Price relationships between domestic wild salmon, aquacultured rainbow trout and norwegian farmed salmon in finland

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In the 90's, the market for salmon and rainbow trout in Finland has changed. The formerly very restricted import of salmon ides has been liberated and is now almost totally free. The seasonal distribution of the catches has changed and the total quantity has dropped. The production of rainbow trout, that rose at an average annual rate of 15% in the 80's, has dropped since 1991 (-4 % per year). After Finland joined the EU in the beginning of 1995, the food prices have generally dropped. The salmon and rainbow trout price collapses can not anymore be explained by the increased catches and increased aquaculture production as before.

Unit roots and co integration are applied to test the linkages between the prices of domestic salmon, imported Norwegian fresh salmon and rainbow trout within the full sample. If the same analyses are conducted for only the time period prior to Finland's membership in the European Union, the conclusion is no co integration. This supports the conclusion that contrary to the beliefs of many fish farmers and fishermen, the import of salmon from Norway did not have a long run effect on the domestic production at the time when it was based on licenses or circumvention of import restrictions.

1. Introduction

The prices of Finnish salmon and aquacultured rainbow trout have dropped to a new all-time low in 1995. The price, in real terms, the fishers were paid for domestic salmon in the beginning of the 90's was only one forth of what it had been in 1980. This price decline during the 80's can, to a large degree, be explained by the increased catches and increased aquaculture production of rainbow trout (Mickwitz 1994).
In the 90's, the market has changed. The formerly very restricted import of salmonides has been liberated and is now almost totally free. The seasonal distribution of the catches has changed and the total quantity has dropped. The production of rainbow trout that rose at an average annual rate of 15% in the 80’s, has dropped in the 90’s. After Finland joined the EU in the beginning of 1995, the food prices in general have been decreasing. The salmon and rainbow trout price collapses can not anymore be explained by the same factors as before.

The task of this study is to examine the linkages between the prices of domestic salmon, aqua cultured domestic rainbow trout and Norwegian farmed salmon in Finland. If these three product forms are substitutes for each other, then there should be a balance between the prices, so that a long run change in one price would so be seen in the long run price for the other products. In the terminology of econometrics, the time series for the price will be examined in order to establish whether they are co integrated or not. If a co integration relationship exists then follows a long run relationship and a set of short run adjustment parameters also can be found.

The domestic salmon, the imported Norwegian salmon and the domestic rainbow trout all have some common characteristics, but they also differ from each other. All the three products are species with red coloured meat. The red colour of the salmon caught in the Baltic Sea is, however, much lighter than that of the two farmed products. The rainbow trout is much smaller (the average weight is 1 to 2 kg) than the imported or domestic salmon. The supply of the farmed products is more certain and the individual fish are much more homogenous within a lot. Because of these and other differences, one can not a priori determine that they (all) are close substitutes.

This study is by no means original with respect to its idea. There have been a lot of studies on the co integration of price series of different fish species and products in recent years, for example by Gordon and Hannesson (1994), Hannesson (1994a and 1994b), and Steen (1994a, 1994b and 1994c). In addition to the studies by Steen of some European salmon markets, the prices of salmon in Europe have also been studied with other methods by for example Asche et al. (1994 and 1995).

In other studies on European salmon markets (for example the studies conducted by Asche, Salvanes and Steen 1994), the domestic production consumed domestically has often been excluded. This has been the case, since in the context of these studies, this production has been considered a small and therefore not very relevant component of the market. In this study the focus is on the relationship between imported salmon from Norway and domestically caught salmon or cultured rainbow trout. Although the amount of salmon caught by Finnish fishermen is small and the Finnish production of rainbow trout is internationally small compared to the Norwegian salmon production the issue is highly relevant. This is the case since trade sanctions against Norway could only be legally motivated under World trade organisation (WTO) and the European Economic Area (EEA) if the import causes serious disturbances for the domestic production. That this has happened has been

[1] They are not three different species, since both the salmon caught in the Baltic Sea and the salmon farmed in Norway are Atlantic salmon (Salmon sa/ar)

[2] Import regulations were circumvented in 1992 and the beginning of 1993 by importing fresh salmon under the tariff heading 03.05.69.90. (Mickwitz 1994). The data series used is therefore a weighted average of the import price from Norway under these two tariff headings.
argued by especially Ireland and Scotland within the EU supported by Finland among others. A pre request for the Norwegian salmon to cause disturbances for Finnish fish farmers and salmon fishermen are of course that the prices are related.

