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**A STATISTICAL ANALYSIS OF  
THE SWEDISH IMPORT OF  
SMOKED SALMON FROM NORWAY**

**by  
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# A Statistical Analysis of the Swedish Import of Smoked Salmon from Norway

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## Abstract

The analysis addresses the question of whether Sweden's membership in the EU has had any influence on the import of smoked salmon from Norway. After Sweden became a member of EU in 1995, the trade conditions changed from free trade to a regime where import of smoked salmon from Norway is imputed a 13% ad valorem duty. Statistical models are applied in testing whether there exists an "EU-effect". The analysis indicates that we cannot reject the possibility of an "EU-effect". The inflicted long-run loss on the Norwegian industry amounts to about 16 million Norwegian kroner per year, which corresponds to about 8% of the average yearly export value before 1995.

**JEL classification number: F10, C01, C22**

**Keywords: Trade barriers, smoked salmon**

## 1 Introduction

Sweden became a member of the European Union (EU) in 1995 after a referendum in 1994. Norwegian smokehouses had for many years exported smoked salmon to Sweden without any import tariff, but from 1995 the Norwegian salmon was charged a 13% ad valorem import duty.

The paper analyzes whether Sweden's membership in the EU has had any influence on the Norwegian export of smoked salmon to Sweden, and tries to

quantify the economic effect the membership has generated and probably will generate in the future. We apply statistical methodology to test the potential “*EU-effect*”, i.e. whether Sweden’s membership has had any influence on the import of Norwegian smoked salmon.

The remaining of the paper is structured as follows. The next section, Section Two, describes the export of smoked salmon from Norway. Section Three analyzes whether it is possible to measure any “*EU-effect*” due to the Swedish membership. Econometrics are applied in measuring the “*EU-effect*”. The last section, Section Four, concludes. Appendix A presents the stationarity tests of the variables applied in the analysis. Appendix B measures the relationship between price of farmed Atlantic salmon and the price of smoked salmon. Appendix C measures the relationship between the costs of producing farmed Atlantic salmon and the price of smoked salmon.

## 2 Descriptive statistics

Figure 1 shows the total export of smoked Norwegian salmon for the period 1974-2004. If we look at the last four to five years, the aggregated exported quantity is about 3.5 thousand tons and the export value is over 300 million Norwegian kroner (2005-value) per year.

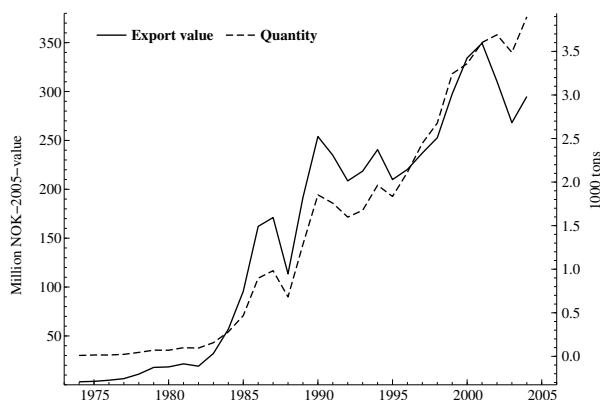


Figure 1: Total export of smoked salmon from Norway.  
Source: Seafood Norway

Figure 1 shows that exported quantity and value have an overall positive trend during the period 1974-2004. There is also some indication of variation.

The weakest growth periods are 1974-83, 1987-88, 1990-95/96 and 2001-03. At the moment we have no information to explain causes behind the weak periods 1987-88 and 1990-95/96, except that the reduction in the export value during 2001-02 could be explained by an unfortunate development due to an increase in the interest rate and an appreciation of the exchange rate (Lorentzen et al 2003).

The general increase in the export could be explained by the continuous reduction of the price level of smoked salmon. Farmed salmon is an important input factor in the production of smoked salmon. The raw material cost of unprocessed salmon amounts to about 50% of the total production cost in the smoking industry. A 10% reduction in the raw fish salmon price reduces the production costs in the smoking industry by about 5%. During the period 1994-2004, the real production costs of farming salmon were reduced by about 35% (Lorentzen 2006).

Norway exports smoked salmon to a lot of countries, and the industry competes with smoked salmon produced in the importing countries. This situation characterises the European market. There are also signs that some export markets are increasing their demand for smoked Norwegian salmon. USA, Switzerland, Japan, Singapore, Canada, Arabic Emirates are examples of expanding non-EU markets.

Most of the countries which import smoked salmon from Norway operate with a protective import duty. EU charges a 13% ad valorem duty on imported Norwegian salmon. EU imports about 1000 tons of smoked Norwegian salmon, which amounts to about 60-70 million Norwegian kroner per year. Figure 2 shows how the quantity and real price (2005-value) of imported Norwegian salmon by EU have developed during the period 1974-2004.

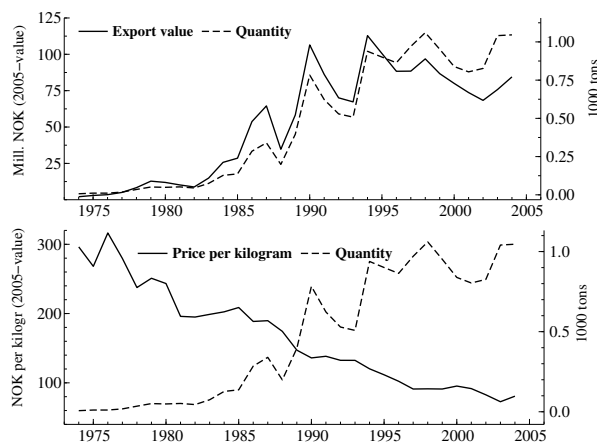


Figure 2: Price and exported quantity of smoked salmon to EU.  
Source: Norwegian Seafood Export Council

Figure 2 shows that the export of smoked salmon from Norway to EU has a smooth positive trend from the start in the 1970s and to the end of the 1980s. During the last part of the 1980s there is actually an increase in the export, but the export oscillates more widely. After 1994-95 it looks like the positive trend has flattened. Figures show that EU's share of the total Norwegian export value of smoked salmon is decreasing. The astonishing part is that EU's import share is flattening even though Sweden, Austria and Finland became new members of the EU in 1995. This indicates that tariff barriers are *not* the only factor that affects the export to EU. If we look at figure 1, it shows that the aggregated export increases during the last part of the 1990s. This is probably an indication that the export naturally expands to other countries rather than to the EU market which seems to be stagnating. The decline in the export share to EU can probably be explained partly by the fact that exporters meet higher trade barriers because new member countries in the EU have to apply EU's external customs duty system, and partly by growth in non-EU countries having stimulated the general purchasing power.

Note the significant reduction in the real export price of smoked salmon. During the period 1974-2004 the real price was reduced by about 70%. The average reduction is estimated to about -4.8% per year during the period covered in figure 2. As mentioned, the real production costs of farming Atlantic salmon in Norway were reduced by about 35% during the period 1994-2004. Appendix C shows that there exists a statistical significant relationship between the export price and the costs of producing farmed salmon. The estimation shows that a 1% reduction in the farming costs, reduces the

export price of smoked salmon by about 0.5%.

Farmed salmon is an important input factor for the smoking industry. Farmed salmon is an international traded commodity and it is to expect that producers world wide are confronted with the identical prices, adjusted for trading costs. Appendix B estimates the statistical relationship between the real export price level of smoked Norwegian salmon and the export price level of farmed Atlantic salmon in Norway. The estimation shows that the 1% increase (decrease) in the export price level of farmed salmon increases (decreases) the export price of smoked salmon by about 0.8%.

Norwegian salmon farming industry is involved in a lengthy trade dispute with the European Union (EU) which started in 1989/90. The Norwegian industry is accused of dumping of farmed salmon in the EU market and of receiving subsidies. EU imputed minimum prices on all sorts of imported products of salmon from Norway. The stagnation or flattening out of the trend in the beginning of the 1990s may therefore have been influenced by the trade measures.

## 2.1 Falling gross margin in the smoking industry

The real gross margin (2005-value) in the smoking industry can be approximated as the difference between the real export price of Norwegian smoked salmon  $p_S$  and the real export price of Norwegian farmed salmon  $p_F$ . The margin can be expressed as  $(p_S - p_F)$ . The operationalization of the variables is based on total export, so at the moment we will leave Sweden out for now. The gross margin is a residual value which can be shared between production factors labour and capital, respectively. Figure 3 shows how the gross margin has evolved during the period 1988-2004.

