The demand for salmon in the European Union : the importance of product form and origin

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Abstract

Tins paper addresses the importance of different product farms and their origin when considering the market structure in the European salmon market. The competition between Farmed Atlantic salmon and wild-caught pacific salmon has received some attention previously. However, this was before frozen Atlantic salmon emerged as an important product form in the market. This could be important as frozen Atlantic salmon is more likely to be a close substitute for Pacific salmon, which is mostly marketed frozen, than is fresh Atlantic salmon. In this paper, an almost ideal demand system is used to estimate the demand for fresh Atlantic salmon, frozen Atlantic salmon and frozen Pacific salmon in the European Union.

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I. Introduction

In this paper, we will investigate the importance of product form and origin in the European salmon market. This is done by estimating the demand for fresh Atlantic, frozen Atlantic and frozen Pacific salmon. Recently, and particularly after the introduction of fanned salmon, the demand for salmon has been studied extensively.'1[1] These studies cover many different markets, using data at different aggregation levels and different demand specifications. However, the importance of product form and the origin of the product have received less attention. Herrmann and Lin (1988) and Herrmann, Mitlelhammer and Lin (1993) consider the relationship between Salmon of different origin when estimating single equation demand equations for Norwegian farmed salmon and North American wild salmon in the European Union, Japan and North America. However, they do not consider different product forms.2[2] DeVoretz and Salvanes (1993) use high-valued Pacific salmon as a substitute for Norwegian farmed salmon. Wessells and Wilen (1993; 1994) consider TWO product forms, fresh and salted. In the Japanese market, in a demand system considering many forms of seafood, Asche, Salvanes and Steen (1996) consider fresh and frozen salmon in a demand system together with crustaceans in the European Union, while Asche (1995, 1996a) considers fresh, frozen and smoked salmon in a demand system in the European Union. However, in these studies, the distinction between different product forms of Atlantic and Pacific salmon is not made.

In this paper, we will consider the demand for fresh Atlantic, frozen Atlantic and frozen Pacific salmon in the European Union. The demand equations will be estimated with the almost ideal demand system of Deaton and Muellbauer (1980). The product forms fresh and frozen are chosen, as they are the most important product forms imported to the European Union. The supply of fresh salmon is dominated by European salmon farmers (99%), while the frozen product form is supplied both from North-American fishermen (Pacific salmon) and from farmers (Atlantic salmon), European and non-

European. Since the early 1980s the imports of fresh salmon to the European Union has increased vastly, and beginning in the mid 1980s, imports of frozen Atlantic salmon has also increased significantly. The import of frozen Pacific salmon has on the other hand, been rather stable, but with a decline in the late 1980s and a rebound in the early 1990s. Figures for the imports can be found in Table 1. To consider all these product forms are important if one wants information about the market structure for salmon in the European Union.

The substitution relationship between the different products is also important when the question of market power in the European Union and the effect of projectionist measures are discussed. In particular, there have recently been many attempts to stabilize the price of fresh salmon, including implementation of minimum prices on imports to the European Union. There have also been discussions about forming a European producer organization, whose aim is to stabilize prices in the European market for fresh salmon by controlling the supply. The likelihood of success for a producer organization is critically dependent on the assumption that there are no close substitutes for European farmed salmon, as the ability to control price by controlling supply is dependent on market power. Hence, if frozen Pacific, and, to a lesser extent, frozen Atlantic salmon, are significant substitutes for fresh Atlantic salmon, it is unlikely a producer organization will succeed.

This paper is organized as follows. In the next section, recent developments in the European salmon market are reviewed. In section 3, the data set and the almost ideal demand system are described. The empirical results are reported in section 4, while concluding remarks are given in section 5.

2. Background

Japan and the United States have traditionally been the world's major markets for salmon, with Japan as the largest. However, the market for salmon in the European Union has increased vastly during the last decade, fueled by the expansion of salmon aquaculture. Imported quantity and value to the European Union for the three product forms considered here can be seen in Table 1. Note that fresh salmon has replaced frozen Pacific salmon as the most important product form.

Table 1

The growth of salmon aquaculture has also changed the uses of Atlantic salmon in Europe until the early 1980s. Atlantic salmon was mostly consumed fresh, and was regarded as a luxury product. The available supply was also very limited. However, in the Pacific, large quantities of salmon were landed. Until the mid 1980s, most salmon imports to Europe was frozen Pacific salmon, which mostly was used as inputs in the smoking industry 3[3]. Pacific salmon is considered to be of lower quality than Atlantic salmon. This is reflected in the lower price it commands. The import prices are graphed in Figure 1.4[4]

Figure 1

When salmon aquaculture started to grow, the high-end market for Atlantic salmon was targeted. However, as the production increased, one had to find new markets. The European smoking industry was a natural target, as this industry was based on

salmon, albeit the lower quality Pacific salmon. With the increase in production of farmed Atlantic salmon, the price was also decreasing, making farmed Atlantic salmon more competitive. While the smoking industry is an important purchaser of farmed salmon, also new markets have been found, in particular, home consumption of salmon purchased in supermarkets has become an important market.