The paper is structured as follows: In section 2, the Finnish market for salmon and rainbow trout is briefly described and the data used for the analyses is presented. In section 3, the concepts of unit roots and co integration are briefly described. The results of the econometric analyses are presented in section 4 and the conclusions are drawn and discussed in section 5.

2. The market for salmon in Finland and the data used in the study

The market in Finland of fish species with red coloured meet consist mainly of Atlantic salmon and rainbow trout. There are also some other species (e.g. arctic char), but the amounts can be neglected. For the last decades, the supply of these species has been dominated by the domestic farmed rainbow trout. The growth of the overall supply, of fish species with red coloured meet, in the 80's was mainly caused by the increase in the production of rainbow trout, from about 4.5 million kilogram in 1980 to about 18.5 million kilogram in 1990. The Finnish catches of salmon did, however, also grow during the 80's, from about 0.5 million kilogram in 1980 to about 2 million kilogram in 1990.

Until Finland joined the European Union the import of salmonids was restricted and during the whole 80's, imports were so small that they could be neglected. During the 90's, import licenses have been issued more freely and during a time-period the restrictions were effectively circumvented. Since Finland joined the EU in the beginning of 1995, the import is almost unrestricted.

The market shares of domestic and imported salmon and rainbow trout in the 90's are shown in figure 1. As can be seen most of the imports come from Norway. The import of fresh salmon from Norway has increased rapidly during the last year and accounted for about 15 per cent in 1995. The import of fresh salmon fillets from Norway has accounted for a couple per cent of the market, however, its share has decreased recently. The import of other products was significant only in 1994 when about 1.2 mill. Kg of fresh rainbow trout was imported, about half of it came from Norway and the rest from Sweden and in 1995 when about 0.4 mill. Kg of fresh rainbow trout was imported mainly from Sweden.
The prices focused on in this study are: the monthly salmon price paid to Finnish fishermen, the monthly import price of fresh Norwegian salmon (03.02.12.00)[2], the monthly import price of fresh Norwegian salmon fillets (03.04.20.10), and the monthly rainbow trout price paid to fishermen. No monthly data on the price paid to fish farmers for rainbow trout is available, therefore the price paid to fishermen, of which some are also farmers has to be used. The time period considered is December 1991 to December 1995, since only since December 1991 has there been a continuous import of fresh salmon to Finland.

The price series used have been deflated using the consumer price index, with December 1995 as the base month and a common logarithmic transformation has been undertaken (as for example in Asche et al. 1994).

3. Methods

3.1 The properties of the time series

It is common that economic time series change over time. If they change so that also the mean and the variance changes then the time series are said to be non-stationary. Non-stationary time series can often be made stationary if it is differenced one or several times. If a time series is non-stationary but its first difference is stationary it is said to have a unit root and to be integrated of order one (1(1)). A time series that has to be differenced times before it becomes stationary is integrated of order one (1(d)).

Already since Yule in 1926, the problems of determining relationships between non-stationary time series with ordinary regression have been known. If there are two independent time series y and z, that each are 1(1), then testing the hypotheses that they are independent by a normal regression (OLS) would give a rejection rate of 60 to 80 per cent (Hendry 1995). Time does not cure the problem, since the longer the time series the larger is the probability of rejecting the true hypotheses of no relationship.

The problem of how to test dependencies between 1(1) time series has been solved by the concept of co integration. Linear combinations of 1(1) time series are usually 1(1), but sometimes the integration between the series cancels so that the combination is 1(0), then the series are called co integrated. Before turning into the concept of co integration the procedure to determine the order of integration is needed.

The order of integration of a time series can be tested by an Augmented Dickey Fuller (ADF) test. The ADF test is a test of the t-value for $\beta$ in equation 1. A small t-value would indicate that $H_0: \beta = 0$, that is a unit root, is maintained and rejection would imply stationary. The t-value for $\beta$ has to be compared to critical values that depend on whether or not a trend (T) and a constant (a) are included.

$$
(1) \Delta p_{i,t} = \alpha + \mu T + \beta p_{i,t-k} + \sum_{\gamma=1}^{n} \eta_{\gamma} \Delta p_{i,t-\gamma} + \epsilon_t
$$
3.2 Test of Co-integration

A dynamic system for the prices can be formalised in which Pt is a vector of the prices of interest and it depends on a constant, the time trend and k lags of the price vector. This is

\[ p_t = \lambda_0 + \phi T + \sum_{\gamma=1}^{k} \delta_\gamma p_{t-\gamma} + \varepsilon_t \]

expressed in equation 2.

