

The effect of trade liberation on the salmon market in Finland

Jari Setälä¹⁾, Per Mickwitz,²⁾ Jarno Virtanen³⁾, Asmo Honkanen³⁾ and Kaija Saarni¹⁾

¹⁾ Finnish Game and Fisheries Research Institute, Turku Game and Fisheries Research, Itäinen Pitkätatu 3, FIN-20520 Turku, Finland ²⁾ Finnish Environment Institute, P.O.Box 140, FIN-00251 Helsinki, Finland ³⁾ Finnish Game and Fisheries Research Institute, P.O.Box 6, FIN-00721, Helsinki, Finland

Abstract. The fish markets in Finland were formerly protected from international competition. The markets were gradually opened to free competition in the 1990s due to the EEA agreement and EU membership. As a consequence, the importation of fresh salmon from Norway rapidly increased, and imported salmon captured the markets from domestic salmon trout and wild salmon. In this study we use price series data and apply co-integration techniques to analyse how the trade liberation affected salmon markets in Finland. The study reveals that the price of imported salmon determines the price of wild salmon and that it also had a clear effect on the price of salmon trout.

Keywords: Salmon markets, Time series analysis, Co-integration analysis, Structural breaks

1. INTRODUCTION

Although Finnish markets are very small from a world-wide perspective, the Finnish salmon market is an interesting case to analyse what happens when protected markets are opened to free international competition. In the 1980s, the importation of fresh salmon was totally prohibited and the increasing demand for salmonids was satisfied by domestic fisheries and expanding salmon trout farming. In 1990s, salmon importation to Finland was gradually liberated, first import licences were more freely issued due to the EEA-agreement and later, when Finland joined the EU in 1995, importation was totally liberated. The import volume increased quickly and rapid changes in the market prices caused profitability problems for Finnish fishermen and fish farmers. Along with other fish producers in the EU Finnish fish farmers accused Norwegian exporters of price dumping, and in 1997 a minimum import price (MIP) was set for Norwegian salmon imported into the EU.

Co-integration analyses have been widely applied to market integration studies (for example Ardeni 1989; Goodwin and Schroeder 1991; Gordon, Salvanes and Atkins 1993; Asche, Salvanes and Steen 1997; Asche and Steen 1998). In this study we apply co-integration analysis to assess how the importation of salmon has affected the salmon market in Finland. *A priori*, one could assume that imported salmon has substituted domestic salmon and salmon trout. According to Stigler and Sherwin (1985), two products are substitutes, if they are in the same market and their relative prices maintain a stable ratio. They defined the market as the area within which the price is determined. Co-integration analysis has been used to test if the price series of Norwegian imported salmon and two domestic fish species - farmed salmon trout and salmon from commercial fisheries - are linked and exhibit stable long-term relationships, which would indicate that these products are substitutes and part of the same market. Furthermore we have divided the examination period from 1992 to 2000 into different lengths of time series to analyse possible changes in the competition between fish species during the period.

The paper is henceforward organised as follows. First we describe the development of the salmon market in Finland during the last two decades. In the following chapter we briefly present the data and the methodology used in the analysis. In the last two sections the results are shown and discussed.

2. EVOLUTION OF SALMON MARKET IN FINLAND

In the 1980s the salmon market in Finland comprised domestic farmed salmon trout and wild salmon caught by professional fishermen and imported frozen salmon fillets (Figure 1). Importation was still of minor importance because import licences for fresh salmon were virtually prohibited. Fish farming, which expanded prominently in the 1980s, became a new source of income in the Finnish archipelago area. Alongside this, salmon fisheries still remained an important source of employment in rural coastal areas. In 1990 Finland produced almost 19 000 tons of rainbow trout, and the commercial catch was about 2 000 tons. At that time, only 700 tons of frozen salmon fillets measured in live weight was imported into Finland.

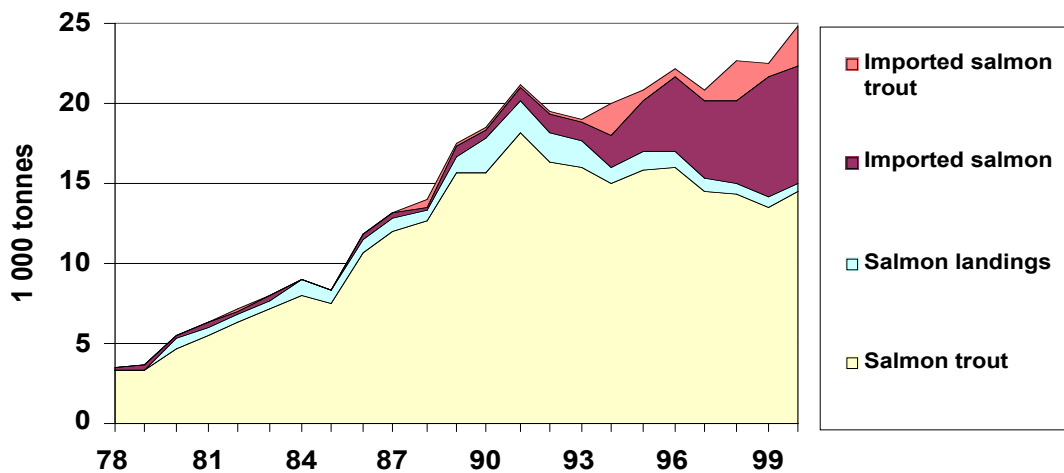


Figure 1. Development of the salmon market in Finland 1978-2000.

