), Norway (frozen), Chile (frozen), ROW (fresh), and ROW (frozen) salmon in the US market are -1.6, -1.5, -0.4, -0.7, and -1, respectively. The demand elasticities are elastic for Norwegian fresh and frozen salmon, while Chile frozen and ROW fresh salmon have inelastic own price elasticities, whereas ROW frozen salmon has unitarily elastic demand. Norwegian salmon demand is more sensitive to its price than Chilean and ROW salmon demand. That means that Norwegian salmon has more substitutes in the US salmon market than ROW and Chilean salmon. In the US salmon market, the Norwegian fresh salmon demand is most sensitive to its price whereas the Chilean frozen salmon demand is the least sensitive to its price.

Fourteen of the 20 cross-price elasticities are significant at the 5 per cent significance level. Chilean frozen salmon and ROW fresh salmon are good substitutes for Norwegian fresh salmon, but Chilean frozen (e_{68}=0.93) salmon has a higher substitution effect than ROW fresh (e_{69}=0.46) salmon. So when the price of Chilean frozen salmon decreases, the demand for Norwegian fresh salmon will also decline and vice versa. When Norwegian salmon becomes more expensive among US consumers, they will prefer to buy its substitutes such as fresh salmon from ROW and also frozen salmon from Chile. Norwegian frozen and ROW frozen salmon are gross complements for Norwegian fresh salmon in the US market. Chilean frozen salmon has a strong substitution effect for Norwegian frozen salmon: e_{78}=2 and e_{87}=0.61. So the Chilean frozen salmon price has a strong impact on the demand for Norwegian frozen salmon, but the Norwegian frozen salmon price effect on Chilean frozen salmon demand is not very strong. Chilean frozen salmon and ROW fresh salmon are gross complements to each other. Although the price of ROW (fresh) salmon has a strong effect on the demand for Chilean frozen salmon as e_{89}=-1.8, the impact of the Chilean frozen salmon price (e_{98}=-0.32) on the quantity demand for ROW fresh salmon is not as effective, since ROW fresh salmon has a 74 per cent market share whereas Chilean frozen salmon has only a 16 per cent mean market share in the US salmon market. Moreover, Norwegian fresh salmon has a 4 per cent market share so the Norwegian fresh salmon price does not have a significant effect on the demand for ROW (fresh) salmon. Norwegian fresh and frozen salmon are considered to be gross complements for ROW (frozen) salmon. Moreover, Chilean (frozen) salmon is a substitute for ROW frozen salmon.

All of the income elasticities are significant at the 5 per cent critical level and have the expected positive sign except for Norwegian fresh salmon, which has a negative sign. Having negative income elasticity, with A_6=-1.04, shows that Norwegian fresh salmon is considered an inferior commodity among US consumers within their salmon budget. The income elasticity is near unity for ROW (fresh) salmon (1.04) and income elasticity for Norwegian frozen salmon is inelastic (0.66). Moreover, expenditure elasticities for Chile (frozen) and

ROW (frozen) are elastic with A_8=1.38 and A_{10}=1.85, respectively. Frozen salmon from ROW and Chile are considered luxury commodities among US consumers whereas the Norwegian frozen salmon is considered a necessary good for them.

5.3 EU and US salmon markets

Equations 1 to 5 are used to estimate the demand elasticities in the EU market and equations 6 to 10 belong to the demand elasticities in the US salmon market. Now we estimate all these ten equations together by imposing homogeneity and symmetry on them to achieve the corresponding demand elasticities. Homogeneity and symmetry were tested for both markets but were rejected. However, we keep these restrictions while estimating the elasticities to obtain the elasticities that would be consistent with theory. To make a proper comparison between the demand elasticities of farmed fresh and frozen salmon in the EU and US salmon markets, we estimated the elasticities as a system of combined equations. That will provide us with a more accurate relationship among these products, in terms of own price sensitivities, complementary and substitute relationships, than the demand elasticities that we obtained individually for both the EU and US salmon markets. The estimated coefficients of all equations are presented in Table 8, and p-values are also reported in parentheses.

Table 8: Parameter estimates for LA/AIDS model in EU & US markets (2002–2014)

Independent variable	Norway (fresh))	Norway (frozen)	Chile (frozen)	ROW (fresh)	ROW (frozen)
$\ln p_1$	0.016	-0.053**	-0.021	0.081**	-0.023**
	(0.63)	(0.00)	(0.17)	(0.00)	(0.00)
$\ln p_2$	-0.053**	0.033**	0.004	0.001	0.015**
	(0.00)	(0.00)	(0.63)	(0.93)	(0.00)
$\ln p_3$	-0.021	0.004	-0.025*	0.040**	0.003
	(0.17)	(0.63)	(0.09)	(0.00)	(0.48)
$\ln p_4$	0.081**	0.001	0.040**	-0.120**	-0.001
	(0.00)	(0.93)	(0.00)	(0.00)	(0.82)
$\ln p_5$	-0.023**	0.015**	0.003	-0.001	0.007**
	(0.00)	(0.00)	(0.48)	(0.82)	(0.00)
$\ln Y_{EU}P_{EU}$	0.153**	-0.039**	-0.033**	-0.081**	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.97)
Intercept	-0.900**	0.475**	0.406**	0.998**	-0.043
	(0.00)	(0.00)	(0.00)	(0.00)	(0.13)
R^2	0.72	0.44	0.20	0.59	0.19
DW	0.55	0.46	0.37	0.70	1.34
Independent variable	Norway (fresh))	Norway (frozen)	Chile (frozen)	ROW (fresh)	ROW (frozen)
$\ln p_6$	-0.073**	-0.042**	0.003	0.112**	0.000
	(0.00)	(0.00)	(0.85)	(0.00)	(0.97)
$\ln p_7$	-0.055**	0.003	0.066**	0.096**	0.022**
	(0.00)	(0.85)	(0.04)	(0.00)	(0.00)
$\ln p_8$	0.087**	0.112**	0.096**	-0.307**	0.012**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)
$\ln p_9$	0.045*	-0.069**	-0.040*	0.097**	-0.034**
	(0.07)	(0.00)	(0.06)	(0.00)	(0.00)
$\ln p_{10}$	-0.003	-0.005**	0.007**	0.002	-0.001
	(0.12)	(0.00)	(0.00)	(0.58)	(0.20)
$\ln Y_{US}P_{US}$	-0.040**	-0.000	0.064**	-0.019	-0.004
	(0.03)	(0.99)	(0.00)	(0.46)	(0.23)
Intercept	0.477**	0.065	-0.483**	0.887**	0.001
	(0.01)	(0.55)	(0.00)	(0.00)	(0.97)
R^2	0.23	0.44	0.29	0.32	0.20
DW	0.19	0.56	0.62	0.66	1.14

Note: Numbers in parentheses are p-values. * and ** represent significance at the 10 per cent and 5 per cent level of significance, respectively.

In the EU salmon market, all equations have significant trend effects except for ROW frozen salmon, whereas in the US salmon market, three equations have significant intercept at the 5 per cent significance level. ROW frozen salmon and Norwegian frozen salmon have insignificant trend effects in the US salmon market. The R^2 ranges from 0.19 to 0.72. The ROW frozen salmon in the EU market has the least explanatory power whereas Norwegian fresh salmon in the EU market has the most explanatory power. In all ten equations, 33 of the 50 price parameters are significant at the 10 per cent significance level. The Marshallian price and expenditure elasticities for both the EU and US salmon markets are reported in Table 9.

Table 9: Estimated price and expenditure elasticities in the EU & US markets (2002–2014)

EU Quantity Demanded from	e_{i1}	e_{i2}	e_{i3}	e_{i4}	e_{i5}	A_i
	SUR estimates					
Norway (fresh)	-1.131**	-0.083**	-0.041*	0.087**	-0.037**	1.205**
	(0.00)	(0.00)	(0.05)	(0.02)	(0.00)	(0.00)
Norway (frozen)	-0.384	-0.421**	0.109	0.085	0.256**	0.355**
	(0.12)	(0.02)	(0.45)	(0.68)	(0.00)	(0.00)
Chile (frozen)	0.050	0.103	-1.389**	0.709**	0.063	0.465**
	(0.85)	(0.48)	(0.00)	(0.00)	(0.35)	(0.00)
ROW (fresh)	1.360**	0.058	0.431**	-2.079**	0.009	0.217**
	(0.00)	(0.62)	(0.00)	(0.00)	(0.87)	(0.00)
ROW (frozen)	-0.823**	0.052**	0.104	-0.048	-0.753**	1.003**
	(0.00)	(0.00)	(0.49)	(0.81)	(0.00)	(0.00)
US Quantity Demanded from	e_{i6}	e_{i7}	e_{i8}	e_{i9}	e_{i10}	A_i
	SUR estimates					
Norway (fresh)	-2.706**	-1.271**	2.216**	1.784**	-0.062	0.040
	(0.00)	(0.01)	(0.00)	(0.00)	(0.18)	(0.92)
Norway (frozen)	-0.840**	-0.942**	2.245**	-1.370**	-0.090**	0.997**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Chile (frozen)	0.001	-0.450**	-0.438**	-0.565**	0.037**	1.415**
	(0.99)	(0.03)	(0.01)	(0.00)	(0.00)	(0.00)
ROW (fresh)	0.152**	0.131**	-0.411**	-0.850**	0.003	0.974**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.51)	(0.00)
ROW (frozen)	0.031**	1.892**	1.070**	-2.578**	-1.040**	0.625*
	(0.03)	(0.00)	(0.01)	(0.00)	(0.00)	(0.05)

Note: Numbers in parentheses are p-values. * and ** represent significance at the 10 per cent and 5 per cent level of significance, respectively.

Marshallian own price elasticities are all significant at 5 per cent for the EU salmon market. Norwegian frozen and ROW frozen salmon have inelastic demand elasticities towards their prices at -0.42 and -0.75, respectively. Norwegian fresh salmon is the least elastic demand while ROW fresh salmon is the most elastic demand elasticity in the EU salmon market towards their prices, -1.13 and -2.08, respectively.

All own price elasticities have the expected negative sign in the US salmon market and are significant at the 5 per cent significance level. Norwegian frozen, Chilean frozen, and ROW fresh salmon have inelastic demand elasticities with respect to their prices, -0.94, -0.44, and -0.85, respectively, while the demands for Norwegian fresh and ROW frozen salmon are price elastic at -2.71 and -1.04, respectively, for the US salmon market. Chilean frozen salmon is the least sensitive to its price whereas Norwegian fresh salmon is the most sensitive towards its price.

Marshallian income elasticities are all significant and have the expected positive sign, which means that when the income of EU consumers increases, the import of salmon from all countries will also increase and vice versa. Norwegian fresh salmon has elastic income elasticity (A_1=1.2). Norwegian frozen, Chilean frozen, and ROW fresh salmon have inelastic income elasticities (A_2=0.35, (A_3=0.46, and A_4=0.22, respectively). ROW frozen salmon has unitary income elasticity (A_5=1). Norwegian fresh salmon is considered a luxury product among EU consumers and would benefit the most from an income-induced market size, whereas ROW fresh salmon would benefit the least. Reversing this means that Norwegian fresh salmon would experience the most harm from a reduction in EU expenditures.