The system in 2 can be reformulated by subtracting Pt-i from both sides of the equation and redefining the parameters. By doing this, a 50 called vector equilibrium correction is formulated (equation 3).

\[ \Delta p_t = \lambda_0 + \phi T + \rho p_{t-k} + \sum_{\gamma=1}^{k-1} \eta_\gamma \Delta p_{t-\gamma} + \varepsilon_t \]

The system in 3 can be written as 4, which will be the representation used in this study [3].

\[ \Delta p_t = \lambda_0 + \phi T + \rho \Delta p_{t-1} + \sum_{\gamma=1}^{k-1} \varphi_\gamma \Delta p_{t-\gamma} + \varepsilon_t \]
If the time series in the vector $\mathbf{p_t}$ in equation 4, all are $1(1)$, then by definition their differences $\Delta \mathbf{p_t}$ are $1(0)$. This means that the left hand side of the equation 4 is $1(0)$ and therefore also the right hand side of the equation must be $1(0)$. From the definition also follows that $\Sigma \alpha \Delta \mathbf{p_t}$ are $1(0)$. The constant, the trend component and the error are $1(0)$. There for, the element $\mathbf{pp_{hi}}$ also has to be $1(0)$, in order to make the right hand side of the equation integrated of the same order as the left one. In order to make $\mathbf{pp_{hi}}$ $1(0)$ either $\mathbf{p}$ has to be a matrix of zeros or $\mathbf{P_t-i}$ contain a number of co integrated vectors which makes $\mathbf{pp_{hi}}$ $1(0)$. The number of co integrated vectors is determined by the rank (r) of $\mathbf{p}$. If $\mathbf{p}$ would be full rank since then $\mathbf{pp_{hi}}$ would be $1(0)$ and not $1(1)$. The matrix $\mathbf{p}$ can be factorised, so that $\mathbf{pp_{hi}} = \mathbf{A}^t \mathbf{B}$, where $\mathbf{A}$ and $\mathbf{B}$ are matrices and is the co integration vectors and a the adjustment parameters. (Hendry 1995, p 315).

When the system 4 has been formed the rank of $\mathbf{p}$ can be tested by a maximum likelihood method proposed by Johansen (1988) and Johansen and Jusehus (1990). This results in two tests statistics, the maximum eigen-value statistic, $\xi_r = -T \log(1-\mu)$, and the trace statistic, $\eta = T \log(1+\mu)$. Both statistics have non-standard distributions, which are functional of multivariate Wiener processes. Although there are no analytical forms for the distributions, critical values, for each null, can be obtained by Monte Carlo simulation.

4. Results

4.1 The order of integration of the time series for salmon and rainbow trout prices

First the order of integration for each price series in $\mathbf{P_t} = [\mathbf{p_{DS,t}}, \mathbf{p_{NS,t}}, \mathbf{p_{NSF,t}}, \mathbf{p_{RT,t}}]$ was tested by the ADF-test described in section 3.1. A constant, a trend and il seasonal dummies were used while conducting the unit root test. The results are presented in table 1.

Based on the augmented Dickey-Fuller unit root test we conduct that the hypothesis of a unit root can not be rejected for the price of domestic salmon ($p_{DS,t}$), the price of imported fresh Norwegian salmon ($p_{NS,t}$) and the price of domestic rainbow trout ($p_{RT,t}$). For the import price of Norwegian salmon fillets ($p_{NSF,t}$), the unit root is rejected. Based on the test results the price series of Norwegian salmon fillets ($p_{NSF,t}$) is considered stationary and the other price series non stationary and integrated of order one.

Table 1. The Augmented Dickey-Fuller unit root test ($H_0$: $1(1)$)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test statistic$^a$</th>
<th>No. of Lags$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic salmon price, $p_{DS,t}$</td>
<td>1.82</td>
<td>12</td>
</tr>
<tr>
<td>Price of fresh Norwegian salmon, $p_{NS,t}$</td>
<td>-3.46</td>
<td>0</td>
</tr>
<tr>
<td>Price of Norwegian salmon fillets, $p_{NSF,t}$</td>
<td>4.16$^*$</td>
<td>0$^c$</td>
</tr>
<tr>
<td>Rainbow trout price, $p_{RT,t}$</td>
<td>-2.54</td>
<td>0</td>
</tr>
</tbody>
</table>

$^a$ Test statistic

$^b$ No. of Lags

$^c$ Critical value
The critical values for the test statistic are not the ordinary t-test values. In this case, with a constant, a trend and seasonal, the relevant critical values are: 5% - 3.539, 1% -4.232 (MacKinnon 1991).