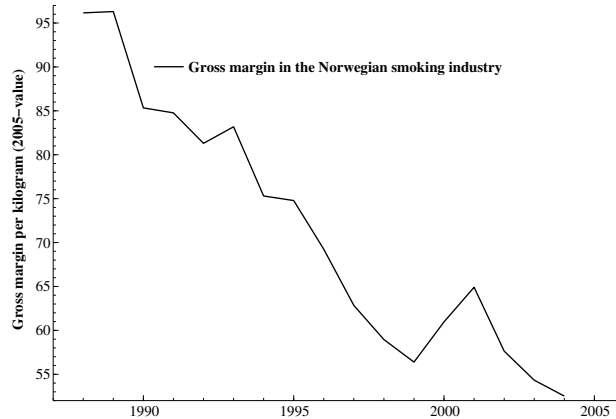


Figure 3: Gross margin per kilogram for the Norwegian smoking industry during 1988-2004

Figure 3 shows that the overall trend of the gross margin is negative. The margin is reduced from about 80 Norwegian kroner per kilogram in the 1990s to about 50 Norwegian kroner in 2004. The reduced margin signals that the profitability in the industry has declined, and affects the actors' incentive to invest and expand the industry.

## 2.2 Export to Sweden and the EU-effect

When Sweden, Finland and Austria became new members of the EU, the trade conditions for the export of Norwegian salmon also changed overnight. During the 1990s smoked Norwegian salmon was imported to Sweden without any restrictions. After Sweden became a member of the EU, import of Norwegian salmon was imposed a 13% customs duty. It is assumed that higher trade barriers will have a negative impact on the Norwegian export to Sweden.<sup>1</sup> The following section looks closer at the export of smoked salmon to Sweden, and analyzes whether the membership in 1995 has had any influence on the Swedish import of Norwegian salmon. The data and selection of models are described below.

Smoked salmon is a processed product and it is possible that consumers regard it as a differentiated, branded product. We expect that a general increase in the consumers' income level will increase the demand for the commodity, given that the commodity is a normal or luxurious good. Figure

<sup>1</sup>See Lorentzen 2007 for a description of the welfare economic effects induced by trade barriers (SNF Working paper 3/07).

4 shows how the export of Norwegian smoked salmon to Sweden has evolved during 1988-2004.

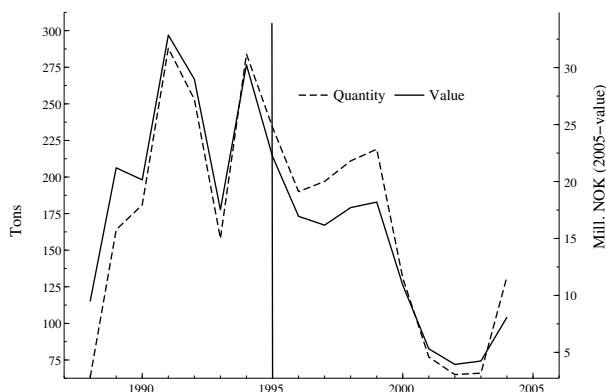


Figure 4: Export of smoked salmon to Sweden 1988-2004.  
Source: Norwegian Seafood Export Council

Figure 4 shows that the export to Sweden has been reduced after 1994-1995, after a slightly rise in the first part of the 1990s. The vertical line illustrates when Sweden became a member of the EU. According to the hypothesis we expect that the Swedish membership in the EU contributes to heavier trade barriers and makes running the business more difficult for the Norwegian exporters of smoked salmon. Figure 4 also shows that the export to Sweden stagnated before 1995 and the export is also volatile. Is there any structural change in the export pattern *before* and *after* the membership? The average yearly exported quantity was about 200 tons for the period 1988-1994. The average exported quantity was about 150 tons per year during 1995-2004. A statistical test shows that the average yearly exported quantity the years before the membership was not significantly higher compared to the exported quantity after the membership:<sup>2</sup>  $t_{n_1+n_2-2} = 1.297$  ( $p = 0.107$ ), given 5% significance level and critical value  $t^C = 1.753$ . Visual inspection of figure 4 shows that the export seems to run into a recession immediately after Sweden became a member of the EU, and the rough test shows that the null hypothesis of equal averages is close to being rejected.

<sup>2</sup>We tested whether the average ( $\mu_1$ ) for the period 1988-1994 was significantly higher than the average ( $\mu_2$ ) for 1995-2004. Fisher's test for identical variance ( $s_1^2 = s_2^2$ ) between the samples ( $n_1$  and  $n_2$ ) is not rejected, so the following test operator is applied  $t_{n_1+n_2-2} = \frac{\mu_1 - \mu_2}{s\sqrt{1/n_1 + 1/n_2}}$  where the sample variance  $s^2 = [(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2]$ .



We should also be sceptical with regard to the alternative explanation that the smoking industry located in other countries (among others producers in EU) are expanding and that they are competitive and could ousting some of the Norwegian suppliers out of the Swedish market. French and Danish producers are modern and efficient and they are considered as big and competitive but they are probably not doing economically well in the Swedish market because the traded volume is low.

Statistics show that the market for smoked salmon has a short history. It is a relatively young market with low traded volume and has probably not penetrated the foodstuff markets. The markets for smoked salmon are therefore not stable – in other words, no stable structures are established. If we look at the Swedish market, we recognize that trading in smoked salmon started to evolve in the late 1970s. The expansion of trading in smoked salmon is parallel to the expansion of the farming of Atlantic salmon. The farming of Atlantic salmon made it possible to produce smoked salmon at a relatively low price. The time series for the Swedish smoked salmon market does not show any signs of stability. The Norwegian export to Sweden is dominated by first expanding and thereafter running into a recession.

### 2.2.1 Market share

Figure 5 shows the market share for the largest suppliers to the Swedish market. Herfindal's index is also included. The assessments are based on quantities.

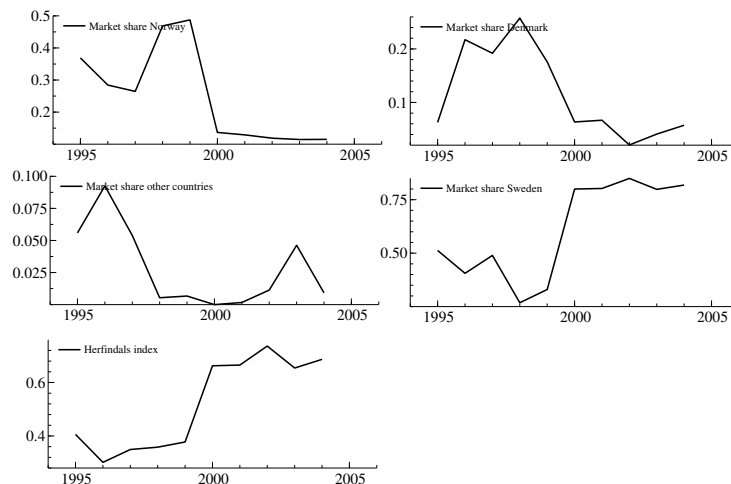


Figure 5: Development of the market share for Norway, Denmark and Sweden and the market concentration. Source: Eurostat

Figure 5 shows that Norwegian suppliers have lost their market share over time. Notice that the market share dropped during 1995-1977 for then to increase during 1998-1999, and finally drop significantly after 1999. It looks like smoked Norwegian salmon is thrown out of the market. The Danish suppliers increased their market share during 1995-1998 and thereafter lost their position. “Other” suppliers cover Finland and for occasional years France. They are marginal suppliers. The “winners” are the Swedish producers (or producers located in Sweden). Theirs market share has increased from about 10-20% in the late 1990s to about 75% in 2000 and successive years. Hirschman-Herfindal’s index measures the market concentration and the concentration has increased significantly.<sup>3</sup> On a national level the market concentration has increased but the index does not say anything about the concentration between individual firms.