All income elasticities have the expected positive sign and all are significant except for Norwegian fresh salmon income elasticity for the US salmon market. Norwegian fresh salmon has a relatively small budget share, which might explain its insensitivity to the changes in total expenditure. Chilean frozen salmon (A_8=1.42) benefits the most from increasing expenditure while ROW frozen (A_{10}=0.63) salmon benefits the least. ROW fresh salmon and Norwegian frozen salmon have almost unitary income elasticity (A_9=0.97 and A_7=0.99, respectively) in the US market.

Twenty-seven of the 40 cross-price elasticities are significant at 5 per cent in both the EU and US markets. Cross-price elasticities show which product is a substitute or complement for another product; a positive sign with cross-price elasticities means that goods are substitutes for other goods and a negative sign makes them complements to other products. Norwegian fresh salmon in the EU market captured a 75 per cent market share, so none of the other salmon prices affect its demand strongly, but it has some substitution effect with ROW fresh salmon (e_{14}=0.087). Norwegian frozen, Chilean frozen, and ROW frozen salmon are gross complements for Norwegian fresh salmon, which shows that when prices of these products decrease, the demand for Norwegian fresh salmon increases and vice versa. The second largest market share in the EU salmon market belongs to ROW fresh salmon at around 10 per cent. So the Norwegian fresh salmon price has a strong substitution effect on the demand for ROW fresh salmon, e_{41}=1.36, which shows that when the price of Norwegian fresh salmon increases, the demand for ROW fresh salmon increases and vice versa. Moreover, Norwegian fresh salmon is a gross complement for ROW frozen, e_{51}=-0.82, and when the price of Norwegian fresh salmon decreases, the demand for ROW frozen will surge up and vice versa.

ROW fresh salmon has a 74 per cent market share in total exported salmon to the US. However, Chilean frozen salmon has only a 16 per cent market share. So ROW fresh and Chilean frozen salmon captured a 90 per cent market share in total exported salmon in the US market. Therefore, these are the main exporters of salmon to this market, and half of the share in ROW fresh salmon belongs to Chilean fresh salmon only. Chilean frozen and ROW fresh salmon are the main substitutes for Norwegian fresh salmon in the US market as e_{68}=2.2 and e_{69}=1.8, which shows there is strong competition for Norwegian fresh salmon, which has high substitution elasticities. However, the Norwegian fresh salmon price does not have a strong effect on the demand for Chilean frozen and ROW fresh salmon, e_{86}=0.001 and e_{96}=0.152, respectively. Chilean frozen and ROW fresh salmon are gross complements for each other, which shows that when the price of one product decreases, the demand for other products increases and vice versa. Norwegian frozen salmon is a substitute for ROW frozen salmon, and when the price of Norwegian frozen salmon increases, the demand for ROW frozen salmon will increase and vice versa in the US salmon market.

5.4 EU and US salmon markets before financial crisis

We have already estimated the parameters and demand elasticities of the EU and US salmon markets for the whole period from January 2002 to November 2014. Now we estimate the demand elasticities of farmed salmon for both markets before the financial crisis, which comprises the period from January 2002 to October 2008. Further, we will estimate the demand elasticities of farmed salmon in the EU and US after the financial crisis, which comprises the period from November 2008 to November 2014. The aim of this analysis is to capture the effect of the financial crisis in the EU and US salmon markets and to compare the extent of change in the elasticities of demand for salmon in each market. The parameters of the EU and US salmon markets before the financial crisis are reported in Table 10, and the p-values are stated in parentheses.

Table 10: Parameter estimates of LA/AIDS before the crisis in EU and US (Jan2002–October2008)

Independent variable	Norway (fresh)	Norway (frozen)	Chile (frozen)	ROW (fresh)	ROW (frozen)
$\ln p_1$	0.038	-0.050**	-0.075**	0.115**	-0.028**
	(0.45)	(0.04)	(0.00)	(0.00)	(0.01)
$\ln p_2$	-0.050**	0.029*	0.025*	-0.025	0.021**
	(0.04)	(0.09)	(0.09)	(0.18)	(0.00)
$\ln p_3$	-0.076**	0.025*	-0.047*	0.093**	0.005
	(0.00)	(0.09)	(0.05)	(0.00)	(0.39)
$\ln p_4$	0.115**	-0.025	0.093**	-0.173**	-0.009
	(0.00)	(0.18)	(0.00)	(0.00)	(0.27)
$\ln p_5$	-0.028**	0.021**	0.005	-0.009	0.011**
	(0.01)	(0.00)	(0.39)	(0.27)	(0.00)
$\ln Y_{EU} P_{EU}$	0.173**	-0.073**	0.022	-0.113**	-0.009*
	(0.00)	(0.00)	(0.15)	(0.00)	(0.05)
Intercept	-1.141**	0.838**	-0.177	1.365**	-0.043
	(0.00)	(0.00)	(0.29)	(0.00)	(0.13)
R^2	0.60	0.58	0.25	0.57	0.19
DW	0.98	0.92	0.97	0.90	1.34
Independent variable	Norway (fresh)	Norway (frozen)	Chile (frozen)	ROW (fresh)	ROW (frozen)
$\ln p_6$	-0.015**	-0.015**	0.025**	0.007	-0.002
	(0.00)	(0.01)	(0.00)	(0.36)	(0.66)
$\ln p_7$	-0.011*	0.025**	-0.177**	0.166**	-0.004
	(0.09)	(0.00)	(0.00)	(0.00)	(0.56)
$\ln p_8$	-0.002	0.007	0.165**	-0.177**	0.006
	(0.66)	(0.36)	(0.00)	(0.00)	(0.33)
$\ln p_9$	0.028**	-0.016**	-0.023**	0.011	-0.000
	(0.00)	(0.00)	(0.03)	(0.26)	(0.97)
$\ln p_{10}$	0.001*	-0.001	0.008**	-0.008**	-0.000
	(0.06)	(0.10)	(0.00)	(0.01)	(0.81)
$\ln Y_{US} P_{US}$	0.006	-0.004	0.067	-0.026	-0.044**
	(0.35)	(0.68)	(0.11)	(0.59)	(0.00)
Intercept	-0.044	0.066	-0.476	1.002**	0.001
	(0.52)	(0.48)	(0.27)	(0.04)	(0.97)
R^2	0.22	0.10	0.25	0.17	0.20
DW	0.78	1.32	1.06	1.00	1.14

Note: Numbers in parentheses are p-values. * and ** represent significance at the 10 per cent and 5 per cent level of significance, respectively.

The R^2 ranges from 0.1 to 0.6; the Norway (frozen) equation for the US salmon market shows the least explanatory power while the Norway (fresh) equation for the EU market has the most. Four of the ten equations have significant intercept in both salmon markets. Durbin-Watson results range from 0.78 to 1.34. The Marshallian price and income elasticities of farmed salmon before the financial crisis for the EU and US markets are presented in Table 11.

Table 11: Price and expenditure elasticities in EU and US markets before crisis (Jan 2002–Oct 2008)

EU Quantity Demanded from	e_{i1}	e_{i2}	e_{i3}	e_{i4}	e_{i5}	A_i
	SUR estimates					
Norway (fresh)	-1.123**	-0.081**	-0.115**	0.130**	-0.044**	1.232**
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)
Norway (frozen)	-0.082	-0.446	0.478*	-0.288	0.377**	-0.203
	(0.82)	(0.12)	(0.05)	(0.36)	(0.00)	(0.22)
Chile (frozen)	-1.519**	0.385	-1.798**	1.489**	0.075	1.368**
	(0.00)	(0.11)	(0.00)	(0.00)	(0.45)	(0.00)
ROW (fresh)	1.930**	-0.176	0.962**	-2.565**	-0.057	-0.094
	(0.00)	(0.33)	(0.00)	(0.00)	(0.47)	(0.58)
ROW (frozen)	-0.745**	0.766**	0.205	-0.291	-0.609**	0.675**
	(0.02)	(0.00)	(0.35)	(0.32)	(0.00)	(0.00)
US Quantity Demanded from	e_{i6}	e_{i7}	e_{i8}	e_{i9}	e_{i10}	A_i
	SUR estimates					
Norway (fresh)	-1.373**	-0.262*	-0.084	0.550**	0.019*	1.151**
	(0.00)	(0.08)	(0.54)	(0.00)	(0.07)	(0.00)
Norway (frozen)	-0.297**	-0.487**	0.149	-0.269	-0.019	0.923**
	(0.02)	(0.00)	(0.33)	(0.11)	(0.11)	(0.00)
Chile (frozen)	0.147**	-1.167**	0.009	-0.471**	0.045**	1.437**
	(0.01)	(0.00)	(0.97)	(0.03)	(0.01)	(0.00)
ROW (fresh)	0.011	0.225**	-0.233**	-0.958**	-0.010**	0.965**
	(0.32)	(0.00)	(0.00)	(0.00)	(0.02)	(0.00)
ROW (frozen)	0.006	-0.167	1.110*	2.699**	-0.966**	-2.669**
	(0.99)	(0.78)	(0.05)	(0.00)	(0.00)	(0.00)

Note: Numbers in parentheses are p-values. * and ** represent significance at the 10 per cent and 5 per cent level of significance, respectively.

Except for Norwegian frozen salmon, all the Marshallian own price elasticities have the expected negative sign and are significant at the 5 per cent significance level in the EU salmon market. Norwegian fresh, Chilean frozen, and ROW fresh salmon have elastic demand with respect to their prices at -1.12, -1.79, and -2.56, respectively, in the EU salmon market before the emergence of financial crisis, while demand for ROW frozen salmon is price inelastic at -0.61. The demand for ROW fresh salmon is the most elastic while the demand for ROW frozen salmon is the least elastic with respect to their prices in the EU salmon market.

Three of the five Marshallian income elasticities are significant and have a positive sign, which shows that when the income of EU consumers increases, the import of salmon from these three regions will also increase. Norwegian fresh and Chilean frozen salmon have elastic expenditure elasticities of 1.23 and 1.36, respectively, while ROW frozen salmon income elasticity is inelastic at 0.67 in the EU salmon market. Thus, when the income of EU consumers increases, Chilean frozen salmon will benefit the most and ROW frozen salmon the least. Norwegian frozen and ROW fresh salmon have insignificant expenditure elasticities.