The growth and high profitability in salmon aquaculture in the early 1980s attracted many new entrants. As the price declined at the end of the 1980s, a number of farmers had economic problems and were forced into bankruptcy. Also fishermen on the Pacific coast of North America experienced economic problems due to weak salmon prices. This has led to calls for protectionism measures from farmers inside the European Union, as Ireland and Scotland are members of the European Union, while the largest producer, Norway, is not5[5]. Several attempts have also been made to stabilize the price of fresh salmon. This includes a freezing program for Norwegian salmon in 1990-91 to hold fresh salmon back from the market, minimum prices on fresh salmon imports to the European Union (last time on December 16, 1995) and quantity regulations on Norwegian production. There have also been negotiations about forming a European producer organisation for salmon.

The only opening in the treaty of Rome for allowing collusion between producers is the possibility to establish producer organizations in agriculture and fisheries. The purpose of a producer organization is to stabilize supply and the producers' income, and it is meant TO benefit both consumers and producers. It is not allowed to extract excessive profits. Following the decline in the price of salmon until 1990, Scottish farmers, who already have a national producer organization, have proposed to form a European producer organization for farmed salmon. The intention is that a European producer organization, consisting of national producer organizations in the Faroe Islands, Ireland, Norway and the United Kingdom should be formed. The producer organization should control supply and thereby prices in the European market for fresh salmon, thereby stabilizing both supply and the farmers' income. However, contrary to agricultural commodities, the European salmon farmers do not have and can not expect to be protected by barriers to trade. Hence, the producer organization must have market power if it is to stabilize prices by controlling supply. The probability of success for a producer organization is therefore critically dependent on the size of the market and possible substitutes to European farmed salmon.

Only a few nations supply salmon on the international market. For Pacific salmon, Canada and the United States are the main suppliers and for farmed Atlantic salmon, Norway, Chile, Canada, Faroe Islands, Ireland and Scotland are the major suppliers.6[6]For fresh Atlantic salmon, the question has been raised whether some producers have market power in the European market. The ability to exploit market power is an important issue in this market, and it is critical for a European producer organization to succeed. Many people inside the industry seem to believe that Irish and Scottish farmers together with Norwegian farmers have market power if they are able to act like a unit, as they provide over 90% of the fresh salmon to the European market. There is some potential for competition, mainly from Chile with a salmon production in 1995 of about 78,000 tons (Bjorndal, 1996). This assumes that the price margin becomes large enough to justify airfreight of Chilean salmon. However, if frozen salmon is a close substitute to fresh salmon, the possibility to exploit market power is limited. This is because the available quantities of wild-caught frozen Pacific salmon are much larger than current European demand. Further, transportation costs

do not disfavour frozen salmon from Chile and other non-European producers in the way they do for fresh. Some of the producers (in particular Norway) that would make up the producer organization also supply large quantities of frozen salmon. Hence, the probability of success for a European producer organization is critically dependent on the possible substitution relationships in the market.

As a note to the discussion of market power in the salmon market, a particularly interesting episode took place in 1990-91, when Norwegian farmers had a market share in Europe of more than 70%. All the Norwegian farmers had a mandatory membership in a common sales organization. To stabilize and increase the price of fresh salmon, the most important product form for Norwegian farmers, a freezing program was implemented by the sales organization to limit the supply of fresh salmon. Over the period, about 88,000 tons were frozen. However, the price continued to decline and the freezing program was abandoned in November 1991, when the sales organization went bankrupt.

3. Data and method

The data set consists of import data from the European Union's trade statistics, Eurostat.7[7] The data set contains deseasonalised data series on value and quantity of quarterly imports of fresh Atlantic salmon, frozen Atlantic salmon and frozen Pacific salmon for the period 1984(1)-1992(4). 8[8] The deseasonalisation of the data series is done by removing deterministic seasonably with quarterly dummy variables, as described by Jorgensen (1964). Real values were obtained using OECD's consumer price index for the European Union.
The demand equations are estimated using the almost ideal demand system of Deaton and Muellbauer (1980). Each equation in the almost ideal demand system is given as

$$w_{it} = \alpha_i + \alpha_{iT}\, t + \sum_j \gamma_{ij} \ln P_{jt} + \beta_i \ln(X_t / P_t) \qquad (1)$$

where w_{it} denotes the share of the i th good, t a linear time trend, P_{jt} the price of the *j* th good in period t, X_t the expenditure on the *n* goods in the system and $\ln P_t$ a price index. The price index is a translog index

$$\ln P_t = \alpha_0 + \sum_i \alpha_i \ln P_{jt} + 1/2 \sum_i \sum_j \gamma_{ij} \ln P_{jt} \ln P_{jt} \qquad (2)$$