### 3 Econometric modelling

What do the presented market data actually measure? The data measure a series of market clearing points, but at this stage of the analysis it is difficult to say anything substantial as to whether the data reflect the demand or the supply curve or a combination of the two curves. How can we identify what we are actually estimating? Previously it was mentioned that the almost continuous reduction in material costs in the smoking industry can actually induce (continuous) shifts in the supply curve which in the next turn contribute to an identification of the demand curve.

The identification problem in econometrics is normally solved by estimating a system of simultaneous equations. The simultaneous-equation market model can take a structural or reduced form. The equations in the structural form are each a statement of basic, primary behavioral or economic relationship. With respect to gaining a sensible economic interpretation it is therefore of interest and importance to quantify (estimate) the parameters in the structural equations. The problem is typically that each structural equation contains more than one endogenous variable. Application of ordinary least squares (OLS) to estimate each structural equation, results in inconsistent and bias coefficient estimates – due to correlation between at least one of the independent variables and the residual term. By applying economic

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<sup>3</sup>Hirschman-Herfindahl’s index can be expressed as  $H = \sum_{i=1}^n (x_i/x)^2$ , where  $x_i$  country  $i$ ’s share of the total market  $x$ .  $H = 1$  indicates monopoly and  $H = 0$  indicates perfect competition. Intermediate values  $0 < H < 1$  indicates oligopoly.

theory, it is possible to formulate a demand and supply system and, utilizing the rank or order condition, to evaluate which equation (and parameters) can be identified and estimated.

The smoking salmon industry is a small part of the big foodstuff industry, and the production decisions and price formation are a result of a large number of determinants. In this case it is difficult to formulate a complete simultaneous equation system because of lack of relevant data and, not least, the system could be loosely specified because of the difficulties in obtaining the overview of how variables are interconnected. The remaining part of the analysis is based on estimating a single equation. The analysis focuses on the demand for Norwegian smoked salmon in Sweden.

The single equation dynamics is essentially based on the assumption of weak exogeneity. Exogeneity is closely related to the concept of causality (Granger 1969). According to economic theory it is expected that the demand (Marshallian, or uncompensated, demand curve) for a good is dependent on respectively, price, income, price on substitutes and a set of other factors which influences consumers' preferences and tastes. The relationship follows from maximizing the consumer's utility  $u(\mathbf{x})$ , given the consumers' budget constraint, income  $y$  and price vector  $\mathbf{p}$ , respectively. The Marshallian demand function is derived by solving the following maximization problem

$$\underset{\{x, \mu\}}{\text{Maximize}} \quad L = u(\mathbf{x}) + \mu(y - \mathbf{p}^T \mathbf{x})$$

The Marshallian demand function for commodity  $x_i$  can in general terms be expressed as follows:  $x_i = f(p_i, p_{-i}, y)$ , where  $p_i$ : price of the commodity  $i$ ,  $p_{-i}$ : price of substitutes and  $y$ : income. If the demand is a function of the commodity's own price, price on substitutes and income, then we implicitly assume that price, trade barriers and income are exogenously given, i.e. the variable Granger-cause consumption.<sup>4</sup> In general we believe that an increase in the trade barriers for import of Norwegian salmon will have a negative effect on the demand, because an increase in trade barriers will increase the trading costs and probably make the product more expensive for the consumers. Further it is assumed that the supply of smoked salmon will be negatively affected because the exporters will realize a lower price. It is assumed that the effect of a heavy trade barrier depends on the elasticity of import demand for Norwegian salmon. The demand elasticity for smoked

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<sup>4</sup>We tested whether price of smoked salmon Granger-cause quantity export of salmon or quantity Granger-cause price. Non of the tests showed significant results. It is *not* possible to draw any further conclusions about the direction of the effects, except from keeping in mind that there exists *no* significant relationship between price and quantity and *vica versa*.

Norwegian salmon is infinite if the consumers have no restrictions in buying perfect substitutes, and that the substitutes can be supplied without any capacity limits. If there exist extremely price sensitive consumers, Norwegian suppliers can not shift the import duty to the consumer price, and exporters have to reduce the price as much as the import duty.

The preceding paragraph shows that the average price of smoked salmon has been reduced over time. The main cause behind the reduction in price, is the continuous increase in productivity in the farming of salmon. The reduction in the production costs in fish farming has also reduced the material costs for the fish processing industry. Changes in the marginal costs shift the supply curve for smoked salmon, and the shifts give the possibility to identify the demand (function) for smoked salmon. Implicitly we assume that the demand function is relatively more stable over time compared to the supply function.

We have estimated a simple demand function for smoked salmon in Sweden. The objective is to test whether the membership has had any influence on the export to Sweden. The fact that we apply a partial model, means that the interaction effects from other suppliers will not be explicitly modelled.

The estimated demand function has the following variables (source: Norwegian Seafood Export Council):  $q_t$ : exported quantity of smoked salmon to Sweden (tons) in year  $t$ : 1988, 1989,..., 2004.  $p_t$ : average price per kilogram (measured in Swedish kroner SEK and free on board FOB) of smoked salmon exported to Sweden in year  $t$ . The price is converted by using the average yearly exchange rate between Norwegian and Swedish kroner (source: Norges Bank).  $x_{1t}$ : gross national product per capita in Sweden (measured in 1000 SEK and 2005-value) in year  $t$  (source: Statistics Sweden),  $x_{2t}$ : dummy variable (shift variable), which has the value 0 for  $t < 1994$ , 1 beyond 1994.  $e_t$ : standard normal distributed residual with zero expectation and constant variance. The statistical properties (mean, standard deviation, variance, minimum, maximum, and coefficient of variation) are presented in table 1.

Table 1: Descriptive statistics price, quantity and income 1988-2004

Name	N	Mean	St. Dev	Variance	Minimum	Maximum	Coefficient of Variation
UNIT PRICE	17	98.131	20.386	415.60	66.820	141.38	0.2077
QUANTITY	17	171.35	74.284	5518.1	63.000	288.00	0.4335
GNP PER CAPITA	17	224.69	21.835	476.75	197.95	264.04	0.0972

Table 1 shows that the mean price is 98 Swedish kroner per kilogram (2005-value). Average exported quantity is 171 tons per year and the average income per capita in Sweden is about 225 thousand Swedish kroner per year. The coefficient of variation shows that the quantity variable has the highest

volatility of the variables. Figure 6 shows how the variables develop during the period 1988-2004. It should also be mentioned that the validity of the descriptive statistics is reduced if the variables are non stationary.

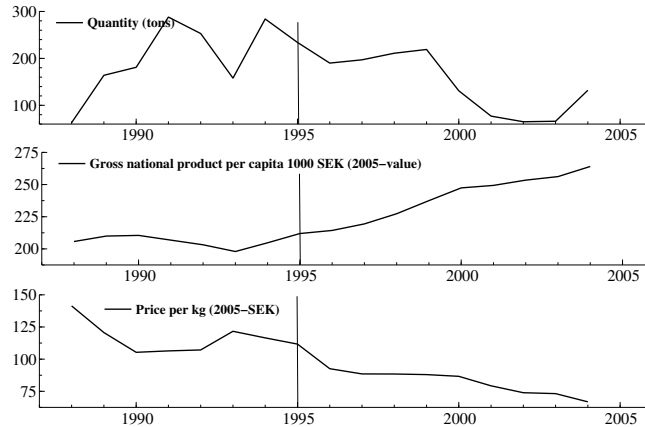


Figure 6: Exported quantity, real income per capita and price for the period 1988-2004. Source: Norwegian Seafood Export Council and Statistics Sweden

### 3.1 Model estimation

Based on a set of tests (see appendix), we conclude that price, income and quantity are non-stationary time series. The tests indicate that the variables probably are integrated processes of order one and that they are difference-stationary (DS) data generating processes. It also remains open whether the income variable are integrated of order two.