In the EU market, 12 out of the 20 cross-price elasticities are significant at the 10 per cent significance level. The cross-price elasticities of Norwegian and ROW fresh salmon are e_{41} = 1.93 and e_{14} =0.13, respectively, which indicates that when there is a reduction in the price of Norwegian fresh salmon, that drags down the ROW fresh salmon price to a larger extent than vice versa. Norwegian fresh salmon has a 75 per cent market share while ROW fresh salmon has only a 10 per cent market share in the total amount of salmon imported to the EU. Chilean frozen and ROW fresh salmon are also substitutes for each other but the ROW fresh salmon price has a greater effect on the demand for Chilean frozen salmon, e_{34}=1.48 and e_{43}=0.96. Norwegian frozen and ROW frozen salmon are considered to be substitutes for each other, e_{25}=0.37 and e_{52}=0.76. However, the Norwegian frozen salmon price has a greater impact on the demand for ROW frozen salmon in the EU salmon market. The cross-price elasticities with a negative sign show that these goods are considered to be complements to other goods, such as e_{31}=-1.52, so Norwegian fresh salmon is a complement for Chilean frozen salmon.

In the US salmon market, except for Chilean frozen salmon, all the own price elasticities are significant and have the expected negative signs. Norwegian frozen, ROW fresh, and ROW frozen salmon have inelastic demand elasticities with respect to their prices at -0.48, -0.95, and -0.96, respectively, while the demand for Norwegian fresh salmon is price elastic at -1.37 in the US salmon market before the financial crisis. The demand for Norwegian frozen salmon is the least sensitive while Norwegian fresh salmon demand is the most sensitive to their prices in the US salmon market. The price of Chilean frozen salmon has no influence on its demand in the US salmon market.

In the US salmon market, all the Marshallian expenditure elasticities are significant at 5 per cent, and all have positive signs except ROW frozen salmon. So having negative income elasticity, frozen salmon from ROW becomes an inferior good among US consumers. Norwegian fresh and Chilean frozen salmon have elastic income elasticities at 1.15 and 1.43, respectively. Norwegian fresh and Chilean frozen salmon are considered luxury commodities among US consumers. Norwegian frozen and ROW fresh salmon have inelastic income elasticities at 0.92 and 0.96, respectively, in the US salmon market. Frozen salmon from Chile will benefit the most from the increase in income of US consumers whereas Norwegian frozen salmon will benefit the least. However, this also means that Chilean frozen salmon would experience the most harm from a reduction in US income.

In the US salmon market, 13 of the 20 cross-price elasticities are significant at the 10 per cent significance level. As Norwegian fresh salmon has only a 4 per cent mean market share of salmon in the US, its price has no significant effect on the demand for ROW fresh salmon. However, the ROW fresh salmon price has a significant impact on the demand for Norwegian fresh salmon, e_{69}=0.55. Chilean frozen salmon has a 16 per cent market share while ROW frozen salmon has only a 1 per cent market share. So the Chilean frozen salmon price has a strong substitution effect with ROW frozen salmon $e_{10\ 8}$ = 1.11. When the price of Chilean salmon decreases, the demand for ROW frozen salmon will also decrease to a greater extent. There is a strong substitution effect between ROW fresh and ROW frozen salmon, $e_{10\ 9}$= 2.69, as a 74 per cent market share belongs to ROW fresh salmon, so the price of this salmon has a stronger effect on the demand for ROW frozen salmon. Norwegian frozen salmon is a gross complement for Chilean frozen salmon, e_{87}= -1.16.

5.5 EU and US salmon markets after financial crisis

After estimating the demand elasticities of salmon in the EU and US markets before the appearance of the financial crisis, now we estimate the demand equations to capture the effect of the financial crisis during the period from November 2008 to November 2014 in the EU and US markets. Estimated parameters from LA/AIDS are reported in Table 12.

Table 12: Parameter estimates for LA/AIDS model in the EU and US markets after the financial crisis (November 2008–November, 2014)

Independent variable	Norway (fresh))	Norway (frozen)	Chile (frozen)	ROW (fresh)	ROW (frozen)
$\ln p_1$	0.016	-0.053**	-0.021	0.081**	-0.023**
	(0.63)	(0.00)	(0.17)	(0.00)	(0.00)
$\ln p_2$	-0.053**	0.033**	0.004	0.001	0.015**
	(0.00)	(0.00)	(0.63)	(0.93)	(0.00)
$\ln p_3$	-0.021	0.004	-0.026*	0.040**	0.003
	(0.17)	(0.63)	(0.09)	(0.00)	(0.48)
$\ln p_4$	0.081**	0.001	0.039**	-0.120**	-0.001
	(0.00)	(0.93)	(0.00)	(0.00)	(0.82)
$\ln p_5$	-0.023**	0.015**	0.003	-0.001	0.007**
	(0.00)	(0.00)	(0.48)	(0.82)	(0.01)
$\ln Y_{EU} P_{EU}$	0.153**	-0.039**	-0.033**	-0.081**	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.97)
Intercept	-0.900**	0.475**	0.406**	1.000**	-0.043
	(0.00)	(0.00)	(0.00)	(0.00)	(0.13)
R^2	0.72	0.44	0.20	0.59	0.19
DW	0.55	0.46	0.37	0.70	1.34
Independent variable	Norway (fresh))	Norway (frozen)	Chile (frozen)	ROW (fresh)	ROW (frozen)
$\ln p_6$	-0.073**	-0.042**	0.003	0.112**	0.000
	(0.00)	(0.00)	(0.85)	(0.00)	(0.97)
$\ln p_7$	-0.055**	0.003	-0.066**	0.096**	0.022**
	(0.01)	(0.85)	(0.04)	(0.00)	(0.00)
$\ln p_8$	0.087**	0.112**	0.096**	-0.307**	0.012**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)
$\ln p_9$	0.045*	-0.069**	-0.040*	0.097**	-0.034**
	(0.07)	(0.00)	(0.06)	(0.00)	(0.00)
$\ln p_{10}$	-0.003	-0.004**	0.007**	0.002	-0.001
	(0.12)	(0.00)	(0.00)	(0.58)	(0.19)
$\ln Y_{US} P_{US}$	-0.040**	-0.000	0.064**	-0.019	-0.004
	(0.02)	(0.99)	(0.00)	(0.46)	(0.23)
Intercept	0.477**	0.065	-0.483**	0.887**	0.001
	(0.01)	(0.55)	(0.00)	(0.00)	(0.97)
R^2	0.23	0.44	0.29	0.32	0.20
DW	0.19	0.56	0.62	0.66	1.14

Note: Numbers in parentheses are p-values. * and ** represent significance at the 10 per cent and 5 per cent level of significance, respectively.

The R^2 ranges from 0.19 to 0.72; the ROW (frozen) equation for the EU salmon market shows the least explanatory power while the Norway (fresh) equation for the EU market has the most. Seven of the ten equations have significant intercept in both salmon markets. Durbin-Watson results range from 0.19 to 1.34. The Marshallian price and income elasticities of farmed salmon after the emergence of the financial crisis in the EU and US are presented in Table 13.

Table 13: Estimated price and expenditure elasticities in the EU and US markets after the financial crisis (November 2008–November 2014)

EU Quantity Demanded from	e_{i1}	e_{i2}	e_{i3}	e_{i4}	e_{i5}	A_i
	SUR estimates					
Norway (fresh)	-0.860**	-0.073**	-0.006	-0.095**	-0.007	1.040**
	(0.00)	(0.00)	(0.68)	(0.00)	(0.56)	(0.00)
Norway (frozen)	-0.726**	-0.185	-0.078	0.119	0.053	0.815**
	(0.00)	(0.34)	(0.42)	(0.55)	(0.62)	(0.00)
Chile (frozen)	-0.175	-0.100	-0.865**	0.103	-0.137*	1.173**
	(0.44)	(0.32)	(0.00)	(0.46)	(0.07)	(0.00)
ROW (fresh)	-0.468**	0.075	0.086	-0.412*	-0.031	0.750**
	(0.03)	(0.53)	(0.28)	(0.09)	(0.70)	(0.00)
ROW (frozen)	-0.062	0.112	-0.279*	-0.130	-0.529**	0.889**
	(0.84)	(0.63)	(0.09)	(0.66)	(0.01)	(0.00)
US Quantity Demanded from	e_{i6}	e_{i7}	e_{i8}	e_{i9}	e_{i10}	A_i
	SUR estimates					
Norway (fresh)	-3.607**	-1.261	-1.266	7.076**	0.237	-1.180**
	(0.00)	(0.18)	(0.22)	(0.00)	(0.10)	(0.03)
Norway (frozen)	-0.772*	-1.000*	2.653**	-1.143**	-0.062	0.324
	(0.08)	(0.06)	(0.00)	(0.02)	(0.34)	(0.19)
Chile (frozen)	-0.034	-0.308	-0.500**	-0.769**	0.055*	1.556**
	(0.84)	(0.35)	(0.03)	(0.00)	(0.05)	(0.00)
ROW (fresh)	0.170**	0.120**	-0.241**	-1.067**	-0.022**	1.041**
	(0.00)	(0.01)	(0.00)	(0.00)	(0.04)	(0.00)
ROW (frozen)	2.278**	0.984	1.927**	-6.053**	-0.927**	1.792**
	(0.00)	(0.27)	(0.00)	(0.00)	(0.00)	(0.00)

Note: Numbers in parentheses are p-values. * and ** represent significance at the 10 per cent and 5 per cent level of significance, respectively.

The own price elasticities of salmon appear to be less responsive after the financial crisis took place in the EU market, as the own price elasticities range from -0.185 to -0.865, which is less than one, which indicates that none of the product demand remains elastic after the financial crisis. The highest value of own price elasticity is that of Chilean frozen salmon, which is -0.865, and the smallest value is achieved by Norwegian frozen salmon, which is -0.185.

Moreover, only six out of 20 cross-price elasticities are significant, but none of them are elastic in the EU market. The highest cross-price elasticity is between Norwegian frozen and fresh salmon, at e_{21} = -0.73. In brief, Norwegian fresh and Norwegian frozen (e_{12}, e_{21}), Norwegian fresh and ROW fresh (e_{14} , e_{41}), and Chilean frozen and ROW frozen salmon (e_{35}, e_{53}) act as complements in the EU market after the financial crisis.

All of the Marshallian expenditure elasticities are significant, having a positive sign in the EU market. That shows that after the financial crisis when the income of EU consumers increases, the import of salmon from all the regions, in both forms (fresh and frozen), will also increase, whereas the demands for fresh salmon from Norway and frozen salmon from Chile are more responsive to change in the income of EU consumers, having elastic income elasticities of 1.04 and 1.17 for Norway and Chile, respectively. That shows that the salmon from these two countries were considered to be luxury goods among EU consumers during the period from November 2008 to November 2014.

In the case of the US market, all of the five own price elasticities of salmon are significant and have the expected negative sign during the post-crisis period. Three out of five own price elasticities are found to be elastic, and the remaining two are inelastic. The own price elasticity of fresh salmon from Norway has an incredibly high value of -3.607. That shows that a tiny change in the price of this commodity can lead to a substantial change in its demand from US consumers and vice versa. Norway frozen and ROW fresh price elasticities are almost unitary whereas Chilean frozen and ROW frozen own price elasticities appear to be less responsive after the financial crisis.