The translog price index makes the demand system nonlinear. To avoid nonlinearity, Deaton and Muellbauer suggested that the price index could be approximated by a Stone price index, i.e., $\ln P_t = \sum_i w_{it} \ln P_{jt}$. Recently, the use of the Stone price index has been shown to beinappropriate as it causes the estimated parameters to be inconsistent (Pashardes, 1993, Buse, 1994; Moschini, 1995). Moschini attributes this problem to the fact that the Stone price index does not satisfy what Diewert calls the commensurability property, and suggests that the problem may be solved by using a price index that satisfies this property.9[9] Moschini suggests several other price indices which satisfy this property, and which may be used to keep the specification of the almost ideal demand system linear. He also shows that these indices perform as well as the translog index in a Monte Carlo experiment. To keep the specification of

the demand system linear, we will here use the price index that Moschini calls the corrected Stone index, which may be written as:

$$\ln P_t = \sum_i w_{it} \ln\left(\frac{p_{it}}{p_i^0}\right)$$

Economic theory implies the following restrictions on the equation system,

adding up: $\sum_i \alpha_i = 1$, $\sum_i \alpha_{iT} = 0$, $\sum_i \gamma_{ij} = 0$, $\sum_i \beta_i = 0$,

homogeneity: $\sum_j \gamma_{ij} = 0$, and

symmetry: $\gamma_{ij} = \gamma_{ji}$, $i \neq j$.

The adding up conditions, which are automatically satisfied by the data, imply that the covariance matrix is singular. This problem can be avoided by deleting one equation from the system. The system is invariant to which equation is deleted, and the parameters in the deleted equation may be retrieved using the adding up conditions.

By limiting the analysis to three product forms of salmon, we implicitly assume weak separability between these three goods and all other goods in the consumer's bundle. This might seem a strict assumption However, market delineation studies indicate that the assumption might not be very restrictive. In particular, Gordon, Salvanes and Atkins (1993) conclude that salmon does not compete in the same market segment as turbot and cod. As this also implies that salmon does not compete in the same market segment as other species, that do compete with turbot and cod, it is reasonable to assume weak separability between salmon and different types of white fish. There might still be a potential problem with other high-valued food products. However, as their budget shares mostly are small, the impact of omitting them should not be too large, if they indeed do belong to the same market segment as salmon.

4. Empirical results

The almost ideal demand system given in equation (1) was estimated with the equation for frozen Pacific salmon deleted. Before we can analyze the elasticities, the system must be tested for this specification. A potential problem when estimating the demand system is that supply may be upward sloping, if this is the case, instrumental variable estimators are necessary to obtain consistent parameter estimates. It is likely that the supply curves are upward sloping if there exists a separate European market for salmon as argued by Herrmann and Lin (1988), while the supply will be completely elastic in sub-markets such as Europe if there is a world market for salmon (see e.g. Bjorndal and Schwindt, 1988; Bjorndal, 1990). To test whether quantities and prices are simultaneously determined, a Hausman test (Hausman, 1978) is utilized, with lagged prices as instruments.10[10] The test statistic is 0.61 and is distributed as $X^2(6)$. As the critical value for $X^2(6)$ is 12.59, we cannot reject the null hypothesis. We will accordingly assume that the prices are predetermined in our demand system. This result is also in accordance with DeVoretz and Salvanes (1993) and Asche (1995).

When using time series data, auto-correlation can be a problem. In demand system analysis, the Durbin-Watson test has been the most common tool when testing for auto-correlation. However, this test has several weaknesses in the demand system context. The Durbin-Watson test is done equation by equation, and its conclusions may not be invariant to which equation is deleted. Also, it cannot account for cross equation auto-correlation in the system. In singular systems, this is a problem, as Berndt and Savin (1975) show that the auto-correlation parameters must be equal in all equations if cross equation auto-correlation is not allowed. Both these problems can be avoided by using a LM-test. This test was provided in a simultaneous equation framework by Godfrey (1981), and it is also applicable in the seemingly unrelated regression case. Asche (1996b) shows that the LM-test is also invariant to which equation is deleted in a singular equation system.

The LM-test is undertaken by first obtaining the residuals from a static regression of the system. In a test against first order auto-correlation, the residuals from all the estimated equations lagged one period are then added to the regressors in each equation, and this new system is estimated. The null hypothesis of no auto-correlation can then be tested by testing the hypothesis that the parameters on all the lagged residuals equal zero in this auxiliary regression. To test for auto-correlation of higher orders, the residuals lagged more periods are included in the auxiliary regression. In our system we perform two tests, one against first order auto-correlation and one against auto-correlation up to the fourth order. The first test gives a test statistic of 4.233, and as the critical value at a 5%, level for a $X^2(4)$ is 9.49. The hypothesis of no first order auto-correlation cannot be rejected. The test statistic in the test of up to fourth order auto-correlation is 23.511, and as the critical value for a $X^2(16)$ is 26.3, we cannot reject this hypothesis. A static specification of the system therefore seems appropriate.