### 3.2 Are the variables cointegrated?

We also tested whether a linear combination of the non-stationary variables is cointegrated, i.e. whether there exists a stationary long run relationship between the variables in question. Engle and Granger methodology is applied (Engle and Granger 1987). The residual  $e_t$  in the regression model  $q_t = \alpha + \beta_1 p_t + \beta_2 x_{1t} + \beta_3 x_{2t} + e_t$  (see below for definition of variables) is analyzed by applying ADF and Phillips-Perron test. The tests are carried out with and without a dummy variable which is applied for absorbing the EU effect. The result shows that the variables are *not* cointegrated. The error term is not stationary. The result of the general autoregressive distributed lag

model (ADL) gave a relatively good fit to data, but the sign of the estimated coefficients in the static long-run solution are *not* consistent with economic theory given that we are estimating a demand function. We can probably conclude that the data do not contain sufficient information to estimate the long-run relationship between the variables, and maybe there does not exist any long-run, cointegrated relationship between the variables either. In a previous section we argued that it is not clear, from an identification point of view, which relation we are estimating – the demand or the supply schedule. The variables are not cointegrated so the best we can do is to formulate and estimate a short-run model with limited information. We therefore work through a “traditional” causal analysis. The variables are made stationary by differencing and the possibility for spurious regression is reduced. Stationary variables are required if we apply ordinary statistical tests. All variables are differenced (except the dummy variable), i.e.  $\Delta z_t = z_t - z_{t-1}$ , given  $z_t \subset q_t, p_t, x_{1t}$ . The problem by differencing is that we rip off some basic information. The fact that the variables are logarithmically transformed, means that they measure roughly the percentage change per year.

### 3.2.1 Model I

The following model is estimated:

$$\Delta q_t = \alpha + \beta_1 \Delta p_t + \beta_2 \Delta x_{1t} + \beta_3 x_{2t} + e_t$$

- $\alpha$  : constant term
- $\Delta q_t$  : change in exported quantity to Sweden year  $t$
- $\Delta p_t$  : change in average export price of smoked salmon to Sweden year  $t$
- $\Delta x_{1t}$  : change in gross national product per capita in Sweden year  $t$
- $x_{2t}$  : dummy variable  $x_{2t} = 0$  given  $t \leq 1994$  and  $x_{2t} = 1$  given  $t > 1994$
- $e_t$  : stochastic residual year  $t$

Unfortunately the model does not include prices or a price index for close substitutes. The number of observations is 16. It should be mentioned that a small sample size does not allow for a general model specification. The result of the estimation is presented in table 2.

Table 2: Coefficient estimates

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	p-Value (12 DF)	Partial Correlation	Standardised Coefficient	Elasticity at Means
CHANGE IN PRICE	-1.6354	1.259	-1.299	0.218	-0.351	-0.2868	-1.6354
CHANGE IN INCOME PER CAPITA	10.744	5.502	1.953	0.075	0.491	0.5355	10.7438
DUMMY	-0.64782	0.2310	-2.805	0.016	-0.629	-0.7453	-0.6478
CONSTANT	0.20698	0.1511	1.369	0.196	0.368	0.0000	0.2070

The model explains 33% of the variation in the dependent variable ( $\bar{R}^2 = 0.33$ ). Table 2 shows that the dummy variable for membership in the EU is significantly different for zero, given 2.5% significance level and one-sided test. Even though the model has some explanatory power, the F-test of the hypothesis  $H_0: R^2 = 0$ , gives the p-value 0.084. Note also that (standard deviation of the error term)  $\sigma_e = 0.355$ , which is very high and indicates clearly that the regression is not “good”. The variable which covers the change in gross national product per capita is significant, given 5% significance level and one-sided test. The change in price level is not significant. However the sign of the coefficient is consistent with economic theory, which also applies to the other variables. A series of tests are applied for checking the statistical properties of the complete model. Hansen-stability test (10% significance level) shows that all coefficients are stable.

Note that *before* the dummy variable is included in the model, we tested for structural change: A sequential Chow-test indicates *no* general structural change in the parameters of the model. The unrestricted form of the model consists of two models, respectively one for the period before the EU-membership (1989-1994) and one for the period after the membership (1995-2004). The unrestricted model assumes that the intercepts and slopes are different. On the other hand, the restricted form of the model (the null hypothesis) assumes that the coefficients are identical before and after the membership.<sup>5</sup> The result from the test shows no significant difference between the samples. The result does not support the hypothesis that the Swedish membership in EU has any influence on the trade pattern. On the other hand, figure 4 which shows the export of smoked Norwegian salmon to Sweden indicates a change in the time series at the referendum-point. Sweden joins the EU, and a new trade regime is established for Norwegian

<sup>5</sup>We test the hypothesis:  $H_0: \mathbf{R}\boldsymbol{\beta} = \mathbf{r}$ . The following test-operator is applied:  $F_{q,n-k} \sim \frac{(\mathbf{R}\boldsymbol{\beta} - \mathbf{r})^T [\mathbf{R}(\mathbf{x}^T \mathbf{x})^{-1} \mathbf{R}^T]^{-1} (\mathbf{r} - \mathbf{R}\boldsymbol{\beta}) / q}{\mathbf{e}^T \mathbf{e} / (n-k)}$ . The calculations gave the following result:  $F_{3,10} = 2.2617$ . The critical  $F$ -value is 3.71 (given 5% significance level) and  $p = 0.144$ . The null hypothesis is not rejected.

and Swedish actors. They probably experience new conditions, new prices and/or changes in quantity because of an import duty on smoked salmon.

The Goldfeld-Quandt test (including the dummy variable) shows no sign of changes in the variance of the residuals. The same conclusion can be drawn by using the Harvey-Phillips test for heteroscedasticity. Durbin-Watson (DW) = 1.49 and it is in the indeterminate interval. The DW positive autocorrelation test gives a p-value equal 0.065 and it is close to rejecting the null hypothesis of no first order autocorrelation. Jarque-Bera's normality test of the distribution of the residual is not rejected. Ljung-Box test shows no indication of joint autocorrelation. Finally, there is no correlation between the residual and the independent variables.

We can conclude that we maintain the hypothesis that Sweden's membership in the EU, and the new trade regime, has a possible statistically identifiable negative influence on the import of smoked Norwegian salmon to Sweden but the statistical evidence is weak. The percentage change in the intercept (with and without the dummy), assesses the effect the membership has on the export. Calculation shows that the membership reduced the export by about 47%.<sup>6</sup> Further, the demand for salmon responds to a change in the price. The demand elasticity is estimated to  $-1.64$ , but notice that the standard deviation is extremely large  $\pm 1.25$ . The value of the elasticity indicates that a 1% increase in the price reduces the quantity demanded by 1.64%. The estimated coefficient for the income variable indicates that smoked salmon is a luxury good. A change in income seems to have a large impact on the demand for smoked salmon. If the real income increases by 1%, the demand increases on average by about 10%. Notice that the standard deviation for each of the estimated coefficients is high. The result should therefore be interpreted with care. Note that the real income per capita in Sweden has mainly increased during the period we are here considering, except for the period 1991-1993 where the change was *negative* (see Lorentzen 2007 for a description of the Swedish seafood market).

### 3.2.2 Model II

We also estimated a model with the same variables but without a constant term. In a first order difference equation a constant term represents a linear trend, i.e. the constant (in model I) measures an "autonomous" growth rate per year of about 20% *before* 1995 and -44% per year *after* 1995. The estimation gave the following result:

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<sup>6</sup>The shift in export is calculated as follows: no shift  $e^{0.21} = 1.23$  and shift  $e^{(0.21-0.65)} = 0.64$ . Percentage change:  $\frac{(0.64-1.23)}{1.23} 100 \approx 47\%$ .



Table 3: Coefficient estimates

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	p-Value (13 DF)	Partial Correlation	Standardised Coefficient	Elasticity at Means
CHANGE IN PRICE	-2.1109	1.251	-1.688	0.115	-0.424	-0.3701	-2.1109
CHANGE IN INCOME PER CAPITA	10.019	5.657	1.771	0.100	0.441	0.4994	10.0188
DUMMY	-0.44884	0.1855	-2.420	0.031	-0.557	-0.5164	-0.4488

The raw moment multiple correlation coefficient,  $R_M^2 = 1 - \frac{e^T e}{Y^T Y}$ , is equal to 0.39. Notice that  $Y$  is not the deviation from the sample mean. The estimated price elasticity is  $-2.11$ . The income elasticity is not changed while the coefficient (shift variable) is lower compared to the first model. The same selection of tests is also applied on this model. DW test for no first order positive autocorrelation shows that the null hypothesis is close to being rejected ( $p = 0.091$ ). The Chow test indicates no structural break in 1994, but the null hypothesis is close to being rejected  $F_{2,12} = 2.651$  and  $p = 0.111$ . Goldfeld-Quant test (including the dummy variable) indicates a change in variance between the sub-samples 1989-1994 and 1995-2004 ( $p = 0.055$ ). Ljung-Box joint test shows no indication of joint autocorrelation. Finally, there is no correlation between the residual and the independent variables. However the standard deviation is still large which implies uncertain estimates.