In the 1990s import restrictions were gradually abolished. Although a low import tariff of 5 per cent was still applied, import licences were increasingly issued to importers due to the EEA-agreement. This process was accelerated by the fact that in 1992 and 1993 import regulations were effectively circumvented: fresh salmon was imported in seawater barrels under a licence-free tariff heading (03.05.69.90, salted salmon). Finally, in 1995, the importation of fresh salmon from Norway was totally liberated as Finland joined the EU and the common community legislation was adopted.

Since 1993 the importation of fresh salmon has increased very rapidly. In the middle of the 1990s the prices of domestic wild salmon and salmon trout followed the falling trend of the price of imported salmon (Figure 2), leading to profitability problems for domestic producers. The crisis was deepened by the fact that value added tax was extended to cover primary production, and the overall food prices fell when Finland joined the EU. The Finnish fish farmers, along with the producers from Ireland and Scotland, accused Norway of misusing its position as the leading producer and exporter by dumping prices. As the consequence, the producers within the EU were losing market shares in their home markets. This dispute ended when the EU set a minimum import price of 3.25 €/kg for Norwegian salmon imports in July 1997.

Since then salmon prices have stabilised, but the import volume has continued to grow (Figure 2). Salmon has overtaken domestic fish species in the markets. By the end of the 1990s the market share of salmon was one-third of the total market: in 2000 Finns consumed about 7 000 tons of imported salmon, compared to 15 000 tons of domestic salmon trout. Salmon fisheries have almost disappeared. Only about 600 tons of wild salmon was caught in 2000.

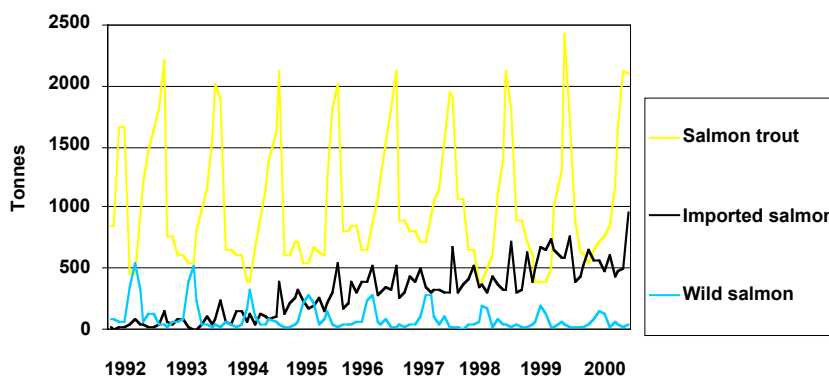


Figure 2. Monthly quantities of salmon trout production, salmon catches and salmon import in 1992-2000.

3 MATERIAL AND METHODS

3.1. The aim of the study

The first task of this study is to examine the link between the prices of domestic salmon and rainbow trout and Norwegian salmon in Finland. From the market development one could assume that these three product forms¹ are substitutes for each other. In that case there should be a balance between the prices, so that a long-term change in one price would also be reflected in the long-term 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, it implies that a long-term relationship and a set of adjustment parameters can be determined.

The domestic wild salmon, the imported farmed Norwegian salmon and the domestic farmed salmon trout all have some common characteristics, but they also differ from each other. All three products are fish with red meat. However, the colour of the wild salmon is lighter than the colour of the farmed products. The salmon trout is smaller (the average weight is 1 to 3 kg) than imported or domestic salmon (3 to 5 kg). The supply of farmed products is more stable and individual fish are more homogenous within a lot. Because of these and other differences, one cannot definitely *a priori* determine that they all are close substitutes.

The main purpose of this study is to investigate if the price relationships remain stable over time. It has been widely noticed in the econometric literature that structural breaks may cause problems in respect of both the tests of the order of integration and co-integration. In the presence of a structural break, for example the Dickey-Fuller unit root test and the Augmented Dickey-Fuller (ADF) unit root test, have low power. (Campos, Ericsson and Hendry 1996, Gregory and Hansen 1996, Maddala and Kim 1998)

There are *a priori* reasons to expect that the relationship between price series could have structural breaks. The most obvious candidates for structural breaks are the beginning of 1995, when Finland joined the European Union, and July 1997, when MIP was set. Although the exact time for an exogenous change can be determined, it does not definitely imply the time at which the structural break can be detected in the co-integration relationship. This is the case, since it might take some time for the market to react to the change or there might be expectations, which would cause a reaction to occur even before the policy change. Thus we will test different lengths of time series within the time period 1992 to 2000 in order to see if there is evidence for a structural break or not.