One of the main result from Anderson and Blundell's studies (1983; 1984) is that with a proper dynamic specification of the estimated equations, the homogeneity and symmetry restrictions implied by economic theory cannot be rejected. These restrictions are here tested using a Wald test. The null hypothesis of homogeneity and symmetry cannot be rejected separately nor jointly, as the test statistics with critical value at a 5% level in the parenthesis are: homogeneity, 2.49 (5.99), symmetry 2.443 (3.84) and homogeneity and symmetry 5.762 (7.82). Hence, in this case, when we cannot reject the hypothesis of no auto-correlation. We found no evidence against the homogeneity and symmetry restrictions implied by consumer theory.

In the literature, fresh salmon or a salmon aggregate is the most studied product form.11[11] Although the results vary, some conclusions may be drawn. The demand for fresh salmon or an aggregate (farmed) salmon category is own-price elastic, as the own-price elasticities are mostly found to be in the range -1 to -3 and it is also expenditure elastic, with most reported elasticities in the range 1 to 5. For frozen salmon, there are fewer results, but all recent studies indicate that it is expenditure inelastic. It is found to be both price elastic and price inelastic.

The parameter estimates are presented in Table 2, and the compensated and uncompensated elasticities are presented in Tables 3 and 4. The compensated own-price elasticities indicate that both fresh Atlantic salmon and frozen Pacific salmon are price inelastic, while frozen Atlantic Salmon is price elastic. For the uncompensated elasticities, the expenditure effect makes fresh salmon price elastic, while the magnitudes of the elasticities for the other two product forms only increase slightly.

Table 2

Table 3

Table 4

The compensated cross-price elasticities indicate that all the product forms are significant substitutes for each other. The effects of changes in the price of fresh salmon on the two frozen product forms are the strongest effects in the system, as the cross-price elasticities are 1.073 and 0.449. Hence, an increase in the price of fresh salmon will significantly increase demand for the frozen salmon. Also the prices of the two frozen product forms significantly affect the demand for fresh salmon. The price of frozen Pacific salmon is also important in the demand for frozen Atlantic salmon, but the effect the other way is not as strong, as the elasticity of frozen Atlantic salmon in the equation for frozen Pacific is 0.150. The uncompensated cross-price elasticities are more ambiguous. However, the strong expenditure effects clearly play a major part here, and the compensated cross-price elasticities are anyway the most appropriate when one wants information about substitution possibilities.

The most striking feature is the expenditure elasticities. Both fresh and frozen Atlantic salmon are expenditure elastic, while frozen Pacific salmon seems to be an inferior good. That fresh salmon is expenditure elastic is as expected. As well, it is not unreasonable that frozen Atlantic salmon is expenditure elastic, although the high magnitude of the elasticity is somewhat surprising. This may be explained by the strong growth of the frozen Atlantic salmon category, in particular from 1988 onwards. It is not too surprising that the expenditure elasticity for frozen Pacific salmon is inelastic, as it is the lowest valued of the three product forms. It is also reasonable, as the market share for frozen Pacific salmon has declined substantially while the market has expanded. However, that frozen Pacific salmon seems to be an inferior good is unexpected. To investigate this further, we computed the expenditure elasticities for each year in the data set. These are graphed in Figure 2. We can here see that all elasticities are declining throughout the sample, with the exception of frozen Atlantic salmon in 1992, when The imports of this product form declined significantly. That the expenditure elasticities for fresh and frozen Atlantic salmon declines when the imports increases is reasonable, since a commodity cannot always be expenditure elastic.12[12] Frozen Pacific salmon is a normal good in the first three years of the sample. However, following the strong growth in frozen Atlantic salmon, it seems to be inferior thereafter. The magnitude of the elasticity is declining throughout the period. This is reasonable, and may be explained by the vast increase in the imports of the other two product forms, and particularly of frozen Atlantic salmon from 1988 onwards, giving frozen Pacific salmon a significantly smaller market share in an increasing market. However, it is surprising that this effect seems to be strong enough to make frozen Pacific salmon seems like an inferior good. If frozen Pacific salmon is indeed inferior, this implies that the European Union will not import any frozen Pacific salmon if the market for salmon grows sufficiently. While somewhat surprising, this might not be too unreasonable if the salmon market continues to grow because of lower prices on the higher quality Atlantic salmon.