The number of lags were selected as the highest lag with a significant coefficient based on the conventional t-value (5%), within the range 0-12 (Gregory and Hansen 1996 and Doornik and Hendry 1994a). Another possibility used in the literature is to select the number of lags based on a statistical information criteria for the models (e.g. Gordon and Hannesson 1994). In this case, the chosen lags are the same if Schwarz criterion is used. The price of Norwegian salmon fillets is the only variable for which the chosen number of lags matters for the outcome, for 0, 1 or 5 lags the H₀ is rejected while the other numbers of lags would result in acceptance of H₀.

In order to make sure that the conclusion of I(1) is correct the integrated order of the differences was tested with the ADF-test. The H₀ is now that the differences are I(1), which means that the series them self would be 1(2). The H₀ is rejected for all the time series, i.e. all the differences are stationary.

**Table 2. The Augmented Dickey-Fuller unit root test of differences (H₀:~ 1(2))**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test statistic</th>
<th>No. of Lags</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic salmon price, P&lt;sub&gt;DS,t&lt;/sub&gt;</td>
<td>-7.46**</td>
<td>0</td>
</tr>
<tr>
<td>Price of fresh Norwegian salmon, P&lt;sub&gt;N,t&lt;/sub&gt;</td>
<td>-6.32**</td>
<td>1</td>
</tr>
<tr>
<td>Price of Norwegian salmon fillets, P&lt;sub&gt;NF,t&lt;/sub&gt;</td>
<td>-6.27**</td>
<td>0</td>
</tr>
<tr>
<td>Rainbow trout price, P&lt;sub&gt;RT,t&lt;/sub&gt;</td>
<td>-6.83**</td>
<td>0</td>
</tr>
</tbody>
</table>

The critical values for the test statistic are not the ordinary t-test values. In this case, with a constant and seasonal, the relevant critical values are: 5% -2.947, 1% -3.629 (MacKinnon 1991). Although it is most common to test the stationary of second differences without a trend including a trend would not change the outcomes.

The number of lags were selected as the highest lag with a significant coefficient based on the conventional t-value (5%), within the range 0-12 (Gregory and Hansen 1996 and Doornik and Hendry 1994a).

**4.2 Co integration results**

Based on the results of the augmented Dickey-Fuller unit root test we concluded that the price of domestic salmon (P<sub>DS,t</sub>), the price of imported Norwegian salmon (P<sub>N,t</sub>) and the price of domestic rainbow trout (P<sub>RT,t</sub>) were non-stationary but have unit roots these variables will there for be our data set when we examine the possible co integration of the prices.

The system expressed in equation 4 is estimated:
Where $\Delta p_t$ is the vector $[P_{DS,t} - P_{DS,t-1}, P_{NS,t} - P_{NS,t-1}, P_{RT,t} - P_{RT,t-1}]$, $T$ is the trend, $p_{t-1}$ is the vector $[P_{DS,t-1}, P_{NS,t-1}, P_{RT,t-1}]$ and $\Delta p_{\gamma}$ is the $\gamma$th lag of the vector $\Delta p_t$. 

The first question is how the lag length of $\Delta p_\gamma$ should be chosen. The use of Schwartz criterion, for which there are strong arguments in many cases of model formulation, might penalize additional lags too heavily when the model is formed for co integration tests. (Banerjee et al. 1993) In our particular case, the possible lag length is limited by the length of the time series. When seasonal dummies, a trend are included the maximum number of lags is 8. We start to model the system with 8 lags for the differenced prices. Then we remove the lags one by one, but keep the same sample period in order to allow a model comparison. If we would make the model selection based on the Schwartz criterion, then we would chose zero lags. If, on the other hand, we stop the process of model reduction when a F-test, of the significance of the legged variable in the system, for one of the variables indicates significance at 5 % level, we would include 2 lags of the differenced prices. Since too many lags are considered less a problem than too few (Banerjee et al. 1993), we will use the second strategy and choose two lags. After the decision to use two lags of the differenced prices has been made the error correction model is re-estimated with the longest possible sample, that is 1992(3) to 1995(12). The number of co integrated vectors is determined, by testing the rank of the matrix $\rho$, the results are presented in Table 3.