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 (*Salmo salar*). The large market size of rainbow trout (*Oncorhynchus mykiss*) is called salmon trout in this paper to separate it from the small portion-size rainbow trout.

3.2. Material

The prices series used 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 and the monthly rainbow trout price paid to fish farmers. Salmon trout were imported during some years in the 90s (see Figure 1). However, we did not include imported salmon trout in the analysis because the price data is not appropriate due to the fact that low-priced portion-size rainbow trout cannot be separated from salmon trout. The salmon import prices are received from Finnish board of customs, the salmon trout prices from Finnish Fish Farmers' Association and domestic salmon prices from Finnish Game and Fisheries Research Institute.

The data covers the time period from January 1992 to December 2000 (Figure 3). The series starts from January 1992 because there has been importation of fresh salmon to Finland since that time. The price series used have been deflated using the consumer price index, with December 2000 as the base month, and a common logarithmic transformation has been undertaken.

3.3. Method

Co-integration analysis has become the most commonly used methodology for delineation markets and the methodology has been thoroughly presented in various papers. Hence we only briefly describe the main idea of the analyses in this paper. The economic time series are often non-stationary (i.e. the mean and variance are time-variant). In these circumstances ordinary least squares (OLS) may lead to incorrect correlation. Instead, co-integration analysis offers an appropriate tool to infer causal long-term relationship between non-stationary variables. If two or more non-stationary series are linked and can form an equilibrium relationship in the long term, the difference between them will be stationary (Harris 1995). The series are co-integrated if the linear combination (the so-called co-integration vectors) of the non-stationary series produces a residual series, which is stationary. When co-integration is verified, the variables exhibit stable long-term relationships. The variables may drift apart from another due to random shocks in the short term, but in the long term they will return to their long-term equilibrium (Engle and Granger 1991). In this study the economic interpretation is that salmonids are part of the same market if their prices are co-integrated.

A prerequisite for co-integration tests is to verify that the series are non-stationary at their levels and become stationary after differencing. We used ADF unit root test to see if the series are stationary or not (Dickey and Fuller 1979; 1981). The series that are non-stationary at their levels and stationary in their first differences, are chosen for further analysis.

We used Johansen's co-integration test (Johansen 1988; 1991 and Johansen and Juselius 1990), which has been used in recent market delineation studies (Asche and Steen 1998, Clay and Fofana 1999). First of all the prices were analysed by multivariate tests to see if all three product prices formed a common system. The conclusions were drawn on the basis of maximum eigenvalue statistics as the trace test tend to accept co-integration too often (Johansen and Juselius 1990). Exclusion tests were conducted to verify that every variable contributes significantly to the long-run relationship (Hamilton 1994, Steen 1995, Gordon and Hannesson 1996, Asche, Salvanes and Steen 1997). This analysis was further completed by pair-wise bivariate tests (Asche and Bremnes 1997, Asche, Bremnes and Wessels 1999). In addition we examine the adjustment parameters, which gives information about the speed of the adjustment to equilibrium. We also tested the weak exogeneity of the prices. Weak exogeneity implies that the price is determined by exogenous factors, and that the other prices are determined from this leading price. A precise definition of weak exogeneity can be found in Hendry (1995).

To identify possible structural changes, the time series pre and post EU-membership, and the setting of the minimum price, were tested. Based on graphical examination, the change in the market has been most radical during the period from 1993 to the middle of 1996, and the prices of domestic fish species seem to have reacted to the price trends of imported salmon. Thus this period was tested. Finally, we examined the stability of the results by extending the short time period 1992-1994 year by year until the time series covering the complete data was analysed. Altogether, 11 time periods were analysed (Table 1).

Table 1. Time series analysed.

Time series	Representing
January 1992 - December 1994	Pre EU
January 1995 - December 2000	Post EU
January 1992 - June 1997	Pre MIP
June 1997 - December 2000	Post MIP
January 1993 - June 1996	Radical changes in the market prices
January 1992 - December 1995	

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

Unit root tests were conducted by PcGive (Doornik and Hendry 1996) and cointegration analyses by PcFiml modelling program (Doornik and Hendry 2000).

4. Results

4.1. Unit root tests

First, the order of integration for each price series was tested by the ADF-test. The results are presented in Appendix A. Based on the ADF unit root tests, all the price series except that of salmon trout from year 1992 to 1994 were found to have a unit root and could therefore be included in the Johansen test for co-integration.

4.2 Graphical examination

The time series are graphically presented in Figure 3. All three series seem to have a common behaviour. The prices are more widely spread at the beginning of the period and in 1997 and 1998. The series for domestic fish species seem to have their own seasonality throughout the whole sample period. On the contrary, the series for imported salmon is more stable in the late 1990s due to the setting of MIP. The prices of domestic fish species move similarly all the time although they have their own seasonal variation. The series for salmon trout and imported salmon seem to move independently at the very beginning of the period and have a common falling trend from 1994 to 1996. From 1997 to the beginning of 2000 salmon trout has an upward trend and the price of imported salmon has stabilised with the exception of some peaks near the MIP. At the very end of the period the prices fall together. The price of domestic salmon has always been lower than the price of imported salmon and the series seem to move rather similarly with the exception of two years at the beginning of the investigated period.