### 3.2.3 Modell III

The ADF tests presented in appendix indicate that the income variable is integrated of order two, i.e.  $x_t \sim I(2)$ . The twice differenced income variable is integrated in the model. The result of the regression is presented in table 4.

Table 4: Coefficient estimates

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	p-Value 12 DF	Partial Correlat.	Standardised Coefficient	Elasticity at Means
Income differenced twice	10.213	3.644	2.802	0.016	0.629	0.6055	-0.4673
Change in price	-1.7647	1.173	-1.505	0.158	-0.398	-0.3435	-4.8053
DUMMY	-0.1713	0.1148	-1.492	0.162	-0.396	-0.2240	7.8902

The raw moment multiple correlation coefficient,  $R_M^2 = 1 - \frac{e^T e}{Y^T Y}$ , is equal to 0.45 and the model is better than model II. It is only the coefficient for the transformed income variable which is significantly different from zero, given 5% significance level. The signs of the coefficients are consistent with

economic theory. Test of the hypothesis of normally distributed residuals is close to being rejected: Runs test shows -1.8667 and the chi-square distributed goodness of fit test for normality of residuals is measured to  $\chi^2_{(1)} = 3.36$  ( $p = 0.067$ ). DW-test, LM-test and Ljung-Box-Pierce indicates no significant first order or joint autocorrelated residuals. The Hansen's instability test indicates that the coefficient for the transformed income is instable, given 10% significance level.

As far as we know no econometric analysis of the demand for smoked salmon has been carried out. It is therefore difficult to compare the results with related analyses. The closest we come to a comparison, is to look at results drawn by statistical analysis of the demand for unprocessed, round Atlantic salmon. In the 1980s and in the beginning of the 1990s it was popular to analyze the demand for round Atlantic salmon. The huge number of analyses show that the ownprice elasticity for salmon is between  $-4$  and  $-1$ . A summary of the studies is presented in Bjørndal et al. 1992a and 1992b and in Asche, Bjørndal og Gordon 2005. Based on 13 demand studies, the average demand elasticity for round Atlantic salmon is calculated to  $-2.16$ . The results presented here show that the demand for salmon responds negatively to an increase in price: A one percent increase in the price reduces, on average, the demand for smoked salmon by between  $-2.1$  and  $-1.6$  percent. The statistical analyses also show that the demand for smoked salmon is sensitive to a change in real income level: a one percentage increase in income increases the demand by about 10 percent. The deterministic shift variable, i.e. the dummy variable for Sweden's membership, shows that there is a significant shift in the export before and after 1995. But as already mentioned, the effect could be spurious and the estimated coefficients are statistically weak. See also a broader descriptive analysis of the Swedish fish market by Lorentzen 2007.

Figure 7 shows the observed export quantity and the estimated volumes in levels based on the estimated models for the period 1988 til 2004.<sup>7</sup>

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<sup>7</sup>An example of how model III (no constant and twiced differenced income variable) predicts exported volume in levels  $\hat{Q}_t = e^{[q_{t-1} - 1.765(p_t - p_{t-1}) + 10.213(x_{1t} - 2x_{1t-1} + x_{1t-2}) - 0.171x_{2t}]}$

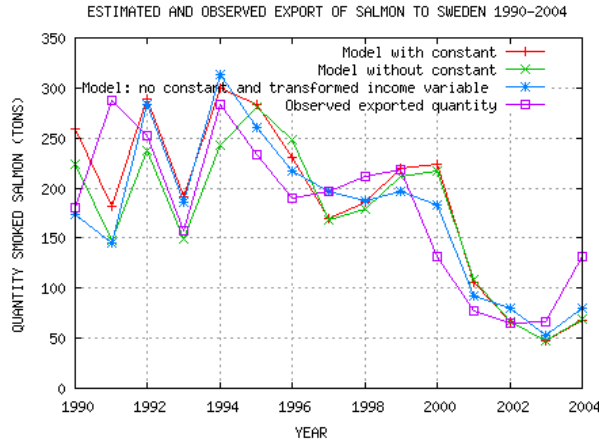


Figure 7: Observed and estimated quantity exported smoked salmon to Sweden 1988-2004

Figure 5 shows that the model predicts relatively well the actual development of the Swedish demand for Norwegian smoked salmon even though the statistical tests are weak. Notice that the models are not capable of explaining the exported quantity in 1991. By integrating a dummy variable for 1991, it is possible to absorb the effect from this observation which seems to be an outlier.

### 3.3 Intervention model

A simple *intervention* model is estimated in order to analyze the extent of the change in the export volume to Sweden before and after Sweden joined the EU. The following linear model was estimated:

$$y_t = \alpha + \beta_1 y_{t-1} + \beta_2 D_t + e_t, \quad |\beta_1| < 1$$

- $\alpha$  : constant term
- $y_t$  : natural log of the export volume (ton) to Sweden year  $t$
- $y_{t-1}$  : export volume to Sweden year  $t - 1$
- $D_t$  : dummy variable  $D_t = 0$  for  $t \leq 1994$  and  $D_t = 1$  for  $t > 1994$
- $e_t$  : stochastic residual year  $t$

The motivation for applying the intervention model is the possibility to do a formal test of changes in the mean of the exported quantity. It follows from the model formulation that the intercept term jumps to  $\alpha + \beta_2$  for  $t > 1994$ . The consequence of the Swedish membership for the Norwegian export of smoked salmon is measured by the magnitude of  $\beta_2$  – the so called

“*impact effect*” of the EU membership. It follows from the model that  $\{D_t\}$  follows a deterministic time path. Notice that the formulation of the model presupposes that the dependent variable (quantity) is a stationary series. Previously we have shown that it is difficult to conclude clearly what kind of data generating process is behind the quantity series. In the following we treat the series as a stationary series, even though an “assumption” does not solve the problem analogously to the ostrich which puts its head deep in the sand to get rid of the problem. The result from the estimation is presented in table 5.

Table 5: Coefficient estimates

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	p-Value 13 DF	Partial Correlation	Standardised Coefficient	Elasticity at Means
LAG LOG QUANTITY	0.5368	0.1655	3.243	0.006	0.669	0.5961	0.5368
DUMMY	-0.3836	0.1775	-2.161	0.050	-0.514	-0.3972	-0.3836
CONSTANT	2.6211	0.8583	3.054	0.009	0.646	0.0000	2.6211

$\bar{R}^2 \approx 0.50$ ,  $F = 8.5$  and the null hypothesis  $\bar{R}^2 = 0$  can be rejected. The standard error of estimate  $\sigma_e = 0.34$  which is high. The Durbin-Watson  $h$  statistic is applied as a test for first order autocorrelation when the model includes a lagged dependent variable.<sup>8</sup> The asymptotic normal distributed  $h$  is calculated to  $h = 1.112$  and it is not possible to reject the null hypothesis of *no* first order autocorrelation. The ordinary Durbin-Watson is  $DW = 1.48$ . The model explains about 50% of the variation of the export volume. The  $F$ -value indicates that the model has explanatory power. The sequential Chow test indicates a general structural shift (this test is worked out *without* including the dummy variable) in 1995. The  $F_{2,12} = 4.145$  and  $p = 0.043$ , and according to a mid-sample-split there is a structural shift in 1997. All coefficients are significantly different from zero. Related to demand theory, the model excludes important explanatory variables. The Ljung-Box statistics show no joint autocorrelation;  $\chi^2_{(2)} = 0.88$ ,  $\chi^2_{(4)} = 4.67$  and  $\chi^2_{(6)} = 5.79$ . Jarque-Bera test for normal distributed residuals is not rejected. Harvey’s and Glejser’s chi-square tests, respectively  $\chi^2_{(2)} = 0.507$  and  $\chi^2_{(2)} = 0.805$ , indicate no heteroscedasticity.