Moreover, 13 out of 20 cross-price elasticities are significant but six of them are elastic in the US market. The strongest cross-price elasticity is e_{69} = 7.076, which means that 1 unit increase in the price of ROW fresh salmon will lead to a 7.076 unit increase in the demand for Norwegian fresh salmon in the US market. However, a decrease in the price of Norwegian fresh salmon will result in a slight rise in the demand for ROW fresh salmon as e_{96} = 0.17. If the price of ROW fresh salmon increases by 1 unit, the demand for ROW frozen salmon decreases by 6.053 units. Moreover, Norwegian frozen and Chilean frozen (e_{78}=2.653), ROW frozen and Norwegian fresh ($e_{10,6}$=2.278), and ROW frozen and Chilean frozen ($e_{10,8}$=1.927) salmon are potential substitutes in the US after the appearance of the financial crisis.

In the US salmon market, four out of five Marshallian income elasticities are significant and are elastic. Apart from Norwegian fresh salmon all have positive values, indicating consumer preference for buying more salmon from these markets except for Norwegian fresh salmon, as their income increases. Overall, the expenditure elasticity of ROW frozen salmon is highest, at A_{10}=1.792, which means that after the financial crisis, US consumers will be most responsive to the demand for frozen salmon from ROW with the change in their income and least responsive to the demand for fresh salmon from ROW (A_9=1.041) as their income changes. Norwegian fresh salmon becomes an inferior good among US consumers, having negative income elasticity (A_6=-1.18). Expenditure elasticity for Norwegian frozen salmon is insignificant after the financial crisis.

5.6 Justification for the analysis of demand elasticities of farmed salmon before and after financial crisis in the EU and US salmon markets

We used a t-test to see whether the demand elasticities of the same product are similar or different in these two separate markets. For instance, the own price elasticity of Norwegian fresh salmon in the EU is equal or different to the own price elasticity of Norwegian fresh salmon for the US market. We found that the null hypothesis was rejected for Norwegian fresh salmon for both markets (H_0: e_{11}=e_{66}). That indicates that these demand elasticities are not the same in these two different markets. Similarly, we followed this procedure for the remaining four regions.

Moreover, we apply the t-test to check that the demand elasticities are significantly different from zero before and after the financial crisis. Before that, we introduced a dummy variable in October 2008 to see whether the shift is significantly different from zero or not and run the ordinary least square for e_{11} along that dummy (D). We found a significant constant term and also that dummy, which indicates that the shift is significantly different from zero for Norwegian fresh salmon to the EU salmon market. That is e_{11} = constant + D, which is the summation of the dummy and a constant together and we have a mean own price elasticity of Norwegian fresh salmon of -1.13 for the EU market and this is exactly the sum of what we found (-1.1292 plus -0.0031) for the whole period from January 2002 to November 2014.

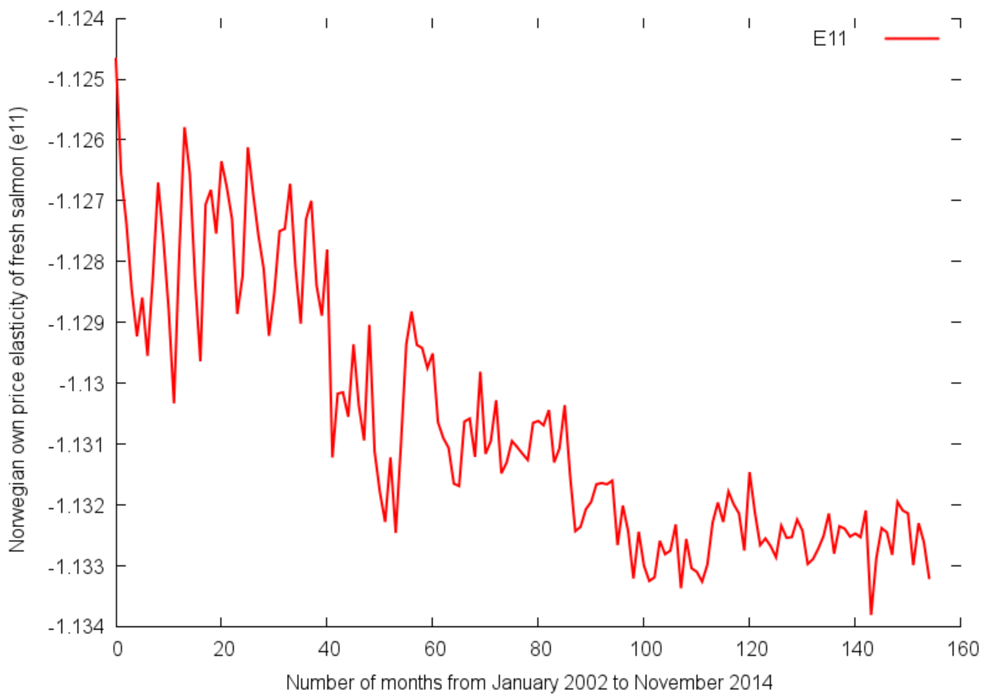

Figure 3: Own price elasticity of Norwegian fresh salmon in the EU market (2002 to 2014).

We found that the shifts are significantly different from zero for all other own price elasticities in both markets. Figure 3 shows the fluctuation in own price elasticities of Norwegian fresh salmon during the months from January 2002 to November 2014 in the EU salmon market. After finding the significant shift, now we are interested in applying the t-test on the elasticities before and after the financial crisis. Moreover, we found that the elasticities are significantly different from zero in both the EU and US markets before and after the financial crisis. The average elasticity is -1.13 for the whole period, however the mean elasticity before the financial crisis is -1.12 and the mean own price elasticity of Norwegian fresh salmon in the EU after the financial crisis is -0.86 and all elasticities are statistically significantly different from zero.

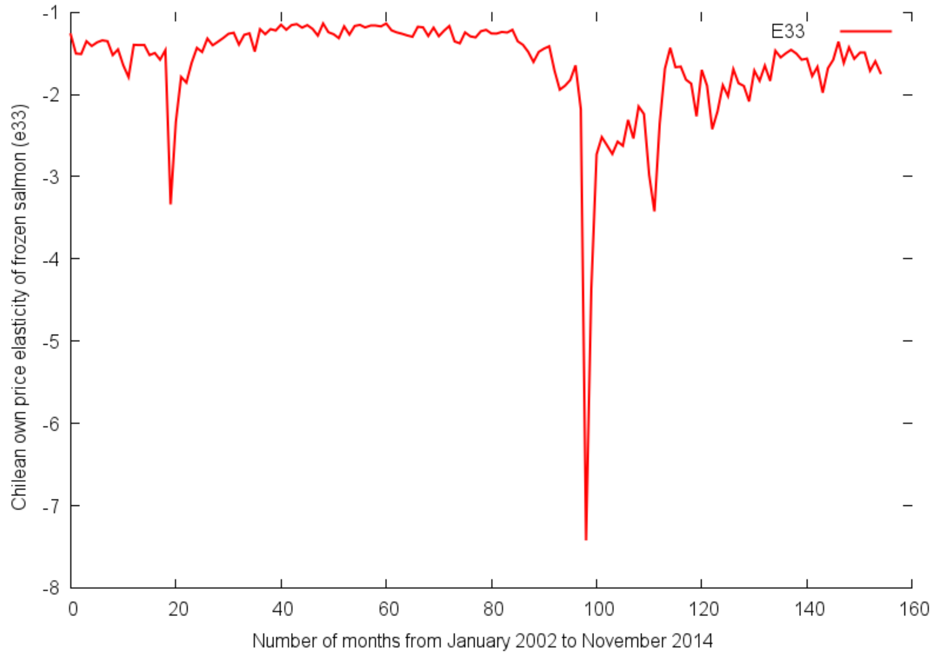

Figure 4: Own price elasticity of Chilean frozen salmon in the EU market (2002 to 2014).

Figure 4 shows the changes in the own price elasticity of Chilean frozen salmon in the EU market during January 2002 to November 2014. We can see clearly that the own price elasticity of Chilean frozen salmon becomes more elastic after the financial crisis and then changes again, as our result concludes that the EU salmon market is a stable market. The reason that the own price elasticity of Chilean frozen salmon becomes very elastic after 2003 and again after 2009 was the disease crisis there (Asche et al., 2009). The shift is also significantly different from zero in the own price elasticity of the Chilean frozen salmon case. The average elasticity is -1.38 for the whole period, although the mean elasticity before the financial crisis is -1.79 and the average own price elasticity of Chilean frozen salmon after the financial crisis is -0.86 for the EU market and all elasticities are significantly different from zero.

CHAPTER 6

DISCUSSION AND FINDINGS

In this study, the demand structure of farmed salmon in the EU and US salmon markets have been investigated by using the LA/AIDS model. Individual as well as integrated demand models are estimated to discover whether the sensitivity of demand for farmed salmon exported from the same origin varies or not in the EU and US salmon markets. Elasticity estimates indicate that there exists a visible difference in the structure of demand for farmed salmon in the EU and US markets from 2002 to 2014. Moreover, the impact of financial crisis on demand for salmon has also been monitored by estimating the demand elasticities before and after the financial crisis.

In the EU market, fresh salmon from ROW is very sensitive to the change in its price, followed by Norwegian fresh and Chilean frozen salmon. Norwegian and ROW frozen salmon have inelastic demand elasticity with respect to their prices. On the whole, the EU demand for fresh farmed salmon is price elastic at -1.28[1] and it is price inelastic at -0.77 for frozen farmed salmon. Norwegian fresh salmon is a close substitute for ROW fresh salmon in the EU market, whereas the effect of a change in the price of ROW salmon on the demand for Norwegian fresh salmon is quite minimal. Norwegian fresh salmon falls into the luxury items category and ROW frozen salmon is treated as a normal good by EU consumers while Norwegian frozen and ROW fresh salmon are considered necessary goods, having inelastic income elasticities.

In the US market, demands for Norwegian fresh and frozen salmon are found to be very elastic with respect to their price. Frozen salmon from ROW is unitarily elastic, whereas frozen salmon from Chile and fresh salmon from ROW are less sensitive to change in their price. On the whole, US demands for fresh and frozen salmon are inelastic at -0.78 and -0.74, respectively. Chilean frozen salmon has a strong substitution effect with Norwegian frozen and ROW frozen salmon. So a small drop in the price of Chilean frozen salmon will sharply decrease the demand for frozen salmon from Norway and ROW. The income elasticities of

[1] The fresh and frozen mean market shares for Norway, Chile and ROW are used to compute the whole or aggregate elasticity in the EU and US markets, described in Appendix A.

ROW frozen and Chilean frozen salmon are elastic, so both commodities are considered luxury commodities among US consumers, whereas ROW fresh salmon is considered a normal product, having unitary income elasticity. Norwegian frozen salmon is a necessity; however, Norwegian fresh salmon appears to be an inferior good among US consumers. Negative income elasticity can be explained by the imposition of trade restrictions on Norwegian fresh salmon exported to the US.