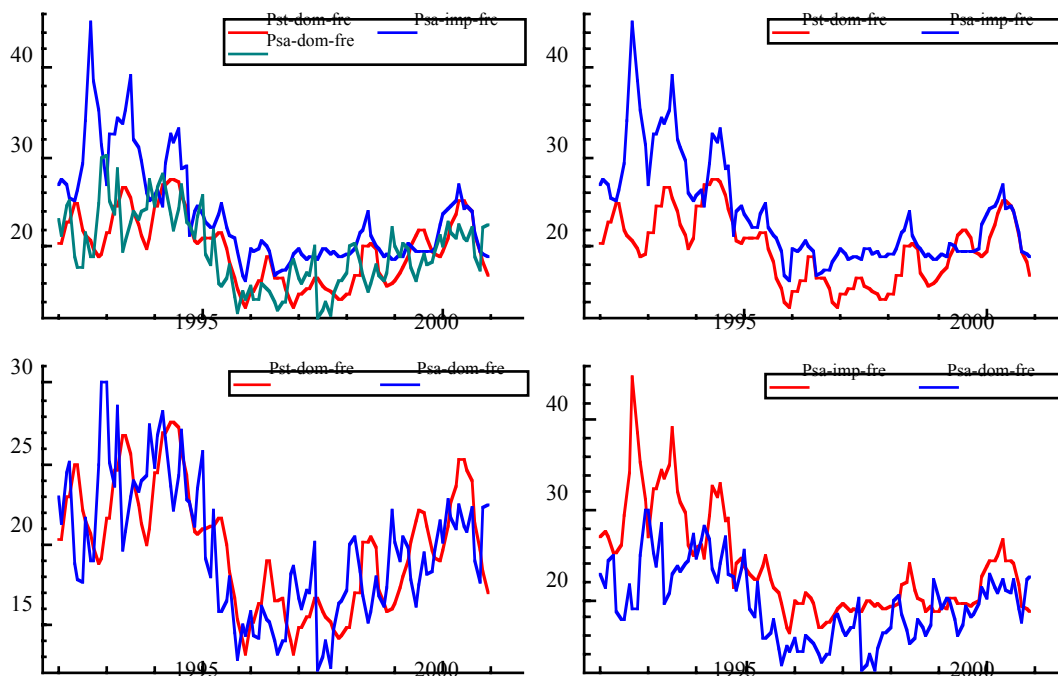


Figure 3. Price series of salmon trout (Pst-dom-fre), imported salmon (Psa-imp-fre) and domestic wild salmon (Psa-dom-fre) in 1992 to 2000.

4.3. Co-integration analyses

The time series were first analysed with multivariate co-integration analysis, in which all three fish species were simultaneously included in the analysis. The results of the multivariate tests are presented in the table below and in detail in Appendix B.

Table 2. The results of multivariate analyses

Time period	All species
1992-1994 Prior EU	-
1995-2000 Post EU	**
1992-1997 (6) Prior MIP	**
1997 (7)-2000 Post MIP	ns
1993 –1996(6)	**
1992-1995	**
1992-1996	**
1992-1997	**
1992-1998	**
1992-1999	**
1992-2000	**

- = not tested, ** = co-integration was found at 1 % significance level, ns = no co-integration at significant level

Co-integration was found for all the time series, except for the period post MIP. To make sure that all three prices are significantly linked, we tested exclusion of the prices from the co-integration relationship one by one. The results of the exclusion tests are presented in table 3, and in more detail in Appendix B. The hypothesis of exclusion is rejected for other series except for imported salmon for the period 1992-1995 and the periods post EU and post MIP, indicating that imported salmon was not then included in the common co-integration system.

Table 3. Exclusion tests

Time period	Rainbow trout	Imported salmon	Domestic salmon
1995-2000 Post EU	**	ns	**
1992-1997 (6) Pre MIP	**	**	**
1993 –1996(6)	**	**	**
1992-1995	**	ns	**
1992-1996	**	*	**
1992-1997	**	*	**
1992-1998	**	**	**
1992-1999	**	**	**
1992-2000	**	**	**

- = not tested, ** = part of the system at 1 % significance level, * = part of the system at 5 % significance level, ns = excluded from the system

The adjustment coefficients can be interpreted as the speed of adjustment towards the estimated equilibrium state. A low coefficient indicates slow adjustment and a high one rapid adjustment. The adjustment coefficients are shown in Table 4. The obtained coefficients indicate that the price of wild-caught salmon is systematically more quickly adjusted towards the equilibrium than the prices of the other products.