The ADF-tests presented in appendix indicate that the exported quantity has a unit root. If the series is non-stationary, it is necessary to transform the variables before applying them in the analysis. If quantity has a unit root, it follows that the jump-function  $\beta_2 D_t$  will act as a drift term. A

<sup>8</sup>The test operator is defined as:  $h = \hat{\rho} \left( \frac{N}{1 - N \text{Var}(\hat{\beta}_1)} \right)^{\frac{1}{2}}$ , where  $N$ : number of observations,  $\text{Var}(\hat{\beta}_1)$ : variance of the coefficient of the lagged dependent variable and  $\hat{\rho}$  is the estimated (OLS) coefficient between  $e_t$  and  $e_{t-1}$ .

regression based on  $\Delta q_t$  as the transformed variable on the other hand gives no significant results, except for the membership effect.

The long run exported volume can be extrapolated. The long run export volume can be expressed as  $e^{\frac{\alpha}{1-\beta_1}}$ , given that Sweden is not a member of the EU. By substitution the long run average export volume of smoked Norwegian salmon is calculated to  $\bar{y}_0 \approx 287$  tons per year. On the other hand, the long run average export volume to Sweden is as follows, given Swedish membership;  $\bar{y}_0 = e^{\frac{\alpha+\beta_2}{1-\beta_1}} \approx 125$  tons per year. The difference in the long run average exported quantity is  $\Delta = e^{\frac{\alpha}{1-\beta_1}} - e^{\frac{\alpha+\beta_2}{1-\beta_1}} \approx 161$  tons per year. The estimated model is illustrated in figure 8, and it clearly shows that the standard error of estimate is high, and it is not a “good” model.

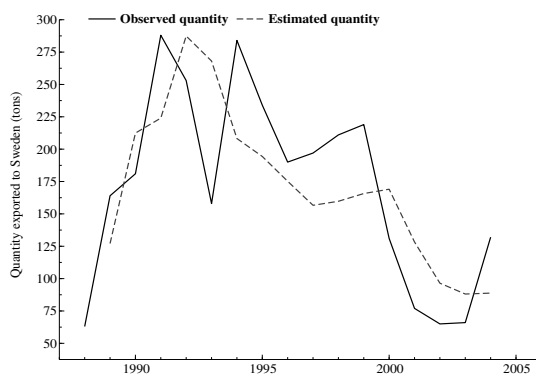


Figure 8: Estimated and observed export of smoked salmon to Sweden

According to the intervention model, the Swedish membership in EU has a negative long-run dynamic effect on the export of smoked salmon produced in Norway. The “EU-effect” has, according to the model, reduced the long run export by about 160 tons per year. Calculation based on the sample period 1988-2004 shows that the average export price is about 95 Norwegian 2005-kroner per kilogram. The “lost” quantity due to the trade barrier represents a gross value of about  $161\,000 \times 95 \approx 16$  million Norwegian kroner per year.

We cannot conclude that a membership is the only factor that explains the significant reduction in the long run average export volume. The estimated models indicate that the Swedish membership in the EU has a weak effect on the import of smoked salmon from Norway. A closer, more firm oriented and detailed analysis of the export of smoked salmon to Sweden, or to the EU

in general, could probably detect the most important factors which influence the development of the export of smoked salmon from Norway.

The intervention model can also be extended to a general ARMA( $p, q$ ) model by including higher order autoregressive terms in the intervention function, i.e.  $y_t = A(L)y_t + \beta_2 z_t + B(L)e_t$ . The intervention function can be modified as a; pulse, gradually changing or prolonged pulse function. The residuals can also be modelled as moving average process of order  $q$ . The linear intervention model assumes that the coefficients are invariant to the intervention. A procedure to check whether the coefficients have changed is to estimate the most appropriate ARIMA( $p, d, q$ ) model for the pre- and post-intervention periods. The procedure will require a relatively big number of observations (more than 50). Detection of different coefficients for the two models is an indication that the AR and MA coefficients have changed due to the intervention. In this case we do not have enough observations to work through the suggested procedure.

## 4 Concluding remarks

Sweden became a member of the European Union (EU) in 1995, after a referendum in 1994. The membership changed overnight the trade condition for smoked salmon between Norway and Sweden. The condition changed from free trade to a regulated system with an import duty of 13%. The objective of the paper is to estimate whether the Swedish membership changed the actual trade pattern for smoked salmon between Norway and Sweden.

Three or four years before the Swedish membership, the Norwegian producers exported smoked salmon for about 23 million Norwegian kroner per year to Sweden. The export has not been stable over the period we are looking at. The export to Sweden has increased significantly from the middle of the 1980s to 1994. A statistical analysis is applied in testing the hypothesis of an “EU effect”. The analysis is based on observations for the period 1988-2004. Two model categories are estimated; the demand functions and an intervention model. In order to test the effect from the EU-membership, both types of models integrate a dummy variable. The statistical results are weak, in the sense that each coefficient estimate has high variance and is unprecise. Both models indicate a weak negative “EU-effect”. The short run *demand models* indicate that the Swedish membership has a negative impact on the Norwegian export of smoked salmon. Coefficients based on model I indicate, with uncertainty, that the export is reduced by about 47%. If we look at numbers, the average is reduced from about 200 tons before the membership in EU (1988-1994) to an average of about 150 tons after the

membership (1995-2004), which represents a reduction of 25%. A statistical *test of means* shows that the average yearly exported quantity after Sweden joined the EU is nearly significantly lower compared to the average level before the membership. The *intervention* model indicates that the Swedish membership has a negative effect on the Norwegian export to Sweden. The Chow test indicates a structural shift in 1995. According to the model, Sweden's EU membership reduces the long-run export by about 160 tons per year. The loss represents a value of about 16 million Norwegian kroner per year.

Due to the lack of data it is difficult to formulate a general long run model for the market for smoked salmon. A single equation approach is selected, but as mentioned it is not obvious whether it is the demand or the supply function which is estimated. The statistical results were barely significant and interpretable, and the weak statistical results indicate misspecification and a problem in identifying a model. The fact that the variables are non-stationary, not cointegrated and that the coefficient estimates lack validity due to high variance, makes it difficult to draw clear conclusions.

Trade statistics indicate that the trading in smoked salmon started after the expansion of the farming of Atlantic salmon. Cheaper raw material made it possible to produce smoked salmon at a relatively low price. By supplying a traditional luxurious product at a low price, a bigger market is reached. The analysis indicates, paradoxically, that it is difficult to find a significant overall relationship between price and quantity. Maybe smoked salmon is a product which must be treated as a heterogeneous and differentiated product, and that price is not the only factor that determines whether consumers buy it or not. The more the product is differentiated, the less sensitive the consumer is to changes in price. It is assumed that the more differentiated the product is, the more important it is to carry out strategic market investments for promotion and branding. After Sweden became a member of the EU, the export of smoked salmon from Norway is reduced. It is assumed that imposing an import duty has had a negative effect. On the other hand, it is even more important to ask whether Norwegian firms have enough resources to implement strategic marketing investments in the Swedish market. In what way can the export organization Norwegian Seafood Export Council contribute as a catalyst with regard to doing different kind of market investments? A more profound microeconomic analysis of the Swedish market will probably give the answer to some of these questions.

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## A Testing of stationarity

The definition of weak stationarity is as follows: A process  $\{x_t\}$  is defined as weak stationary if the following criteria are fulfilled for all points in time  $t$ : (1) Expectation  $E\{x_t\} = \mu < \infty$ , (2) Variance  $V\{x_t\} = E\{(x_t - \mu)^2\} = \gamma_0 < \infty$  and covariance  $Cov\{x_t, x_{t-k}\} = E\{(x_t - \mu)(x_{t-k} - \mu)\} = \gamma_k$  for  $k = 1, 2, 3, \dots$ . The criteria say that the average, variance and covariance should not change over time for given values of  $k$ .

The vertical line in the figures indicates the period where Swedish actors and businessmen form their expectations about the outcome of the referendum. The general impression is that the exported quantity to Sweden has a positive trend during the first seven-eight years (a short run characteristic), i.e. 1988-1994/95, than it flattens and finally it starts to fall. It is not easy to say whether this process has a unit root and is a non-stationary series. The development of the real price and income per capita seems to be non-stationary. Notice that modelling of time series is conditioned on whether the variables are trend-stationary processes (TS) or difference-stationary processes (DS). The treatment of the variables is conditioned on whether they are DS or TS.