The visible difference within the constitution of salmon demand is recorded after integrating and estimating the joint demand model for both the EU and US salmon markets. In the EU market, the demand for ROW fresh salmon is the most elastic (-2.079), whereas the demand for Norwegian frozen salmon is the least inelastic (-0.421). Fresh salmon from Norway and frozen salmon from Chile are also found to be sensitive to change in their price in the EU market, having elastic demand elasticities with respect to their price. On the other hand, in the US market, demand for Norwegian fresh salmon is the most elastic (-2.706) and for Chilean frozen salmon the least inelastic (-0.438) demand with respect to their prices. Moreover, in the case of US consumers, frozen salmon from Norway and Chile and fresh salmon from ROW are inelastic; only ROW frozen salmon appears to have unitarily elastic demand elasticities.

In the EU market, Norwegian fresh salmon is a substitute for ROW fresh salmon (e_{41} =1.36). Chilean frozen and ROW fresh salmon are both considered good substitutes for Norwegian fresh salmon (e_{68}=2.216 and e_{69} =1.784) in the US market. Chilean frozen salmon is creating firm competition for Norwegian frozen salmon as it has the strongest substitution effect with Norwegian frozen (e_{78} =2.245) salmon in the US market.

In the EU salmon market, all the income elasticities are positive and significant. Norwegian fresh salmon is considered a luxury product while others are necessary goods, having inelastic expenditure elasticities. On the other hand, in the US salmon market, with the exception of Norwegian fresh salmon, an increase in income will benefit all other products. Chilean frozen salmon is considered a luxury product among US consumers, having elastic expenditure elasticity.

Elasticity estimates demonstrate diverse results when the impact of the financial crisis is taken into account in the EU and US salmon markets. In the EU market, before the emergence of the financial crisis, the demand for Norwegian fresh, Chilean frozen, and ROW fresh salmon was very elastic with respect to their price, but none of the products remain elastic after the financial crisis. This shows that salmon consumers became less responsive to changes in their prices after the financial crisis took place in the EU market. On the other hand, in the US market the demand elasticities for Norwegian fresh and frozen salmon became more price elastic after the financial crisis whereas the demand elasticities for ROW and Chilean salmon did not vary significantly. Moreover, Norwegian frozen salmon, which was price inelastic before the financial crisis in the US salmon market, became unitarily elastic after the crisis. ROW fresh and frozen salmon were almost unitarily elastic in both periods. So the EU salmon market is quite stable compared to the US salmon market after the financial crisis.

Cross-price effect also varied before and after the financial crisis in both the EU and US salmon markets. In the EU market, Norwegian fresh salmon was considered a complement for Chilean frozen salmon (e_{31} =-1.519), whereas it was a strong substitute for ROW fresh salmon (e_{41} = 1.93) before the financial crisis. Moreover, after the financial crisis no salmon (fresh and frozen) remained strong substitutes or complements for other salmon products in the EU salmon market.

In the US market, frozen salmon from Norway was considered a complement for Chilean frozen (e_{87} =-1.167) salmon before the financial crisis, whereas Chilean frozen salmon became a strong substitute for Norwegian frozen (e_{78} =2.653) salmon after the financial crisis. Moreover, ROW fresh salmon was considered a strong substitute for ROW frozen ($e_{10\ 9}$ =2.699) salmon before the financial crisis in the US market, whereas this substitution relation turned into a strong complementary relationship ($e_{10\ 9}$ =-6.053) after the financial crisis. In addition, ROW fresh salmon became a strong substitute for Norwegian fresh salmon ($e_{6\ 10}$ =7.076) after the financial crisis whereas this substitution effect between them was minimal ($e_{6\ 10}$ =0.55) before the financial crisis.

Norwegian fresh and Chilean frozen salmon fall into the luxurious items category throughout the period even before and after the financial crisis in the EU salmon market. However, insignificant income elasticities were found for Norwegian frozen and ROW fresh salmon before the crisis and were considered a necessity after the financial crisis. Moreover, ROW frozen salmon were considered a necessity before as well as after the financial crisis in the EU market.

In the US salmon market, Norwegian fresh salmon was considered a luxury product before the financial crisis whereas it became an inferior good after the financial crisis. ROW frozen salmon was considered an inferior good among US consumers before the financial crisis while it became a luxury product after the financial crisis. Chilean frozen salmon was considered a luxury good both before and after the financial crisis. ROW fresh salmon income elasticity did not vary much and was almost unitarily elastic before and after the financial crisis.

CHAPTER 7

SUMMARY AND CONCLUSION

Continuous growth in the production and consumption of salmon has caught the attention of researchers in determining the demand structure of salmon in different world markets. The primary objective of this research is to analyse the market structure of farmed salmon (fresh/frozen) in the EU and US markets, by estimating the elasticity of demand in each market individually and also by integrating both markets to capture the difference in their demand elasticities which have the same origin. Secondly, the impact of the financial crisis on the demand for salmon in these two markets has also been observed, by estimating the elasticity of demand both before and after the emergence of the financial crisis. To achieve the first objective, demand equations of the EU and US markets were estimated by using the LA/AIDS model separately and then jointly from January 2002 to November 2014. Data are then divided into two parts before and after the financial crisis to achieve the second objective of the research.

The contribution of this study of salmon demand is that previous studies have not integrated the EU and US salmon markets in order to investigate demand elasticities. Moreover, the impact of the financial crisis has not been explored either in the earlier literature on salmon demand.

Our findings concluded that demand elasticities are different in these two salmon markets for all products; for example, ROW fresh salmon demand is highly elastic (-2.29) in the EU whereas it is price inelastic (-0.72) in the US salmon market during the same period from January 2002 to November 2014. The market shares are also quite different in these markets: Norwegian fresh salmon capture a 75 per cent market share in the EU while its share is quite low in the US at only 4 per cent. Both markets contain more than 75 per cent shares of fresh salmon. So consumers of both markets prefer fresh salmon to frozen salmon. The demand for fresh farmed salmon is price elastic at -1.28 and it is price inelastic at -0.77 for frozen farmed salmon in the EU market from 2002 to 2014. The demands for fresh and frozen salmon are price inelastic at -0.78 and -0.74, respectively, in the US salmon market during the same period. Moreover, the study found a significant impact of the financial crisis on demand for salmon in the US market. The demand elasticities became more elastic in the US salmon market after the financial crisis. However, the demand elasticities for both fresh and frozen salmon in the EU market became more inelastic after the financial crisis. All forms of salmon were found to be inelastic in the EU market after the crisis. The EU salmon market was found to be a stable market, whereas after the financial crisis US consumers' demand for salmon became more price sensitive.

To summarize, EU consumers prefer Norwegian fresh and Chilean frozen salmon whereas US consumers prefer ROW fresh and Chilean frozen salmon, but there is not fair competition in the US salmon market due to the tariff on Norwegian salmon. Norwegian fresh salmon became an inferior product for US consumers after the crisis, however it was a luxury commodity for them before the financial crisis. Further research may include other salmon markets, advertising, and quality attributes to find a significant impact on farmed salmon demand structure.

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Appendices

Appendix A

Table A1. Descriptive statistics of quantities, prices, and budget shares for EU farmed salmon market (2002–2014)

Salmon from	Mean quantities (MT)	Mean Prices (1000 USD)	Mean Budget shares
Norway (fresh)	42704	4.3483	0.74684
Norway (frozen)	2417	5.7633	0.06093
Chile (frozen)	3560	3.9510	0.06070
ROW (fresh)	5072	4.7421	0.10347
ROW (frozen)	1202	5.8757	0.02805

Table A2. Descriptive statistics of quantities, prices, and budget shares for US farmed salmon market (2002–2014)

Salmon from	Mean quantities (MT)	Mean Prices (1000 USD)	Mean Budget shares
Norway (fresh)	999.65	5.2839	0.04197
Norway (frozen)	1022.8	6.1465	0.05001
Chile (frozen)	4159.2	4.7058	0.15416
ROW (fresh)	19093	4.8367	0.74197
ROW (frozen)	164	54.989	0.01187