Table 4. Adjustment coefficients

Time period	Rainbow trout	Imported salmon	Domestic salmon
1995-2000 Post EU	-0,08	0,17	0,46
1992-1997 (6) Pre MIP	-0,11	-0,11	0,63
1993 –1996(6)	-0,31	-0,16	0,67
1992-1995	-0,11	0,31	0,71
1992-1996	-0,10	-0,20	0,55
1992-1997	-0,09	0,15	0,62
1992-1998	-0,08	0,02	0,59
1992-1999	-0,08	0,15	0,49

1992-2000	-0,10	0,17	0,44
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The tests for weak exogeneity are reported in Table 5 and the parameter values in Appendix B. For the price of wild-caught salmon weak exogeneity is rejected for all periods; for the price of imported fresh Norwegian salmon it is maintained. For the periods 1992 to 1995 and 1993 to June 1996 weak exogeneity was rejected at the 1% confidence level for rainbow trout too. These results indicate that the price of imported salmon is always determined outside the system and the price of wild-caught salmon is always determined by either the price of imported salmon or both imported salmon and salmon trout. Moreover imported salmon also seem to have an effect on the price of salmon trout.

Table 5. Weak exogenous tests.

Time period	Rainbow trout	Imported salmon/	Domestic salmon
1995-2000 Post EU	*	ns	**
1992-1997 (6) Prior MIP	ns	ns	**
1993 –1996(6)	**	ns	**
1992-1995	**	ns	**
1992-1996	ns	ns	**
1992-1997	ns	ns	**
1992-1998	ns	ns	**
1992-1999	ns	ns	**
1992-2000	ns	ns	**

** = exogeneity rejected at 1 % significance level , * =exogeneity rejected at 5 % significance level, ns = exogeneity not rejected at significant level

The price series were also pair-wise tested to complete the previous analysis. The results are shown in Table 6. The prices of salmon trout and domestic salmon, as well the prices of imported and domestic salmon, were co-integrated in all other investigated periods except post MIP. The price of salmon trout and imported salmon were found to be co-integrated in the periods 1992 to 1995, 1993 to June 1996 and post EU. None of these pair-wise tests gave evidence for co-integration during the post MIP (1997 (7) –2000) period.

Table 6. The results of bivariate Johansen co-integration analyses.

Time period	Salmon trout/ Imported salmon	Salmon trout/ Domestic salmon	Imported salmon/ Domestic salmon
1992-1994 Prior EU	-	-	Ns
1995-2000 Post EU	**	**	**
1992-1997 (6) Prior MIP	ns	**	**
1997 (7)-2000 Post MIP	ns	ns	Ns
1993 –1996(6)	**	**	**
1992-1995	**	**	**
1992-1996	ns	**	**
1992-1997	ns	**	**
1992-1998	ns	**	**
1992-1999	ns	*	**
1992-2000	*	**	**

- not tested, ** = co-integrated at 1 % significance level , * = co-integrated at 5 % significance level, ns = no co-integration at significant level

These results suggest that the sample size has an effect on the stability of co-integration. According to graphical examination (see Figure 3), the price of salmon trout and salmon moved similarly and converged from 1993 to 1996. The time series for the period 1993 – 1996 (6) was co-integrated, although a little longer series from 1992 to the end of 1996 and 1997 (6) was not. To examine the stability of co-integration (these tests are called stability tests in the further analysis and discussion), we extend and shorten the time-series from 1993 to June 1996 by 12 months one observation at a time, first at the beginning (Figure 4) and then at the end (Figure 5) of the series. On the basis of maximum eigenvalue statistics, the co-integration began in June 1992 and end in December 1996.

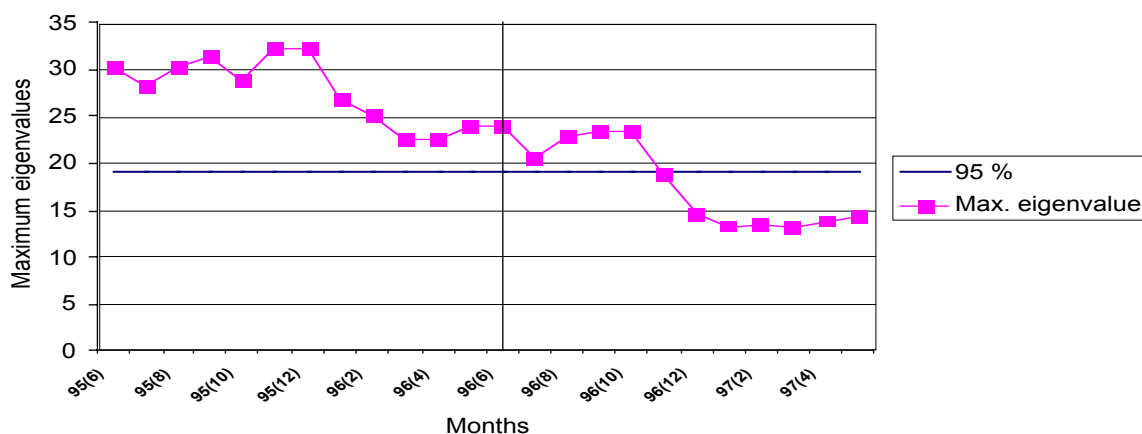


Figure 4. The value of maximum eigenvalue statistics time series 1993-1996 (6) is extended or shrunk from the start of observations (January 1993) by 12 months.