Figure 2

The magnitude of the elasticity for fresh salmon also seem to confirm a trend in many of the recent studies in reporting a less elastic demand for salmon when more recent data sets are used (Bjorndal, Salvanes and Andreassen 1992; DeVoretz and

Salvanes, 1993, Herrmann. Mittelhammer and Lin, 1992, 1993; Wessells and Wilen. 1993; 1994; Asche, 1996a). Accordingly, the scope for expanding the income from this market by increasing supply seem to be narrowing. The expenditure elasticity is also weaker than in most of the studies using single equation demand function specifications. It should also be noted that the other studies that use system specifications (Wessells and Wilen, 1993; 1994. Asche. Salvanes and Steen, 1996. Asche, 1996a), all report expenditure elasticities that are barely elastic or inelastic.

5. Discussion

The demand for fresh, frozen Atlantic and frozen Pacific salmon in the European Union was specified and estimated using the almost ideal demand system of Deaton and Muellbauer (1980). A static specification was found to be appropriate, and the homogeneity and symmetry restrictions implied by economic theory could not be rejected with this specification. The expenditure elasticities are interesting, as frozen Atlantic salmon is found to be strongly expenditure elastic, while frozen Pacific salmon seems to be an inferior good in the last pan of the period studied here. This is probably caused by the strong expansion in the demand for frozen Atlantic salmon while the demand for frozen Pacific salmon has remained fairly stable.
All goods are found to be substitutes, indicating one market for all three product forms. This is important as it implies that the demand for fresh Atlantic salmon depends on the prices of frozen Atlantic and frozen Pacific salmon and vice versa. This limits both the likelihood that any producer can have market power in any segment of the market, and the effect of protectionism measures targeted at particular producers or product forms. Continued growth in salmon aquaculture in Chile and other non-European countries will further limit these effects.

It also limits the likelihood of success for a European producer organization, as it is necessary for the producers to have market power if they are to stabilize the price by controlling the supply. The substitutability between fresh salmon and the frozen product forms is also an important factor when considering reasons for the failure of the Norwegian freezing program in 1990-91. Even with its large market share, the Norwegian sales organization was not able to control price by regulating quantity. The failure of this freezing program should also give an important message to any producer organization that wishes to exercise market power

Acknowledgments

References

Anderson- G, J, and R. W. Blundell (1983) "Testing Restrictions in a Flexible Demand System An Application to Consumers' Expenditure in Canada." Review' of Economic Studies. 50. 397-410.

Anderson, G. J. and R, 'W. Blundell (1984) "Consumer Non-Durables in the U.K.: A Dynamic Demand System." Economic Journal. 94. 35-44.

Asche, F. (1995) "A Linear Dynamic Demand System. The Demand for salmon in the European Union," Foundation for Research in Economics and Business Administration, Norwegian School of Economics and Business Administration, SNF Working Paper No. 35/95,

Asche, F. (1996a) "A System Approach to the Demand for salmon in the European Union." Applied Economics. 28. 97-101

Asche. F. (1996b) Specification of Dynamic Demand Systems: The Demand for Salmon in the European Union. Ph.D dissertation. Norwegian School of Economics and Business Administration.

Asche, F., K- G. Salvanes and F Steen (1996) "Market Delineation and Structure." Forthcoming in American Journal of Agricultural Economics

Berndt. E, R. and N. E. Savin (1975) "Estimation and Hypothesis Testing in Singular Equation Systems with Autoregressive Disturbances," Econometrica. 43, 937-958.

Bird, P. (1986) "Econometric Estimation of World Salmon Demand," Marine Resource Economics. 3, 169-182.

Bjorndal, T, (1990) The Economics of Salmon Aquaculture, Oxford: Blackwell.

Bjorndal. T, (1996) "Genetic Improvement of Coho Salmon in Chile: An Economic Analysis" Mimeo, Norwegian School of Economics and Business Administration.

Bjorndal, T., D. V. Gordon, and K. G. Salvanes (1994) "Elasticity Estimates of Farmed Salmon Demand in Spain and Italy," Empirical Economics, 4, 419-428.

Bjorndal. T., D. V. Gordon, and B. Singh (1993) "A dominant Firm Model of Price Determination in the US Fresh Salmon Market: 1985-1988." Applied Economics, 25, 743-750.

Bjorndal, T., K. G. Salvanes, and J- H Andreassen (1992) 'The Demand for Salmon in France: the Effects of Marketing and Structural Change". Applied Economics, 24, 1027-1034.

Bjorndal. T, and R, Schwindt. (1988) "An International Analysis of the Industrial Economics of Salmon Aquaculture." Institute of Fisheries Economics, Norwegian School of Economics and Business Administration. Working Paper 3/88.

Buse, A. (1994) "Evaluating the Linearized Almost Ideal Demand System," American Journal of Agricultural Economics. 76, 781-793

Deaton. A.S and J Muellbauer (1980) "An Almost Ideal Demand System," American Economic review,70, 312-326.

DeVoretz, D. (1982) "An Econometric Demand Model for Canadian Salmon," Canadian Journal of' Agricultural Economics, 30, 49-60.

DeVoretz, D. J and K. G. Salvanes (1993) "Market Structure for Farmed Salmon," American Journal of Agricultural Economics, 30, 49-60.