Appendix B

Shazam input used to estimate demand elasticities for EU salmon market.

```
sample 1-155
read Time Year Month q1 x1 q2 x2 q3 x3 q4 x4 q5 x5
*Quantity and Value
*q1 (Quantity WFE MT) Norway fresh salmon exported to EU market
*q2 (Quantity WFE MT) Norway frozen salmon exported to EU market
*q3 (Quantity WFE MT) Chile frozen salmon exported to EU market
*q4 (Quantity WFE MT) ROW (AU, CA,CL,FO,GB) fresh salmon exported to EU market
*q5 (Quantity WFE MT) ROW (CA, FO,GB) frozen salmon exported to EU market
*x1 (Value 1000 USD) for Norwegian fresh salmon exported to EU market
*x2 (Value 1000 USD) for Norwegian frozen salmon exported to EU market
*x3 (Value 1000 USD) for Chilean frozen salmon exported to EU market
*x4 (Value 1000 USD) for ROW(AU, CA,CL,FO,GB) fresh salmon exported to EU market
*x5 (Value 1000 USD) for ROW(CA, FO,GB) frozen salmon exported to EU market
*get the price
genr p1=x1/q1
genr p2=x2/q2
genr p3=x3/q3
genr p4=x4/q4
genr p5=x5/q5
*graph p1 p2 p3 p4 p5 / time lineonly
print p1 p2 p3 p4 p5
*get total expenditure
genr totexp=x1+x2+x3+x4+x5
*market share=expenditure share
genr r1=x1/totexp
genr r2=x2/totexp
genr r3=x3/totexp
genr r4=x4/totexp
genr r5=x5/totexp
genr r=r1+r2+r3+r4+r5
print r r1 r2 r3 r4 r5
*get the mean of the expenditure share
stat r1/mean=ms1
stat r2/mean=ms2
stat r3/mean=ms3
stat r4/mean=ms4
stat r5/mean=ms5
print ms1 ms2 ms3 ms4 ms5
genr lnp1=log(p1)
genr lnp2=log(p2)
genr lnp3=log(p3)
genr lnp4=log(p4)
genr lnp5=log(p5)
genr lny=log(totexp)
genr lnP=r1*lnp1+r2*lnp2+r3*lnp3+r4*lnp4+r5*lnp5
genr lnyP=lny-lnP
*estimate the AIDS model using equation 1,2,3 and 4
system 4/iter = 100 piter=0 dn rstat
ols r1 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
```

```
ols r2 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r3 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r4 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
end
* Now estimate equation 2,3,4 and 5 to get the last unconstrained coefficients
system 4/iter = 100 piter=0 dn rstat
ols r2 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r3 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r4 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r5 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
end
*reenter the first set for restriction test
system 4/iter = 100 piter=0 dn rstat
ols r1 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r2 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r3 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r4 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
end
*test homogeneity
test
test lnp1:1+lnp2:1+lnp3:1+lnp4:1+lnp5:1
test lnp1:2+lnp2:2+lnp3:2+lnp4:2+lnp5:2
test lnp1:3+lnp2:3+lnp3:3+lnp4:3+lnp5:3
test lnp1:4+lnp2:4+lnp3:4+lnp4:4+lnp5:4
end
*test symmetry
test
test lnp2:1-lnp1:2
test lnp3:1-lnp1:3
test lnp3:2-lnp2:3
test lnp2:4-lnp4:2
test lnp4:1-lnp1:4
test lnp4:3-lnp3:4
end
*test homogeneity and symmetry together
test
test lnp1:1+lnp2:1+lnp3:1+lnp4:1+lnp5:1
test lnp1:2+lnp2:2+lnp3:2+lnp4:2+lnp5:2
test lnp1:3+lnp2:3+lnp3:3+lnp4:3+lnp5:3
test lnp1:4+lnp2:4+lnp3:4+lnp4:4+lnp5:4
test lnp2:1-lnp1:2
test lnp3:1-lnp1:3
test lnp3:2-lnp2:3
test lnp2:4-lnp4:2
test lnp4:1-lnp1:4
test lnp4:3-lnp3:4
end
*estimate AIDS with both homogeneity and symmetry imposed
system 4/iter = 100 piter=0 dn rstat restrict
ols r1 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r2 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r3 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
ols r4 lnp1 lnp2 lnp3 lnp4 lnp5 lnyP
```

```
restrict lnp1:1+lnp2:1+lnp3:1+lnp4:1+lnp5:1
restrict lnp1:2+lnp2:2+lnp3:2+lnp4:2+lnp5:2
restrict lnp1:3+lnp2:3+lnp3:3+lnp4:3+lnp5:3
restrict lnp1:4+lnp2:4+lnp3:4+lnp4:4+lnp5:4
restrict lnp2:1-lnp1:2
restrict lnp3:1-lnp1:3
restrict lnp3:2-lnp2:3
restrict lnp2:4-lnp4:2
restrict lnp4:1-lnp1:4
restrict lnp4:3-lnp3:4
end
*Estimate elasticities
*E11
test(lnp1:1-ms1*lnyP:1)/ms1-1
*E12
test(lnp2:1-ms2*lnyP:1)/ms1
*E13
test(lnp3:1-ms3*lnyP:1)/ms1
*E14
test(lnp4:1-ms4*lnyP:1)/ms1
*E15
test(lnp5:1-ms5*lnyP:1)/ms1
*E21
test(lnp1:2-ms1*lnyP:2)/ms2
*E22
test(lnp2:2-ms2*lnyP:2)/ms2-1
*E23
test(lnp3:2-ms3*lnyP:2)/ms2
*E24
test(lnp4:2-ms4*lnyP:2)/ms2
*E25
test(lnp5:2-ms5*lnyP:2)/ms2
*E31
test(lnp1:3-ms1*lnyP:3)/ms3
*E32
test(lnp2:3-ms2*lnyP:3)/ms3
*E33
test(lnp3:3-ms3*lnyP:3)/ms3-1
*E34
test(lnp4:3-ms4*lnyP:3)/ms3
*E35
test(lnp5:3-ms5*lnyP:3)/ms3
*E41
test(lnp1:4-ms1*lnyP:4)/ms4
*E42
test(lnp2:4-ms2*lnyP:4)/ms4
*E43
test(lnp3:4-ms3*lnyP:4)/ms4
*E44
test(lnp4:4-ms4*lnyP:4)/ms4-1
*E45
test(lnp5:4-ms5*lnyP:4)/ms4
*A1
```

```
test lnyP:1/ms1+1
*A2
test lnyP:2/ms2+1
*A3
test lnyP:3/ms3+1
*A4
test lnyP:4/ms4+1
* use the adding up to recover the estimation of the deleted equation
* coefficient of the deleted equation
*051
test 0-lnp1:1-lnp1:2-lnp1:3-lnp1:4
*052
test 0-lnp2:1-lnp2:2-lnp2:3-lnp2:4
*053
test 0-lnp3:1-lnp3:2-lnp3:3-lnp3:4
*054
test 0-lnp4:1-lnp4:2-lnp4:3-lnp4:4
*055
test 0-lnp5:1-lnp5:2-lnp5:3-lnp5:4
*U5
test 0-lnyP:1-lnyP:2-lnyP:3-lnyP:4
end
*Estimate the elasticities of the deleted equation
*E51
test ((0-lnp1:1-lnp1:2-lnp1:3-lnp1:4)-ms1*(0-lnyP:1-lnyP:2-lnyP:3-lnyP:4))/ms5
*E52
test ((0-lnp2:1-lnp2:2-lnp2:3-lnp2:4)-ms2*(0-lnyP:1-lnyP:2-lnyP:3-lnyP:4))/ms5
*E53
test ((0-lnp3:1-lnp3:2-lnp3:3-lnp3:4)-ms3*(0-lnyP:1-lnyP:2-lnyP:3-lnyP:4))/ms5
*E54
test ((0-lnp4:1-lnp4:2-lnp4:3-lnp4:4)-ms4*(0-lnyP:1-lnyP:2-lnyP:3-lnyP:4))/ms5
*E55
test ((0-lnp5:1-lnp5:2-lnp5:3-lnp5:4)-ms5*(0-lnyP:1-lnyP:2-lnyP:3-lnyP:4))/ms5-1
*A5
test (0-lnyP:1-lnyP:2-lnyP:3-lnyP:4)/ms5+1
stop
```

Appendix C

Shazam input used to estimate demand elasticities for US salmon market.

```
sample 1-155
read Time Year Month q6 x6 q7 x7 q8 x8 q9 x9 q10 x10
*Quantity and Value
*q6 (Quantity WFE MT) Norway fresh salmon exported to US market
*q7 (Quantity WFE MT) Norway frozen salmon exported to US market
*q8 (Quantity WFE MT) Chile frozen salmon exported to US market
*q9 (Quantity WFE MT) ROW(AU, CA,CL,FO,GB) fresh salmon exported to US market
*q10 (Quantity WFE MT) ROW(AU, CA,FO,GB) frozen salmon exported to US market
*x6 (Value 1000 USD) for Norwegian fresh salmon exported to US market
*x7 (Value 1000 USD) for Norwegian frozen salmon exported to US market
*x8 (Value 1000 USD) for Chilean frozen salmon exported to US market
*x9 (Value 1000 USD) for ROW(AU,CA,CL,FO,GB) fresh salmon exported to US market
*x10 (Value 1000 USD) for ROW(AU,CA,FO,GB) frozen salmon exported to US market
*get the price
genr p6=x6/q6
genr p7=x7/q7
genr p8=x8/q8
genr p9=x9/q9
genr p10=x10/q10
*graph p6 p7 p8 p9 / time lineonly
print p6 p7 p8 p9 p10
*get total expenditure
genr totexp=x6+x7+x8+x9+x10
*market share=expenditure share
genr r6=x6/totexp
genr r7=x7/totexp
genr r8=x8/totexp
genr r9=x9/totexp
genr r10=x10/totexp
genr rUS=r6+r7+r8+r9+r10
print rUS r6 r7 r8 r9 r10
*get the mean of the expenditure share
stat r6/mean=ms6
stat r7/mean=ms7
stat r8/mean=ms8
stat r9/mean=ms9
stat r10/mean=ms10
print ms6 ms7 ms8 ms9 ms10
genr lnp6=log(p6)
genr lnp7=log(p7)
genr lnp8=log(p8)
genr lnp9=log(p9)
genr lnp10=log(p10)
genr lny=log(totexp)
genr lnP=r6*lnp6+r7*lnp7+r8*lnp8+r9*lnp9+r10*lnp10
genr lnyP=lny-lnP
```

```
*estimate the AIDS model using equation 6,7,8 and 9
system 4/iter = 100 piter=0 dn rstat
ols r6 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r7 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r8 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r9 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
end
* Now estimate equation 7,8,9 and 10 to get the last unconstrained coefficients
system 4/iter = 100 piter=0 dn rstat
ols r7 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r8 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r9 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r10 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
end
*reenter the first set for restriction test
system 4/iter = 100 piter=0 dn rstat
ols r6 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r7 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r8 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r9 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
end
*test homogeneity
test
test lnp6:1+lnp7:1+lnp8:1+lnp9:1+lnp10:1
test lnp6:2+lnp7:2+lnp8:2+lnp9:2+lnp10:2
test lnp6:3+lnp7:3+lnp8:3+lnp9:3+lnp10:3
test lnp6:4+lnp7:4+lnp8:4+lnp9:4+lnp10:4
end
*test symmetry
test
test lnp7:1-lnp6:2
test lnp8:1-lnp6:3
test lnp8:2-lnp7:3
test lnp7:4-lnp9:2
test lnp9:1-lnp6:4
test lnp9:3-lnp8:4
end
*test homogeneity and symmetry together
test
test lnp6:1+lnp7:1+lnp8:1+lnp9:1+lnp10:1
test lnp6:2+lnp7:2+lnp8:2+lnp9:2+lnp10:2
test lnp6:3+lnp7:3+lnp8:3+lnp9:3+lnp10:3
test lnp6:4+lnp7:4+lnp8:4+lnp9:4+lnp10:4
test lnp7:1-lnp6:2
test lnp8:1-lnp6:3
test lnp8:2-lnp7:3
test lnp7:4-lnp9:2
test lnp9:1-lnp6:4
test lnp9:3-lnp8:4
end
*estimate AIDS with both homogeneity and symmetry imposed
system 4/iter = 100 piter=0 dn rstat restrict
ols r6 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
```

```
ols r7 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r8 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
ols r9 lnp6 lnp7 lnp8 lnp9 lnp10 lnyP
restrict lnp6:1+lnp7:1+lnp8:1+lnp9:1+lnp10:1
restrict lnp6:2+lnp7:2+lnp8:2+lnp9:2+lnp10:2
restrict lnp6:3+lnp7:3+lnp8:3+lnp9:3+lnp10:3
restrict lnp6:4+lnp7:4+lnp8:4+lnp9:4+lnp10:4
restrict lnp7:1-lnp6:2
restrict lnp8:1-lnp6:3
restrict lnp8:2-lnp7:3
restrict lnp7:4-lnp9:2
restrict lnp9:1-lnp6:4
restrict lnp9:3-lnp8:4
end
*Estimate elasticities
*E66
test(lnp6:1-ms6*lnyP:1)/ms6-1
*E67
test(lnp7:1-ms7*lnyP:1)/ms6
*E68
test(lnp8:1-ms8*lnyP:1)/ms6
*E69
test(lnp9:1-ms9*lnyP:1)/ms6
*E610
test(lnp10:1-ms10*lnyP:1)/ms6
*E76
test(lnp6:2-ms6*lnyP:2)/ms7
*E77
test(lnp7:2-ms7*lnyP:2)/ms7-1
*E78
test(lnp8:2-ms8*lnyP:2)/ms7
*E79
test(lnp9:2-ms9*lnyP:2)/ms7
*E710
test(lnp10:2-ms10*lnyP:2)/ms7
*E86
test(lnp6:3-ms6*lnyP:3)/ms8
*E87
test(lnp7:3-ms7*lnyP:3)/ms8
*E88
test(lnp8:3-ms8*lnyP:3)/ms8-1
*E89
test(lnp9:3-ms9*lnyP:3)/ms8
*E810
test(lnp10:3-ms10*lnyP:3)/ms8
*E96
test(lnp6:4-ms6*lnyP:4)/ms9
*E97
test(lnp7:4-ms7*lnyP:4)/ms9
*E98
test(lnp8:4-ms8*lnyP:4)/ms9
*E99
test(lnp9:4-ms9*lnyP:4)/ms9-1
```

```
*E910
test(lnp10:4-ms10*lnyP:4)/ms9
*A6
test lnyP:1/ms6+1
*A7
test lnyP:2/ms7+1
*A8
test lnyP:3/ms8+1
*A9
test lnyP:4/ms9+1
* use the adding up to recover the estimation of the deleted equation
* coefficient of the deleted equation
*0106
test 0-lnp6:1-lnp6:2-lnp6:3-lnp6:4
*0107
test 0-lnp7:1-lnp7:2-lnp7:3-lnp7:4
*0108
test 0-lnp8:1-lnp8:2-lnp8:3-lnp8:4
*0109
test 0-lnp9:1-lnp9:2-lnp9:3-lnp9:4
*01010
test 0-lnp10:1-lnp10:2-lnp10:3-lnp10:4
*U10
test 0-lnyP:1-lnyP:2-lnyP:3-lnyP:4
end
*Estimate the elasticities of the deleted equation
*E106
test ((0-lnp6:1-lnp6:2-lnp6:3-lnp6:4)-ms6*(0-lnyP:1-lnyP:2-lnyP:3-lnyP:4))/ms10
*E107
test ((0-lnp7:1-lnp7:2-lnp7:3-lnp7:4)-ms7*(0-lnyP:1-lnyP:2-lnyP:3-lnyP:4))/ms10
*E108
test ((0-lnp8:1-lnp8:2-lnp8:3-lnp8:4)-ms8*(0-lnyP:1-lnyP:2-lnyP:3-lnyP:4))/ms10
*E109
test ((0-lnp9:1-lnp9:2-lnp9:3-lnp9:4)-ms9*(0-lnyP:1-lnyP:2-lnyP:3-lnyP:4))/ms10
*E1010
test ((0-lnp10:1-lnp10:2-lnp10:3-lnp10:4)-ms10*(0-lnyP:1-lnyP:2-lnyP:3-lnyP:4))/ms10-1
*A10
test (0-lnyP:1-lnyP:2-lnyP:3-lnyP:4)/ms10+1
stop
```