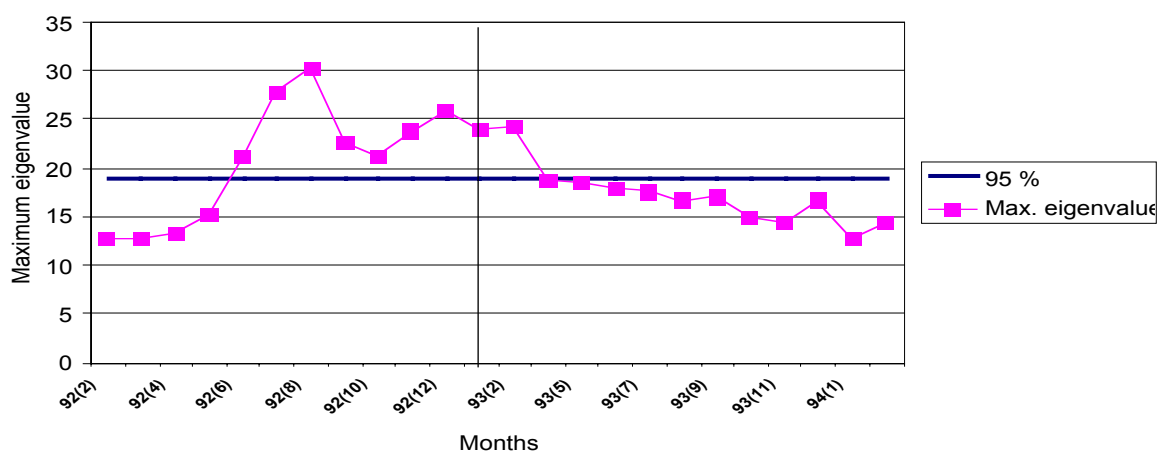


Figure 5. The value of maximum eigenvalue statistics time-series 1993-1996 (6) is extended or shrunk from the last observation (June 1996) by 12 months.

5. DISCUSSION

The multivariate co-integration tests suggest that there is a permanent stable long-term relationship between the prices of imported salmon, domestic salmon and salmon trout. However, the exclusion tests and bivariate analyses suggest that all three prices do not contribute to a common system all the time, and that the nature of the relationships varies over time. The pair-wise analyses explain some aspects of the overall dynamics of the system. The most indisputable conclusion is that the imported salmon is in the same market and is a substitute for domestic wild-caught salmon. Every test indicates this: the price of domestic salmon is co-integrated with the price of imported salmon, the price of imported salmon is exogenous determining the price of domestic salmon, and the price of domestic salmon adjusts fastest towards the long-term equilibrium. The test results are supported by the facts that domestic and imported salmon are the same fish species, even though there is a clear difference in the colour of the meat.

Another rather obvious conclusion is that the price of salmon trout affects the price of domestic salmon: the prices were co-integrated and, according to weak exogenous tests, the salmon trout price together with imported salmon determines the price of wild-caught salmon most of the time. These prices have moved close to each other since the start of the study period. This indicates that contrary to imported salmon, which is a newcomer to the market, wild-caught salmon and salmon trout have for a long time been in the same market, and there are rather stable and predictable competitive relationships between these two domestic fish species.

The most interesting case is the relationship between salmon trout and imported salmon. The bivariate analyses indicate that the fish species were substitutes in the same market from 1992 to 1995, from 1993 to 1996 (6) and from 1995 to 2000. According to the exogenous tests, the price of imported salmon determined the price of salmon trout during these periods. However, the co-integration was not verified for those series, which started in 1992 and lasted beyond 1995. The test results suggest that market integration would be depend on the sample size and the changes in the relationships over the time. This development can be due to a structural break or to cyclical variation in the competitive situation in the world salmon market.

The stability tests (see Figures 4 and 5) suggest that the market was not integrated at the very beginning, when the import volume was still very low. The beginning of the co-integration (first significant maximum eigenvalue) in June 1992 coincides with the increased importation of salted salmon (see Chapter 2), which lasted about as long as the markets were found to be co-integrated (look at the import volumes in Figure 2). The loophole in the import regulations was blocked up in May 1993. Market integration was not found between any products in the post MIP period. This indicates that minimum price has affected the competition and there is a structural change due to the MIP. According to the stability tests, the market integration between salmon trout and imported salmon ended six months prior to the minimum price being set. The prices of imported salmon reached the minimum at the end of 1995, leading to heated discussion about price dumping. In 1996 the EU started to investigate the matter. Hence the increase of import prices before MIP may be caused by a counter-reaction by the Norwegian salmon exporters.