Eales, J. S. and L. J. Unnevehr (1993) "Simultaneity and Structural Change in U.S. Meat Demand." American Journal of Agricultural Economics, 75, 259-268.

Godfrey, L. G. (1981) "On the Invariance of the Invariance Multiplier Test with Respect to Certain Changes in the Alternative Hypothesis," Econometrica. 49. 1443-1455.

Gordon. D V . K G Salvanes and F. Atkins (1993) "A Fish Is a Fish: Testing for Market Linkage on the Paris fish Market," Marine Resource Economics, 8, 331-343.

Hausman. J A (1978) "Specification Tests in Econometrics." Econometrica. 46. 1251-1271

Hermmann, M. R. and B. H Lin (1988) "The Demand and Supply of Norwegian Atlantic Salmon in the United States and the European Community," Canadian Journal of Agricultural Economics, 453-464.

Hermmann. M.. R. C. Mittelhammer, and B. H. Lin (1992) "Applying Almon-Type Polynomials in Modelling Seasonably of the Japanese Demand for Salmon." Marine Resource Economic.7, 3-13.

Herrmann, M. L., R, C, Mittelhammer. and B. H. Lin (1993) "Import Demand for Norwegian Farmed Atlantic Salmon and Wild Pacific Salmon in North America. Japan and the EC."

Jorgenson. D. W. (1964)'"Minimum Variance, Linear, Unbiased Seasonal Adjustment in Economic Time Series." Journal of the American Statistical Association, 59. 681 - 725

Moschini. G. (1995) "Units of Measurement and the Stone Price Index in Demand System Estimation." American Journal of Agricultural Economics, 77. 63-68.

Pashardes. P. (1993) "Bias in Estimating the Almost Ideal Demand System with the Stone Index Approximation," Economic Journal. 103, 908-915.

Wahl, T. 1. and D. J. Hayes (1990) "Demand System Estimation with Upward-Sloping Supply," Canadian Journal of Agricultural Economics, 38, 107-122

Wessells, C. R. and J. E. Wilen (1993) "Economic Analysis of Japanese Household Demand for Salmon", Journal of the World Aquaculture Society, 24, 361-378.

Wessells. C. R. and J. E. Wilen (1994) "Seasonal Patterns and Regional Preferences in Japanese Household Demand for Seafood." Canadian Journal of Agricultural Economics. 42, 87-103

White. K J. (1978) "A General Computer Program for Econometric Methods - SHAZAM," Econometrica. 46, 239-240.

Table 1. **Imports of salmon to the European Union (Values in 1,000 ECU (1984=1), quantities in metric tons).**

	Fresh Atlantic		Frozen Atlantic		Frozen Pacific	
year	Value	Quantity	Value	Quantity	Value	Quantity
1984	91,932	12,707	52,755	6.163	163.524	27.636
1985	126,854	16,866	55.656	6.691	140.121	27.805
1986	142.507	76.952	54.425	7868	109.952	30. 355
1987	204,418	35,742	54.538	8.138	130,432	32.927
1988	266,926	51,820	74.265	15,189	107,345	21.474
1989	308,628	78.062	67,895	16,373	56,393	16,265
1990	350,477	96,566	94,542	26.240	52.104	20,243
1991	349,508	108,432	111,309	33,516	47.429	20,690
1992	401,212	124.273	84.577	23,684	52.574	25.661

Source:Eurostat

Table 2. **Parameter estimates with standard errors.**

Equation		Fresh Atlantic		Frozen Atlantic	
Variable	Estimate	St Dev,	Estimate	St. Dev	
Fresh Atlantic price		-0067	(0.082)	0085 (0.054)	
Frozen Atlantic price		0.085	(0.054)	-0.089	(0.057)
Frozen Pacific price		-0.018	(0.061)	0,004 (0.032)	
Expenditure	0.192*	(0 071)	0.255*	(0.038)	
Trend	0.003	(0.002)	-0.005*	(0.001)	
Constant	-1.022*	(0.468)	-1.608*	(0.251)	
R²		0.824		0.710	

* indicates significant at a 5% significance level.