Appendix D

Shazam input used to estimate demand elasticities by incorporating EU and US farmed salmon market.

```
sample 1-155
read Time      Year   Month  q1   x1   q2   x2   q3   x3   q4   x4   q5
          x5   q6     x6     q7   X7   q8   x8   q9   x9   q10  x10
*Quantity and value
*q1 (Quantity WFE MT) Norway fresh salmon exported to EU market
*q2 (Quantity WFE MT) Norway frozen salmon exported to EU market
*q3 (Quantity WFE MT) Chile frozen salmon exported to EU market
*q4 (Quantity WFE MT) ROW(AU, CA,CL,FO,GB) fresh salmon exported to EU market
*q5 (Quantity WFE MT) ROW(CA, FO,GB) frozen salmon exported to EU market
*q6 (Quantity WFE MT) Norway fresh salmon exported to US market
*q7 (Quantity WFE MT) Norway frozen salmon exported to US market
*q8 (Quantity WFE MT) Chile frozen salmon exported to US market
*q9 (Quantity WFE MT) ROW(AU, CA,CL,FO,GB) fresh salmon exported to US market
*q10 (Quantity WFE MT) ROW(AU, CA,FO,GB) frozen salmon exported to US market
*x1 (Value 1000 USD) for Norwegian fresh salmon exported to EU market
*x2 (Value 1000 USD) for Norwegian frozen salmon exported to EU market
*x3 (Value 1000 USD) for Chilean frozen salmon exported to EU market
*x4 (Value 1000 USD) for ROW(AU, CA,CL,FO,GB) fresh salmon exported to EU market
*x5 (Value 1000 USD) for ROW(CA, FO,GB) frozen salmon exported to EU market
*x6 (Value 1000 USD) for Norwegian fresh salmon exported to US market
*x7 (Value 1000 USD) for Norwegian frozen salmon exported to US market
*x8 (Value 1000 USD) for Chilean frozen salmon exported to US market
*x9 (Value 1000 USD) for ROW (AU,CA,CL,FO,GB) fresh salmon exported to US market
*x10 (Value 1000 USD) for ROW (AU,CA,FO,GB) frozen salmon exported to US market
*get the prices for EU market
genr p1=x1/q1
genr p2=x2/q2
genr p3=x3/q3
genr p4=x4/q4
genr p5=x5/q5
*graph p1 p2 p3 p4 p5 / time lineonly
print p1 p2 p3 p4 p5
*get total expenditure in EU
genr totexpEU=x1+x2+x3+x4+x5
*market share=expenditure share in EU
genr r1=x1/totexpEU
genr r2=x2/totexpEU
genr r3=x3/totexpEU
genr r4=x4/totexpEU
genr r5=x5/totexpEU
genr rEU=r1+r2+r3+r4+r5
print rEU r1 r2 r3 r4 r5
*get the mean of the expenditure share for EU market
stat r1/mean=ms1
stat r2/mean=ms2
stat r3/mean=ms3
stat r4/mean=ms4
stat r5/mean=ms5
```

```
print ms1 ms2 ms3 ms4 ms5
genr lnp1=log(p1)
genr lnp2=log(p2)
genr lnp3=log(p3)
genr lnp4=log(p4)
genr lnp5=log(p5)
genr lnyEU=log(totexpEU)
genr lnPEU=r1*lnp1+r2*lnp2+r3*lnp3+r4*lnp4+r5*lnp5
genr lnyEUPEU=lnyEU-lnPEU
*get the prices for US salmon market
genr p6=x6/q6
genr p7=x7/q7
genr p8=x8/q8
genr p9=x9/q9
genr p10=x10/q10
*graph p6 p7 p8 p9 / time lineonly
print p6 p7 p8 p9 p10
*get total expenditure in US market
genr totexpUS=x6+x7+x8+x9+x10
*market share=expenditure share of US salmon market
genr r6=x6/totexpUS
genr r7=x7/totexpUS
genr r8=x8/totexpUS
genr r9=x9/totexpUS
genr r10=x10/totexpUS
genr rUS=r6+r7+r8+r9+r10
print rUS r6 r7 r8 r9 r10
*get the mean of the expenditure share of US salmon market
stat r6/mean=ms6
stat r7/mean=ms7
stat r8/mean=ms8
stat r9/mean=ms9
stat r10/mean=ms10
print ms6 ms7 ms8 ms9 ms10
stat/all
genr lnp6=log(p6)
genr lnp7=log(p7)
genr lnp8=log(p8)
genr lnp9=log(p9)
genr lnp10=log(p10)
genr lnyUS=log(totexpUS)
genr lnPUS=r6*lnp6+r7*lnp7+r8*lnp8+r9*lnp9+r10*lnp10
genr lnyUSPUS=lnyUS-lnPUS
*estimate the AIDS model using equation 1,2,3,4,6,7,8,9
system 8/iter = 100 piter=0 dn rstat
ols r1 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r2 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r3 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r4 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r6 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r7 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r8 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r9 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
```

```
end
* Now estimate equation 2,3,4 ,5,7,8,9,10 to get the last unconstrained coefficients
system 8/iter = 100 piter=0 dn rstat
ols r2 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r3 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r4 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r5 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r7 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r8 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r9 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r10 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
end
*reenter the first set for restriction test
system 8/iter = 100 piter=0 dn rstat
ols r1 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r2 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r3 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r4 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r6 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r7 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r8 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r9 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
end
*test homogeneity in EU market
test
test lnp1:1+lnp2:1+lnp3:1+lnp4:1+lnp5:1
test lnp1:2+lnp2:2+lnp3:2+lnp4:2+lnp5:2
test lnp1:3+lnp2:3+lnp3:3+lnp4:3+lnp5:3
test lnp1:4+lnp2:4+lnp3:4+lnp4:4+lnp5:4
end
*test symmetry in EU market
test
test lnp2:1-lnp1:2
test lnp3:1-lnp1:3
test lnp3:2-lnp2:3
test lnp2:4-lnp4:2
test lnp4:1-lnp1:4
test lnp4:3-lnp3:4
end
*test homogeneity and symmetry together in EU market
test
test lnp1:1+lnp2:1+lnp3:1+lnp4:1+lnp5:1
test lnp1:2+lnp2:2+lnp3:2+lnp4:2+lnp5:2
test lnp1:3+lnp2:3+lnp3:3+lnp4:3+lnp5:3
test lnp1:4+lnp2:4+lnp3:4+lnp4:4+lnp5:4
test lnp2:1-lnp1:2
test lnp3:1-lnp1:3
test lnp3:2-lnp2:3
test lnp2:4-lnp4:2
test lnp4:1-lnp1:4
test lnp4:3-lnp3:4
end
```

```
*test homogeneity in US market
test
test lnp6:5+lnp7:5+lnp8:5+lnp9:5+lnp10:5
test lnp6:6+lnp7:6+lnp8:6+lnp9:6+lnp10:6
test lnp6:7+lnp7:7+lnp8:7+lnp9:7+lnp10:7
test lnp6:8+lnp7:8+lnp8:8+lnp9:8+lnp10:8
end
*test symmetry in US market
test
test lnp7:6-lnp6:7
test lnp8:6-lnp6:8
test lnp8:7-lnp7:8
end
*test homogeneity and symmetry together in US market
test
test lnp6:5+lnp7:5+lnp8:5+lnp9:5+lnp10:5
test lnp6:6+lnp7:6+lnp8:6+lnp9:6+lnp10:6