The study by Hartman et al (2002) confirms the idea that the markets for salmon and salmon trout are integrated. However, it can be fairly stated that the links between the prices of imported salmon and salmon trout are not as stable as those for the other compared pairs. There certainly are other circumstances alongside the price of imported salmon that affect the price of salmon trout - for instance, the domestic supply and the world-market price of salmon trout. There are also changes in the consumption of salmon trout, which may affect the price: as the competition in the fresh fish market becomes more fierce an increasing share of salmon trout is used as raw material by processing industry; contrary to imported salmon, which is almost totally sold fresh.

The intensity of the competition in the salmon world-market tends to fluctuate depending on the global supply of salmon. There was an over-supply of salmon in the middle of 1990s, resulting in low prices. The latest over-supply period was experienced as recently as 2001, when the world-market prices of salmon and salmon trout collapsed. In Finland the price of salmon trout dropped to a new all-time low in 2001, although the import price of salmon was still regulated. However, the importers tended to buy extra-ordinarily low-priced salmon trout at the same time as they imported salmon. This indicates that the discounts were set to the unregulated salmon trout price. At the same time evidence of widespread double invoicing of salmon has been found in other parts of Europe. These phenomena are in line with the arguments that some sort of black market is an inevitable consequence of effective price floors that prevent the price from falling to its unregulated equilibrium (Hirtshleifer & Hirshleifer 1997).

The overall conclusion is that the prices of salmonids are linked in the long-term, although there are various reasons for variation in the short term. Trade liberation has profoundly affected the salmon markets and production structure in Finland. Salmon fisheries have collapsed. Although imported salmon is not the only reason behind this development, the low price level has made offshore fishing totally unprofitable and has radically cut down incomes in the coastal salmon fisheries. Salmon trout farming is facing global competition and new challenges. Traditionally fish farming has been a source of livelihood for many small family enterprises along the Finnish coast. The trade liberation has forced a structural change, in which a few companies are rapidly growing through the buying out of smaller units that can no longer make profitable business independently. The setting of a minimum price has reduced the competition between salmonids during the investigation period. However, based on the experiences from the year 2001, the MIP might be a rather inefficient tool for the prevention of price dumping in a global over-supply situation.

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Appendix A. The results of the unit root tests.

Time series	Yt			ΔYt		
	c ¹⁾	c+t ²⁾	c+s+t ³⁾	c ¹⁾	C+t ²⁾	c+s+t ³⁾
Fish species						
Prior to EU						
1992–1994						
Salmon trout	-4,19**	-3,73*	-0,55	-3,39*	-6,84**	-2,61
Imported salmon	-1,85	-2,49	-2,71	-5,75**	-5,63**	4,74**
Domestic salmon	-3,48*	-3,41	-2,30	-6,53**	-6,36**	5,02**
Post EU						
1995–2000						
Salmon trout	-1,07	-0,03	-1,88	-4,16**	4,31**	-0,50
Imported salmon	-2,58	-2,55	-3,54*	-2,64	4,32**	-2,00
Domestic salmon	-2,19	-4,41**	-3,37	-7,12**	7,15**	-6,24**
1996–2000						
Salmon trout	-1,43	-3,39	-2,49	-1,10	-0,75	-0,98
Imported salmon	-1,64	-3,42	-5,64**	-5,84**	-5,82**	-2,10
Domestic salmon	0,01	-5,47**	-2,85	-5,76**	-5,75**	-3,60**
Prior to MIP						
1992–1997 (6)						
Salmon trout	-1,05	-2,83	-1,84	1,20	-1,20	-5,94**
Imported salmon	-1,06	-1,83	-3,43	-6,04**	6,05**	-4,48**
Domestic salmon	-1,10	-1,82	-1,72	-7,68**	-7,54**	-9,45**
Post MIP						
1997 (7)-2000						
Salmon trout	-1,07	-0,03	0,87	-4,16**	-4,31**	-1,89
Imported salmon	-2,58	-2,55	-0,77	-2,64	-4,32**	-4,41**
Domestic salmon	-2,19	-4,40**	-2,59	-7,12**	-7,54**	-1,30
1993–1996 (6)						
Salmon trout	-1,75	-1,68	-2,01	-4,38**	-0,01	-3,61*
Imported salmon	-1,32	-2,82	-2,68	-3,96**	-3,87*	-5,66**
Domestic salmon	-0,75	-3,81*	-2,27	-6,92**	-6,80**	-6,48**
Other series						
1992–1995						
Salmon trout	-0,94	-0,52	-0,36	0,81	-1,31	-5,06**
Imported salmon	-0,36	-2,54	-3,17	-4,07**	-4,15**	-6,74**
Domestic salmon	1,77	-1,83	-1,52	-7,69**	-3,97*	-6,29**
1992–1996						
Salmon trout	-1,64	-2,64	-1,70	-1,11	-0,86	-5,23**
Imported salmon	-0,62	-4,75**	-3,37	-5,71**	-5,64**	-3,74**
Domestic salmon	-1,59	-1,44	-2,19	-7,46**	-0,71	-0,55
1992–1997						
Salmon trout	-1,54	-2,84	-1,26	-1,24	-0,96	-8,42**
Imported salmon	-1,32	-1,12	-2,52	-6,31**	-6,40	-5,83**
Domestic salmon	-1,08	-1,69	-3,27	-2,24	-2,10	-3,82*
1992–1998						
Salmon trout	-1,69	-2,30	-0,53	-1,38	-1,38	-7,15**
Imported salmon	-1,83	-0,75	-0,34	-6,69**	-6,98**	-6,01**
Domestic salmon	-1,55	-1,07	-1,58	-2,18	-2,30	-8,05**
1992–1999						
Salmon trout	-1,73	-1,57	-0,19	-1,33	-1,76	-8,41**
Imported salmon	-2,16	-0,74	-0,19	-6,94**	-7,37**	-5,83**
Domestic salmon	-1,68	-1,24	-1,29	-2,54	-2,73	-3,82*
1992–2000						
Salmon trout	-1,98	-2,41	-1,51	-1,73	-1,65	13,62**
Imported salmon	-2,13	-1,49	-2,37	-6,95**	-7,12**	-6,34**
Domestic salmon	-1,78	-1,24	-1,11	-2,05	-2,43	-9,47**