Table 3. Compensated own-price, cross-price and expenditure elasticities [a,b]

	Fresh	Frozen Atlantic	Frozen Pacific	Expenditure
Fresh	-0.634*	0.317*	0 .316*	1 .384*
	(0,164)	(0.l09*)	(0.115)	(0.142)
Frozen Atlantic	1 073*	-1 453*	0.379**	2.724*
	(0.369)	(0.385)	(0.214)	(0.258}
Frozen Pacific	0,449*	0.150**	-0.608*	-0.270**
	(0.162)	(0.090)	(0 .150)	(0.175)

Indicates significant at a 5% significance level and* indicates significant a 10%
significance level. A Standard deviations in parentheses.
[B] The compensated elasticities are given as

Table 4. Uncompensated own-price, cross-price and expenditure elasticities a,b

	Fresh	**Frozen Atlantic**	**Frozen Pacific**	**Expenditure**
Fresh	-1.326*	0.113	-0.171	1.384*
	(0.181)	(0.108)	(0.128)	(0.142)
Frozen Atlantic	-0.288	-1.856*	-0.579*	2.724*
	(0.414)	(0.376)	(0.246)	(0.258)
Frozen Pacific	0.584*	0.199*	-0.513*	-0.270**
	(0.182)	(0.091)	(0.168)	(0.175)

* indicates significant a 5% significance level and ** indicates significant at a 10% significance level.

a Standard deviations in parentheses.

b The uncompensated elasticities are given as

$$\eta_{ij} = \frac{\gamma_{ij}}{w_i} + \beta_i \frac{w_j}{w_i} - \delta, \ \delta=1, \ i=j, \ \delta=0, \ i \neq j$$

Figure1

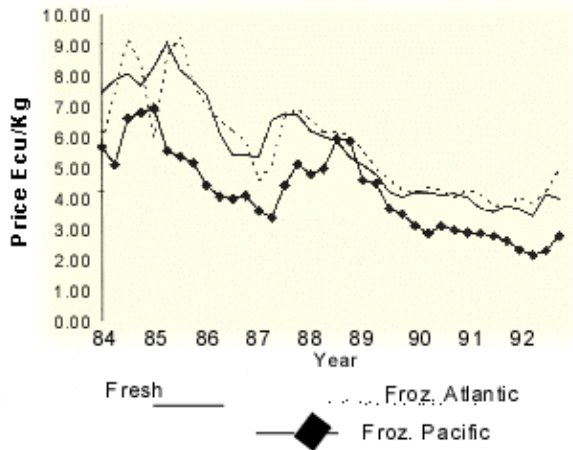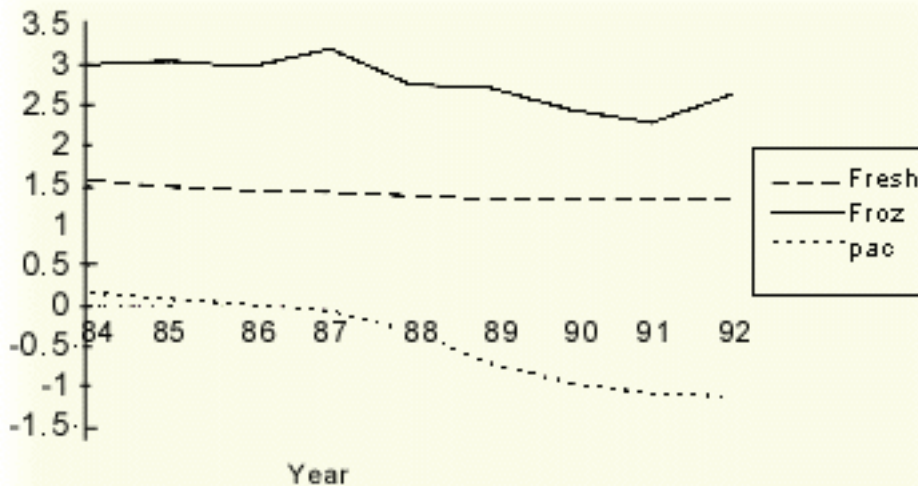### Figure 1. Real prices on salmon imports to the European Union (1984=1)