Table 3. Tests of the rank of matrix $\rho$

<table>
<thead>
<tr>
<th>$H_0$: rank = r</th>
<th>$\xi_r$</th>
<th>95%</th>
<th>$\eta_r$</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>r = 0</td>
<td>26.71</td>
<td>25.5</td>
<td>48.45</td>
<td>42.4</td>
</tr>
<tr>
<td>r ≤ 1</td>
<td>11.22</td>
<td>19.0</td>
<td>21.75</td>
<td>25.3</td>
</tr>
<tr>
<td>r ≤ 2</td>
<td>10.53</td>
<td>12.2</td>
<td>10.53</td>
<td>12.2</td>
</tr>
</tbody>
</table>

1 $\xi_r$ - $T\log(1-\mu)$ and it is called the maximum eigenvalue statistic.

2 The 95 % critical values. Both and have non-standard distributions which are functional of multivariate Wiener processes. Although there are no analytical forms for the distributions critical values, for each null, can be obtained by Monte Carlo simulation. The critical values used here are the once reported by Pc - Fiml 8.1.

3 $\eta_r$ - $T\Sigma\log(1-\mu)$ and it is called the trace statistic.

On the basis of the bathe the maximum eigen-value statistic and the trace statistic the conclusion of rank one is drawn, which means that there is one co integrating vector.

Table 4. Normalized eigen-vectors ($\beta'$)

<table>
<thead>
<tr>
<th>Domestic salmon price $P_{DS,t}$</th>
<th>Price of fresh Norwegian salmon, $P_{NS,t}$</th>
<th>Rainbow trout price, $P_{RT,t}$</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Tables 4 and 5 give the outcome of the co-integration analysis. Since we have concluded that there is one, but only one co-integrated vector, the relevant eigenvector is the first row of table 4 and the relevant adjustment coefficients are in the first column of table 5.

Finally, to make sure that all three prices are linked, we test exclusion of the prices from the co-integration relation one by one. Following the procedure of Johansen and Juseijus (1990) it is possible to test restrictions on $\beta$ by first determining $\beta = H_0$, then determining $H$ to take into account the decider restriction and finally testing the restricted case against the unrestricted one. The test is conditional on the accepted co-integrated rank and the test.

Statistics have conventional $\chi^2$ distributions (asymptotically). In a similar way, weak exogeneity can be tested by first determining $a = \sim$ then determining $a = 0$ that a row is zero (corresponding to the variable which weak exogeneity is tested) and finally testing this case against the unrestricted one. The test is conditional on the accepted co-integrated rank and the test statistics have conventional $\sim \chi^2$ distributions (asymptotically).

The results of the exclusion tests are presented in table 6. For all the variables the hypothesis of exclusion is rejected, so the conclusion that all the price series are co-integrated is maintained.

Table 7. Test of weak exogeneity of the variables, (rank 1)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic salmon price, $P_{D5,t}$</td>
<td>12.35**</td>
<td>0.006</td>
</tr>
<tr>
<td>Price of fresh Norwegian salmon, $P_{N5,t}$</td>
<td>12.33 **</td>
<td>0.006</td>
</tr>
<tr>
<td>Rainbow trout price, $P_{RT,t}$</td>
<td>12.43 **</td>
<td>0.006</td>
</tr>
</tbody>
</table>

The tests of weak exogeneity are reported in table 7. For the domestic salmon price and the rainbow trout price weak exogeneity is rejected and for the price of imported fresh Norwegian salmon it is maintained.

Table 7. Test of weak exogeneity of the variables, (rank 1)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Test statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic salmon price, $P_{DS,t}$</td>
<td>9.77**</td>
<td>0.008</td>
</tr>
<tr>
<td>Price of fresh Norwegian salmon, $P_{NS,t}$</td>
<td>0.44</td>
<td>0.80</td>
</tr>
<tr>
<td>Rainbow trout price, $P_{RT,t}$</td>
<td>10.61**</td>
<td>0.005</td>
</tr>
</tbody>
</table>

4.3 The effect of a possible structural break

It has been widely noticed in the econometric literature that structural breaks may cause problems with respect to both the tests of the order of integration and co integration. In the presence of a structural brake, for example the Dickey-Fuller unit root test (and also the augmented Dickey-Fuller unit root test), have low power. (Campos et al 1996 and Gregory and Hansen 1996)

There are several a priori reasons to expect that the relationship between our price series could have been affected by structural breaks. The most obvious candidate for a cause of a structural break is that Finland joined the European Union from the beginning of 1995. Other possible causes are the fact that, during the period from January 1992 to May 1993, most of the import of Norwegian salmon was due to circumvention of import restrictions and the changes in the import license policy during the end of 1993 and 1994.