1) c=constant included 2) c+t=constant and trend included 3) c+s+t= constant, trend and seasonals included

Appendix B. Detailed results from multivariate co-integration analyses, exclusion and weak exogeneity tests

Ho: rank = p	Max test	Trace test	Exclusion tests:			Weak exogeneity tests:		
			Rainbow trout	Imported salmon	Domestic salmon	Rainbow trout	Imported salmon	Domestic salmon
1992-94, 1 lag								
p = 0	20,6	44,22*	2,61	4,71*	4,84*	0,31	0,30	7,44**
1995-2000, 1 lag								
p = 0	50,93**	73,08**	7,43**	0,02	36,34**	4,32*	2,79	38,00**
1992-1997 (6), 1 lag								
p = 0	37,34**	55,76**	10,74**	10,10**	22,18**	0,53	1,27	22,62**
1997 (6) –2000, 4 lag								
p = 0	24,04	53,36**	5,98*	0,48	4,07*	0,65	0,14	5,60*
1993-1996 (6), 1 lag								
p = 0	34,37**	62,34**	24,14**	19,53**	25,97**	9,01*	5,82	19,15**
1992-95, 1 lag								
p = 0	32,32**	61,28**	10,26**	2,48	10,47**	0,88	0,21	8,21**
1992-96, 1 lag								
p = 0	31,40**	47,99**	11,59**	5,37*	18,60**	0,01	0,02	18,8**
1992-97, 1 lag								
p = 0	39,82**	56,36**	14,22**	6,09*	26,02**	0,01	0,11	25,96**
1992-98, 1 lag								
p = 0	44,15**	62,25**	13,90**	8,13**	26,80**	0,05	0,08	27,35**
1992-99, 1 lag								
p = 0	49,22**	67,07**	17,06**	8,96**	32,00**	0,14	0,00	31,76**
1992-2000, 1 lag								
p = 0	25,16**	26,79**	17,52**	6,73**	35,20**	0,25	0,15	33,84**

The number of lags was 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 1999). Constant, seasonals and trend are included in the models.

** Indicates significant at 1%, * Indicates significant at 5%

Appendix C: Detailed results from bivariate co-integration analyses

Ho: rank = p	Salmon trout/imported salmon		Salmon trout/domestic salmon		Imported salmon/domestic salmon	
	Max test	Trace test	Max test	Trace test	Max test	Trace test
1992-94, p = 0	-	-	-	-	18,13	24,94
1995-2000, 12 lags p = 0	34,46**	40,26**	38,73**	40,36**	30,56**	37,55**
1992-1997 (6), 1 lag p = 0	14,35	19,8	26,06**	36,82**	26,59**	35,37**
1997 (6) –2000, 5 lags p = 0	15,63	27,68*	18,17	20,5	17,39	24,32
1993-1996 (6), 7 lags p = 0	27,27**	41,47**	42,74**	68,9**	26,92**	33,26**
1992-95, 1 lag p = 0	42,96**	47,46**	45,21**	52,43**	68,13**	77,83**
1992-96, 1 lag p = 0	15,07	20,68	42,74**	68,9**	26,86**	45,03**
1992-97, 1 lag p = 0	14,2	15,81	33,67**	51,09**	24,65**	33,16**
1992-98, 1 lag p = 0	15,57	17,39	28,73**	42,62**	29,12**	35,45**
1992-99, 1 lag p = 0	17,28	20,45	19,48*	31,2**	31,65**	36,0**
1992-2000, 1 lag p = 0	19,36*	21,25	40,54**	42,25**	25,24**	29,84*

The number of lags was chosen according to the Akaike information criterium. Constant, seasonals and trend are included in the models.
- not tested, ** Indicates significant at 1%, * Indicates significant at 5%