Figure2

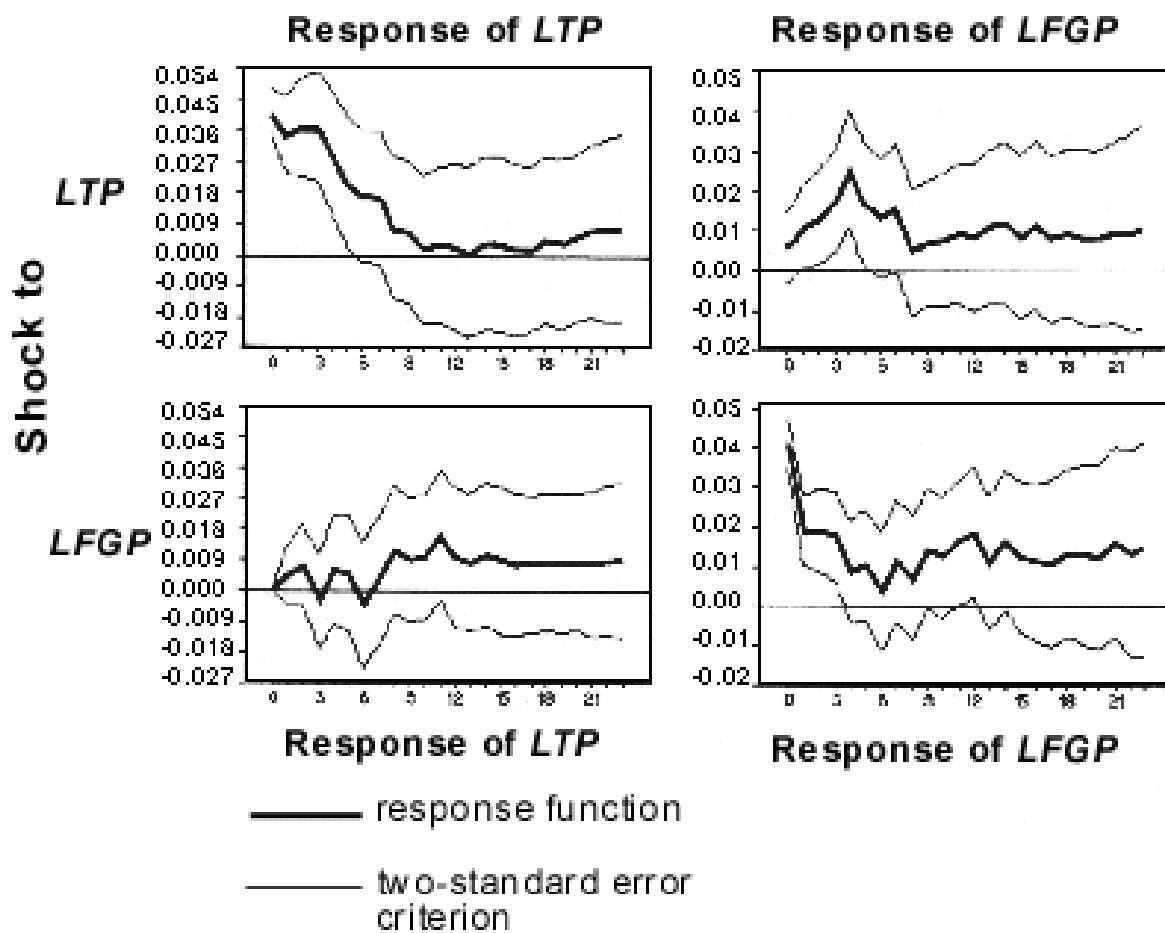### Figure 2 . Expenditure elasticities

FIGURE 4

[1] See DeVoretz (1982). Kabir and Ridter (1984). Bird (1986). Herrmann and Lin (1988). Bjorndal. Salvanes and Andreassen (1992). Herrmann, Mittelhammer and Lin (1992: 1993). Bjorndal, Gordon and Singh (1993). DeVoretz and Salvanes (1993), Wessells and Wilen (1993; 1994). Bjorndal.. Gordon and Salvanes (1994). Asche. Salvanes and Steen (1996). Asche (1995: 1996a).

[2]Also, as their data sets cud in 1988, it is unlikely that they were able to capture much of the expansion or the farmed Atlantic production. Herrmnann and Lin (1987) use monthly data from January 1983 through March 1988, while Herrmann. Mittelhammer and Lin (1993) use important product from in the mid 1980s.

[3] In addition to freezing, canning is an important conserving/processing method for Pacific salmon. However, canned salmon is not in the same market segment as frozen and Atlantic salmon, and will not be considered here.

[4] Note that the prices graphed are not deseasonalised.

[5] In the United States, domestic farmers succeeded in closing the market for Norwegian farmers in April 1991, as a counterceilling tariff was imposed on Norwegian fresh salmon imports.

[6] Also Japan and Russia produce significant quantities of Pacific salmon. However, this is almost exclusively consumed at the market. In Australia, Iceland, New Zealand, and United States there is a small salmon.

[7] The data was made available for this study by the Norwegian Seafood Exports Council in Tromso.

[8] Before 1988 the data source does not differentiate between frozen Atlantic and frozen Pacific salmon. In this period we use the imports from Canada and the United States as a proxy for frozen Pacific salmon imports. As almost all the frozen Pacific salmon imports originate from these two countries in the period where the ran data distinguishes between frozen and Pacific salmon, this should not cause any problems.

[9] The commensurability property means that a price index should be invariant to the units or measurement of prices.

[10] The use of the Hausman test in demand systems was introduced in several recent studies on North American meal demand (Wahl and Hayes, 1990; Eales And Unnevehr, 1993).

[11] Sec DeVorertz (1982). Bird (1986). Herrmman and Lin (1988) Bjorndal. Salvanes and Andreassen (1992). Herrmann Mittelhammer and Lin(1992;1993), Bjorndal. gordon and Singh(1993), . DeVoretz and Salvanes (1993). Wessells and Wilen (1993: 1994). Bjorndal. Gordon and Salvanes (1994). Asche. Salvanes and Steen (1996), Asche (1995: 1996a).

[12] If a commodity is always expenditure elastic. The expenditure on this commodity will exceed the budget when total expenditure increases sufficiently.