Although it is possible to determine the time when certain for the studied time series possibly relevant exogenous changes have occurred it is not possible to a priory determine at what time a structural break in the co integration relationship should be tested. This is the case since it might take some time until the market reacts on the change or there might be expectations which makes the reaction come even before the policy change.

The first step in analysing possible structural breaks is to examine the stability of the results with respect to different sample periods.

First, we look at the conclusion of one co integrated vector, that is the rank of the matrix $p$. When the shrunken from the beginning, by dropping one observation at the time, until twelve observations have been dropped the following results were obtained: The $11^{\sim}$ of rank 0 was rejected in ah cases and the $H_0$ of a rank less than or equal to 2 was also maintained in all cases. The test of one or two co-integrated vectors, that is $H_0$ of a rank less than or equal to 1, depends on the sample. If either just the first observations (1 to 4) or the first year (11 or 12) observations are drat from the sample, then the conclusion is just one co-integrated vector. In the other cases, the result is two co-integrated vectors. (Figure 2)
Secondly, we reduce the data so that the observations in the end of the sample are dropped one by one, giving less weight to the period when Finland has belonged to the EU. As soon as one observation is removed from the end of the sample the hypothesis of no co-integration, the rank of the matrix $\rho$ equals zero can no longer be rejected and this result stays the same when more observations are removed. When the model is estimated without the last year when Finland has been part of EU, the maximum eigenvalue statistic and the trace statistic are far below the critical values (figure 3).

After concluding that the results are very sensitive to the sample size the possibility of one or several structural breaks has to be maintained. In a future study more
advanced methods to explicitly test for structural brakes at any time should be conducted following the methods introduced by Campos et al 1996 and Gregory and Hansen 1996.

**Comments and Conclusions**

In this study, the existence of a long run price relationship between domestic salmon, aqua cultured rainbow trout and farmed salmon imported from Norway is analysed. Based on the Augmented Dickey-Fuller tests of the time series, it was concluded that the price series of domestic salmon, imported Norwegian fresh salmon and rainbow trout were non-stationary, but had stationary differences. Therefore, co-integration analyses were adopted to determine whether or not the price series were linked. The results of the analyses, i.e. the maximum eigenvalue and the trace statistics, indicates that there is a relationship between these prices within the full sample range (March, 1992 to December 1995). This conclusion is further supported by the outcomes of the tests of variable exclusion.

The conclusion that the prices are co-integrated is not sensitive to the choice of lag length in the model. A longer lag length would, however, in some cases result in the judgement of two co-integrated vectors, instead of one, as in the reported case.

The conclusion that the prices are linked is, however, sensitive to the sample size. When the same analyses are conducted for only the time-period prior to Finland's membership in the European Union, one concludes that there is no co-integration. This supports the conclusion from an earlier study (Mickwitz 1994), that contrary to the beliefs of many fish farmers and fishermen, the import of salmon from Norway did not have a long run effect on the domestic production at the time when it was based on licenses or circumvention of import restrictions. From this study the exact time when the structural brake in the relationship between the prices occurred, caused by the change in import restrictions when joining the EU, can not be established. This, however, has to be left to further examinations.

**References**


1 They are not three different species, since both the salmon caught in the Baltic Sea and the salmon farmed in Norway are Atlantic salmon (Salmon sa/ar).

2 Import regulations were circumvented in 1992 and the beginning of 1993 by importing fresh salmon under the tariff heading 03.05.69.90. (Mickwitz 1994). The data series used is therefore a weighted average of the import price from Norway under these two tariff headings.

3 It can easily be shown that for equations 2 - 4 (\(\delta_1, \delta_2, \delta_3, ..., \delta_k\)) = (\(\eta_1 + 1, \eta_2 - \eta_1, \eta_3 - \eta_2, ..., \rho - \eta_{k-1}\)) = 

\(\rho + \varphi_1 + I, \varphi_2 - \varphi_1, \varphi_3 - \varphi_2, ..., \varphi_{k-1}\)

4 Where \(p_{DS,t}\) is the price of domestic salmon at time t, \(p_{NFS,t}\) is the price of imported Norwegian fresh salmon at time t, \(p_{NFF,t}\) is the price of imported Norwegian salmon fillets at time t, and \(p_{RT,t}\) is the price of domestic rainbow trout at time t.