An extended Dickey-Fuller (ADF) and Phillips-Perron (PP) nonparametric test<sup>9</sup> are applied for testing each variable for unit root and stationarity, and for diagnosing whether the variables are TS or DS processes. We must also take into consideration that the sample of 17 years (1988-2004) is *not* a long-run series, so the validity of the tests (especially tests for unit root and cointegration) is low. The following general test function is applied:

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=2}^p \beta_i \Delta y_{t-i+1} + \varepsilon_t$$

where  $y_t$  is the time series to be analyzed,  $a_0, \gamma, a_2$  and  $\beta$  are estimated constants,  $t$  is the time (measured in years) variable,  $\Delta y_t = y_t - y_{t-1}$ ,  $p$  number of lagged periods and  $\varepsilon_t$  is the normal distributed residual.

All variables were logarithmically transformed. Visual inspection of the plot of the sample autocorrelation function (SACF) is also applied for checking for stationarity. The applied lag order  $p$  in the ADF-test is the highest significant lag order from either the autocorrelation function (SACF) or the partial autocorrelation function (PACF) of the first differenced series. The analysis is based on the data for the period 1988-2004. The results of the

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<sup>9</sup>The PP-test is called nonparametric test because there is no parametric specification of the error process.

ADF and Phillips-Perron test of the price variable (measured in Swedish 2005-kroner) are presented in table 6.

Table 6: Test statistics for price 1988-2004

VARIABLE	PP TEST*		ADF**	
	Constant	Constant and trend	Constant	Constant and trend
Price	-0.99	-2.44	0.70	-2.31
Critical value	-2.86	-3.41	-2.86	-3.41

\*Truncation lag is 1, and \*\*Lag order  $p$  in the ADF test is 3

The tests are based on 5% significance level. The result of the tests shows that neither Phillips-Perron test nor the ADF test can reject the null hypothesis that the price has a unit root, given 5% significance level. It should also be mentioned that the power of the unit root tests may have been reduced due to the presence of an unnecessary time trend and/or drift term in the test-function. The Phillips-Perron test (Phillips and Perron 1988) is also worked through by applying different truncation lags, and it has no influence on the statistical result. According to the ADF test there is no deterministic trend, i.e.  $H_0 = a_2 = \gamma = 0$ , because  $F = 3.5319$  and critical value is  $\phi_3 = 6.25$ . There is no significant drift either, given 5% significant level:  $H_0 = a_0 = \gamma = 0$ ,  $F = 4.1951$  and  $\phi_1 = 4.59$ . On the other hand there is indication of drift given 10% significance level. Critical values related to the tests can be found in Dickey and Fuller 1981 and MacKinnon 1991.

The Phillips-Perron and ADF tests show that the time series are made stationary by taking the first difference: PP test for the differenced price variable gave the following test statistics: -3.15. The critical value is -2.86, including a constant in the test function. The ADF test result for the differenced price variable is -3.15. The critical value is -2.86, given 5% significance level. We conclude that price of imported smoked salmon from Norway is a non stationary, integrated time series of order one, i.e.  $q_t \sim I(1)$ . Table 7 shows the results from testing the income per capita in Sweden for unit root.

Table 7: Test statistics for income per capita 1988-2004

VARIABLE	PP TEST*		ADF**	
	Constant	Constant and trend	Constant	Constant and trend
Income	0.66	-1.46	0.99	-1.39
Critical value	-2.86	-3.41	-2.86	-3.41

\*Truncation lag is 1, and \*\*Lag order in the ADF test is 0

The results of the tests show that neither the Phillips-Perron test nor the ADF test can reject the hypothesis that income per capita has a unit root, given 5% significance level. Application of different truncation lags did not change the conclusion of a unit root. Application of a more extended test procedure would probably indicate whether the unit root tests have unnecessarily included a time trend and/or a drift term. Test for no deterministic trend gives the following result:  $H_0 = a_2 = \gamma = 0$ , and the result is  $F = 3.5319$  and  $\phi_3 = 6.25$ . There is no significant drift either:  $H_0 = a_0 = \gamma = 0$ ,  $F = 3.0892$  and  $\phi_1 = 4.59$ .

However the Phillips-Perron (PP) and ADF tests show that the time series are *not* transformed to a stationary series by taking the first order difference. The PP test for the differenced income variable gave the following test statistics: -2.08. The critical value is -2.86, given a constant included in the test function. The test result of the ADF test is -2.01. The critical value is -2.86, given 5% significance level. There is no significant deterministic trend and/or drift in the sample series. The result is probably an indication that the income variable has two unit roots. A similar test of the first order differenced income variable indicates another root. PP and ADF test of the second order differenced variable reject the hypothesis of a unit root. We conclude that income per capita is a non-stationary, integrated time series of order one or two, i.e.  $q_t \sim I(1)$  or  $q_t \sim I(2)$ . Table 4 shows the results from testing the exported quantity of smoked Norwegian salmon to Sweden for unit root and non-stationarity.

Table 8: Test statistics for quantity given sample period 1988-2004

VARIABLE	PP TEST*	PP TEST*	ADF**	ADF**
		Constant		Constant
	Constant	and trend	Constant	and trend
Quantity	-2.38	-3.58	-2.29	-3.60
Critical value	-2.86	-3.41	-2.86	-3.41

\*Truncation lag is 1, and \*\*Lag order in the ADF test is 0

Both tests show diverging results. The test of the hypothesis of random walk with drift could not be rejected and there is a possibility of a unit root. On the other hand, a hypothesis of random walk with drift plus deterministic trend rejects the unit root hypothesis. The conclusion is not influenced by changing the truncation lag in the Phillips-Perron test. The deterministic trend is significantly different from zero. If we follow the test procedures, it can be argued that the quantity has no unit root and it is probably a stationary process. If we look closer at figure 4, the path for exported quantity is bell shaped.

There is no overall trend in the data. If we base the unit root tests on tests which only include a constant, then the tests indicate a unit root (table 4), and no drift, i.e.  $H_0 = a_0 = \gamma = 0$ ,  $F = 2.3558$  and  $\phi_1 = 4.59$ .

### A.1 Do the time series have trend or drift?

The quantity shows a positive trend during the period 1988-1995, and a negative path in the period 1996-2004. The development in one upward phase and one recession phase before and after Sweden joined the EU could be an indication of structural change (see Appendix A.2), and structural changes in the time series will increase the probability that hypotheses are falsely rejected or accepted (Perron 1989). Separated unit root testing for each of these periods shows that the hypothesis of unit root cannot be rejected. The results from these tests are diverging. The results are presented in tables 9 and 10.

Table 9: Test statistics for quantity given the sample period 1988-1994

VARIABLE	PP TEST*	PP TEST*	ADF**	ADF**
		Constant		Constant
	Constant	and trend	Constant	and trend
Quantity	-2.34	-1.87	-2.23	-1.90
Critical value	-2.86	-3.41	-2.86	-3.41

\*Truncation lag is 1, and \*\*Lag order in the ADF test is 0

Table 9 shows that the Phillips-Perron tests do not reject the hypothesis of unit root, and it is not possible to detect any deterministic trend and/or drift in the sub-sample. The ADF based tests show the following: Test for no deterministic trend:  $H_0 = a_2 = \gamma = 0$ ,  $F = 1.8008$  and  $\phi_3 = 6.25$  And there is no significant drift either:  $H_0 = a_0 = \gamma = 0$ ,  $F = 2.8146$  and  $\phi_1 = 4.59$ . What conclusion can be drawn about the process after 1995? Table 10 shows the results.

Table 10: Test statistics for quantity given the sample period 1995-2004

VARIABLE	PP TEST*	PP TEST*	ADF**	ADF**
		Constant		Constant
	Constant	and trend	Constant	and trend
Quantity	-1.23	-1.26	-1.12	-0.93
Critical value	-2.86	-3.41	-2.86	-3.41

\*Truncation lag is 1, and \*\*Lag order in the ADF test is 0

The tests show that the hypothesis of a unit root cannot be rejected. We conclude that the process after 1995 probably also has a unit root. It

should be mentioned that the first difference of the variable should give a stationary process if the variable measured in level is an integrated process of order 1. The PP and ADF-tests of the first order differenced variable still indicates a unit root and non-stationarity. It should also be mentioned that the diagnostic part of the analysis has a serious problem because of few observations.