test lnp6:7+lnp7:7+lnp8:7+lnp9:7+lnp10:7
test lnp6:8+lnp7:8+lnp8:8+lnp9:8+lnp10:8
test lnp7:6-lnp6:7
test lnp8:6-lnp6:8
test lnp8:7-lnp7:8
end
*test homogeneity and symmetry in EU and US together
test
test lnp1:1+lnp2:1+lnp3:1+lnp4:1+lnp5:1
test lnp1:2+lnp2:2+lnp3:2+lnp4:2+lnp5:2
test lnp1:3+lnp2:3+lnp3:3+lnp4:3+lnp5:3
test lnp1:4+lnp2:4+lnp3:4+lnp4:4+lnp5:4
test lnp6:5+lnp7:5+lnp8:5+lnp9:5+lnp10:5
test lnp6:6+lnp7:6+lnp8:6+lnp9:6+lnp10:6
test lnp6:7+lnp7:7+lnp8:7+lnp9:7+lnp10:7
test lnp6:8+lnp7:8+lnp8:8+lnp9:8+lnp10:8
test lnp2:1-lnp1:2
test lnp3:1-lnp1:3
test lnp3:2-lnp2:3
test lnp2:4-lnp4:2
test lnp4:1-lnp1:4
test lnp4:3-lnp3:4
test lnp7:6-lnp6:7
test lnp8:6-lnp6:8
test lnp8:7-lnp7:8
end
*Estimate L/AIDS with both homogeneity and symmetry imposed on both EU and US markets
system 8/iter = 100 piter=0 dn rstat restrict coef=beta
ols r1 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r2 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r3 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r4 lnp1 lnp2 lnp3 lnp4 lnp5 lnyEUPEU
ols r6 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r7 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r8 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
ols r9 lnp6 lnp7 lnp8 lnp9 lnp10 lnyUSPUS
```

```
restrict lnp1:1+lnp2:1+lnp3:1+lnp4:1+lnp5:1
restrict lnp1:2+lnp2:2+lnp3:2+lnp4:2+lnp5:2
restrict lnp1:3+lnp2:3+lnp3:3+lnp4:3+lnp5:3
restrict lnp1:4+lnp2:4+lnp3:4+lnp4:4+lnp5:4
restrict lnp6:5+lnp7:5+lnp8:5+lnp9:5+lnp10:5
restrict lnp6:6+lnp7:6+lnp8:6+lnp9:6+lnp10:6
restrict lnp6:7+lnp7:7+lnp8:7+lnp9:7+lnp10:7
restrict lnp6:8+lnp7:8+lnp8:8+lnp9:8+lnp10:8
restrict lnp2:1-lnp1:2
restrict lnp3:1-lnp1:3
restrict lnp3:2-lnp2:3
restrict lnp2:4-lnp4:2
restrict lnp4:1-lnp1:4
restrict lnp4:3-lnp3:4
restrict lnp7:6-lnp6:7
restrict lnp8:6-lnp6:8
restrict lnp8:7-lnp7:8
end
*Estimate elasticities
*E11
test(lnp1:1-ms1*lnyEUPEU:1)/ms1-1
*E12
test(lnp2:1-ms2*lnyEUPEU:1)/ms1
*E13
test(lnp3:1-ms3*lnyEUPEU:1)/ms1
*E14
test(lnp4:1-ms4*lnyEUPEU:1)/ms1
*E15
test(lnp5:1-ms5*lnyEUPEU:1)/ms1
*E21
test(lnp1:2-ms1*lnyEUPEU:2)/ms2
*E22
test(lnp2:2-ms2*lnyEUPEU:2)/ms2-1
*E23
test(lnp3:2-ms3*lnyEUPEU:2)/ms2
*E24
test(lnp4:2-ms4*lnyEUPEU:2)/ms2
*E25
test(lnp5:2-ms5*lnyEUPEU:2)/ms2
*E31
test(lnp1:3-ms1*lnyEUPEU:3)/ms3
*E32
test(lnp2:3-ms2*lnyEUPEU:3)/ms3
*E33
test(lnp3:3-ms3*lnyEUPEU:3)/ms3-1
*print beta
*gen1 test=(beta:15-ms3*beta:18)/ms3-1
*genr e33=(beta:15-r3*beta:18)/r3-1
*stat e33
*graph e33 / time lineonly
*genr D=dum(time.ge.200810)
*print time d
*ols e33 d
```

```
*stop
*E34
test(lnp4:3-ms4*lnyEUPEU:3)/ms3
*E35
test(lnp5:3-ms5*lnyEUPEU:3)/ms3
*E41
test(lnp1:4-ms1*lnyEUPEU:4)/ms4
*E42
test(lnp2:4-ms2*lnyEUPEU:4)/ms4
*E43
test(lnp3:4-ms3*lnyEUPEU:4)/ms4
*E44
test(lnp4:4-ms4*lnyEUPEU:4)/ms4-1
*E45
test(lnp5:4-ms5*lnyEUPEU:4)/ms4
*E66
test(lnp6:5-ms6*lnyUSPUS:5)/ms6-1
*E67
test(lnp7:5-ms7*lnyUSPUS:5)/ms6
*E68
test(lnp8:5-ms8*lnyUSPUS:5)/ms6
*E69
test(lnp9:5-ms9*lnyUSPUS:5)/ms6
*E610
test(lnp10:5-ms10*lnyUSPUS:5)/ms6
*E76
test(lnp6:6-ms6*lnyUSPUS:6)/ms7
*E77
test(lnp7:6-ms7*lnyUSPUS:6)/ms7-1
*E78
test(lnp8:6-ms8*lnyUSPUS:6)/ms7
*E79
test(lnp9:6-ms9*lnyUSPUS:6)/ms7
*E710
test(lnp10:6-ms10*lnyUSPUS:6)/ms7
*E86
test(lnp6:7-ms6*lnyUSPUS:7)/ms8
*E87
test(lnp7:7-ms7*lnyUSPUS:7)/ms8
*E88
test(lnp8:7-ms8*lnyUSPUS:7)/ms8-1
*E89
test(lnp9:7-ms9*lnyUSPUS:7)/ms8
*E810
test(lnp10:7-ms10*lnyUSPUS:7)/ms8
*E96
test(lnp6:8-ms6*lnyUSPUS:8)/ms9
*E97
test(lnp7:8-ms7*lnyUSPUS:8)/ms9
*E98
test(lnp8:8-ms8*lnyUSPUS:8)/ms9
*E99
test(lnp9:8-ms9*lnyUSPUS:8)/ms9-1
```

```
*E910
test(lnp10:8-ms10*lnyUSPUS:8)/ms9
*A1
test lnyEUPEU:1/ms1+1
*A2
test lnyEUPEU:2/ms2+1
*A3
test lnyEUPEU:3/ms3+1
*A4
test lnyEUPEU:4/ms4+1
*A6
test lnyUSPUS:5/ms6+1
*A7
test lnyUSPUS:6/ms7+1
*A8
test lnyUSPUS:7/ms8+1
*A9
test lnyUSPUS:8/ms9+1
* use the adding up to recover the estimation of the deleted 5th equation
* Coefficient of the deleted equation
*051
test 0-lnp1:1-lnp1:2-lnp1:3-lnp1:4
*052
test 0-lnp2:1-lnp2:2-lnp2:3-lnp2:4
*053
test 0-lnp3:1-lnp3:2-lnp3:3-lnp3:4
*054
test 0-lnp4:1-lnp4:2-lnp4:3-lnp4:4
*055
test 0-lnp5:1-lnp5:2-lnp5:3-lnp5:4
*U5
test 0-lnyEUPEU:1-lnyEUPEU:2-lnyEUPEU:3-lnyEUPEU:4
end
*Estimate the elasticities of the deleted equation
*E51
test ((0-lnp1:1-lnp1:2-lnp1:3-lnp1:4)-ms1*(0-lnyEUPEU:1-lnyEUPEU:2-lnyEUPEU:3-lnyEUPEU:4))/ms5
*E52
test ((0-lnp2:1-lnp2:2-lnp2:3-lnp2:4)-ms2*(0-lnyEUPEU:1-lnyEUPEU:2-lnyEUPEU:3-lnyEUPEU:4))/ms5
*E53
test ((0-lnp3:1-lnp3:2-lnp3:3-lnp3:4)-ms3*(0-lnyEUPEU:1-lnyEUPEU:2-lnyEUPEU:3-lnyEUPEU:4))/ms5
*E54
test ((0-lnp4:1-lnp4:2-lnp4:3-lnp4:4)-ms4*(0-lnyEUPEU:1-lnyEUPEU:2-lnyEUPEU:3-lnyEUPEU:4))/ms5
*E55
test ((0-lnp5:1-lnp5:2-lnp5:3-lnp5:4)-ms5*(0-lnyEUPEU:1-lnyEUPEU:2-lnyEUPEU:3-lnyEUPEU:4))/ms5-1
*A5
test (0-lnyEUPEU:1-lnyEUPEU:2-lnyEUPEU:3-lnyEUPEU:4)/ms5+1
* use the adding up to recover the estimation of the deleted 10th equation
* Coefficient of the deleted equation
*0106
test 0-lnp6:5-lnp6:6-lnp6:7-lnp6:8
*0107
test 0-lnp7:5-lnp7:6-lnp7:7-lnp7:8
*0108
```

```
test 0-lnp8:5-lnp8:6-lnp8:7-lnp8:8
*0109
test 0-lnp9:5-lnp9:6-lnp9:7-lnp9:8
*01010
test 0-lnp10:5-lnp10:6-lnp10:7-lnp10:8
*U10
test 0-lnyUSPUS:5-lnyUSPUS:6-lnyUSPUS:7-lnyUSPUS:8
end
*Estimate the elasticities of the deleted equation
*E106
test ((0-lnp6:5-lnp6:6-lnp6:7-lnp6:8)-ms6*(0-lnyUSPUS:5-lnyUSPUS:6-lnyUSPUS:7-lnyUSPUS:8))/ms10
*E107
test ((0-lnp7:5-lnp7:6-lnp7:7-lnp7:8)-ms7*(0-lnyUSPUS:5-lnyUSPUS:6-lnyUSPUS:7-lnyUSPUS:8))/ms10
*E108
test ((0-lnp8:5-lnp8:6-lnp8:7-lnp8:8)-ms8*(0-lnyUSPUS:5-lnyUSPUS:6-lnyUSPUS:7-lnyUSPUS:8))/ms10
*E109
test ((0-lnp9:5-lnp9:6-lnp9:7-lnp9:8)-ms9*(0-lnyUSPUS:5-lnyUSPUS:6-lnyUSPUS:7-lnyUSPUS:8))/ms10
*E1010
test ((0-lnp10:5-lnp10:6-lnp10:7-lnp10:8)-ms10*(0-lnyUSPUS:5-lnyUSPUS:6-lnyUSPUS:7-lnyUSPUS:8))/ms10-1
*A10
test (0-lnyUSPUS:5-lnyUSPUS:6-lnyUSPUS:7-lnyUSPUS:8)/ms10+1
*test E11=E66 (Elasticity of Norwegian fresh salmon in EU market = Elasticity of Norwegian fresh salmon in US)
is rejected
test ((lnp1:1-ms1*lnyEUPEU:1)/ms1-1)-((lnp6:5-ms6*lnyUSPUS:5)/ms6-1)
*test E44=E99 (ROW fresh in EU = ROW fresh in US) is rejected
test ((lnp4:4-ms4*lnyEUPEU:4)/ms4-1)-((lnp9:8-ms9*lnyUSPUS:8)/ms9-1)
stop
```