## A.2 Structural change and test of unit root

We will compensate as much as possible for few observations by using the method recommended by Perron 1989 given that the time series has been exposed to an exogenous shift. We apply the following test function

$$y_t = a_0 + \mu_1 D_L + a_2 t + a_1 y_{t-1} + \sum_{i=1}^k \beta_i \Delta y_{t-i} + \varepsilon_t$$

where  $y$ : natural logarithm of quantity,  $a_0$ ,  $a_1$ ,  $a_2$ ,  $\mu_1$  and  $\beta$ s are the estimated coefficients.  $D_L$  is the dummy variable such that  $D_L = 1$  if  $t > 1994$  and zero otherwise. We tested the unit root hypothesis  $H_0: a_1 = 1$ . Perron (1989) shows that the residuals are identical and independently distributed, the distribution of  $a_1$  depends on the proportion of observations occurring *prior* to the break. Denote this proportion by  $\lambda = \frac{\tau}{T}$  where  $T$  = total number of observations. The critical values are identical to the Dickey-Fuller statistics when  $\lambda = 0$  and  $\lambda = 1$ . When  $0 < \lambda < 1$  Perron (ibid) shows that there is a difference between the statistics he recommends and the Dickey-Fuller statistics. The maximum difference between the two statistics occurs when  $\lambda = 0.5$ . For  $\lambda = 0.5$ , the critical value of the  $t^c$ -statistics at the 5 percent significance level is -3.75. In this case the proportion  $\lambda = \frac{8}{17} = 0.47$ . We apply -3.75 as the critical value. The test of the hypothesis  $H_0: a_1 = 1$  gave the student  $t$ -value equal  $t = -3.21$ , given  $k = 0$ . The test indicates that  $t < t^c$ , so we cannot reject the hypothesis that the quantity has a unit root. An ADF and PP-test (included a constant) of the first order differenced quantity time series show that the process is stationary, i.e. the process has no unit root or drift (non significant constant). We conclude that  $q_t \sim I(1)$ , i.e. that quantity is integrated of order one. However, the conclusion is not clear. The analysis can undoubtedly be criticized because of few observations and the power of the unit root tests is therefore low.

## B Price of smoked and farmed salmon 1988-2004

Figure 9 shows how the real export price of smoked salmon and the export price of farmed salmon (fresh, round salmon) have developed during the period 1988-2004.

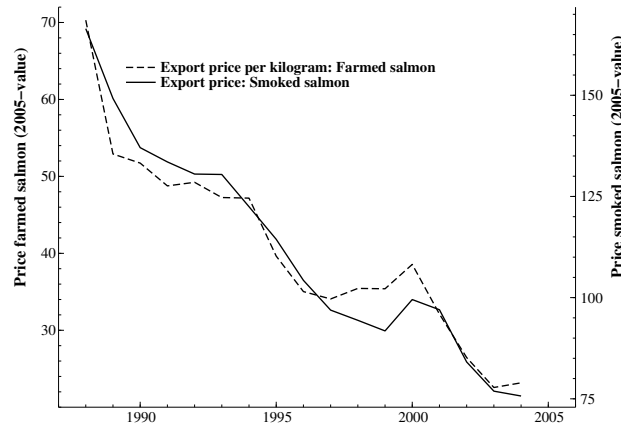


Figure 9: Export price of smoked and farmed Norwegian salmon during the period 1988-2004. Source: Statistics Norway

A visual inspection of the time series shows that the paths are similar and that the covariance is relatively high. The following autoregressive distributed lag model is estimated (Student's  $t$ -values in brackets)

$$y_t = 0.907 + 0.401y_{t-1} + 0.385x_t$$

(5.06)                      (6.79)                      (6.54)

where  $y_t$  is the real export price per kilogram of smoked Norwegian salmon and  $x_t$  is the real unit export price of farmed Atlantic salmon produced in Norway. The variables are logarithmically transformed. The model explains about 98% of the variation in the dependent variable, i.e.  $R^2 = 0.98$ . The estimated standard deviation of the error  $\hat{\sigma} = 0.026$  which indicates a precise model. An approximate 95% confidence interval is about 0.10% of the price of smoked salmon. Durbin-Watson is 1.93 which indicates no first order autocorrelation. ARCH 1-1 test  $F(1,11) = 0.008$  ( $p = 0.93$ ), normality test  $\chi^2_{(2)} = 1.88$  ( $p = 0.39$ ), heteroscedasticity test;  $F(4,8) = 0.664$  ( $p = 0.63$ ). The variables are Engle and Granger cointegrated. The test statistics is -6.752 (critical value is -3.461 given 5% level and 50 observations). The short

run regression model predicts that the export price of smoked salmon is influenced by the previous period price and the present export price level of farmed salmon. The static long-run relationship is as follows

$$y_t = \underset{(9.81)}{1.819} + \underset{(15.4)}{0.772}x_t$$

The long-run relationship shows that a 1% increase in the export price of farmed salmon raises the real export price of smoked Norwegian salmon by about 0.8%.

## C Price of smoked salmon and costs of farming salmon

Figure 10 shows the average export price of smoked Norwegian salmon and costs of farming Atlantic salmon in Norway.

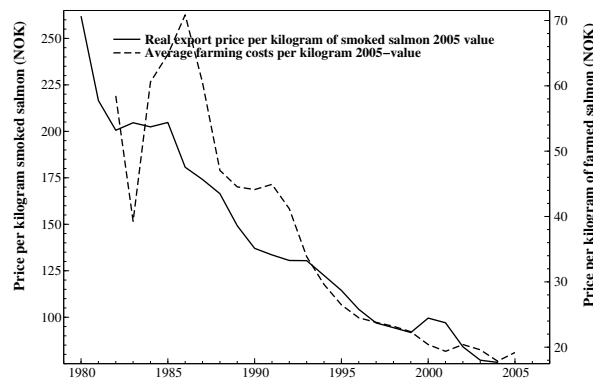


Figure 10: Export price per kilogram of smoked salmon and cost of farming Atlantic salmon in Norway (2005-value). Source: Statistics Norway and Directorate of Fisheries in Norway

Figure 10 shows that the price of exported smoked salmon and the average costs of farming Atlantic salmon share a downward, oscillating trend. The ADF-test indicates that both time series are integrated of order one, i.e. that the series are classified as unit root processes. The following autoregressive distributed lag model estimates the relationship between the export price



of smoked salmon  $y_t$  and the average variable costs  $x_t$ .<sup>10</sup> The figures are measured in 2005-values and the data are transformed logarithmically. The estimation is based on the period 1987-2000 (Student's  $t$ -values in brackets).

$$y_t = \underset{(46.7)}{3.02} - \underset{(-1.70)}{0.18}x_t + \underset{(3.98)}{0.48}x_{t-1} + \underset{(2.93)}{0.20}x_{t-2}$$

$R^2 = 0.98$  and Durbin Watson  $DW = 2.05$ , ARCH 1-1 test  $F(1,8) = 0.20$  ( $p = 0.66$ ), normality test  $\chi^2_{(2)} = 3.29$  ( $p = 0.19$ ), heteroscedasticity test;  $F(6,3) = 1.93$  ( $p = 0.32$ ). Engle and Granger cointegration test rejects the unit root hypothesis, given 5% significance level (estimated  $T = -4.1846$  and the critical value is  $-4.10$ ). The regression shows that there exist a statistical significant connection between the lagged cost level of farming and the price level of exported smoked salmon. However, the estimated function forecast badly the out-of-sample observation, i.e. 2001-2004. The static long-run relationship is as follows (Student's  $t$ -values in brackets)

$$y_t = \underset{(46.7)}{3.02} + \underset{(25.8)}{0.51}x_t$$

The long run relationship indicates that a 1% increase (decrease) in the farming costs increases (decreases) the export price of smoked salmon by about 0.50%. It is difficult to say whether there exists symmetry between increasing - decreasing the cost levels and increasing-decreasing the price level of smoked salmon. It is obviously not not easy for the smoking industry to increase the prices if the competition in the food stuff market is tough and consumers have a lot of substitutes.

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<sup>10</sup>The cost measure includes the following items; smolt, feeding, insurance, wages and salaries, estimated depreciation, net financial expenses and other operational expenses.