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Market Integration of Farmed Trout in Germany

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Abstract *Price formation and integration of markets supplied by both farmed and captured fish is studied. Markets for trout and potential substitutes imported to Germany are analysed, and market delineation and market leaders identified. It is found that markets for small portion-sized farmed trout with white meat are related to, rather than completely separate from, other fish markets, and that markets for these trout are more closely linked to markets for captured fish than to farmed salmon. The implications are that although the part of the trout business operating with small freshwater ponds remains relatively unaffected by developments in other fish markets, careful attention should be paid to markets for and management of capture fisheries like cod, halibut, redfish, and mackerel, than to markets for farmed salmon.*

Key words Price formation, market integration, captured-farmed fish.

JEL Classification Codes F15, Q21, Q22.

Introduction

The purpose of this paper is, through a case study of the German market for farmed trout, to contribute to the understanding of price formation in fish markets supplied by both farmed and captured species. Is the market only for trout, or does the market also consists of other species like salmon and cod? When supply and demand changes and you wish to understand the effect, it is necessary to know whether the market is dedicated to a single species or several species. Market integration analysis is a suitable tool for revealing the adequate delineation of the markets for farmed

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and captured fish. Understanding of the role of market integration allows an assessment of the effects on the trout business of changes in trade policies and fisheries management of other species. The subject is analysed within a multivariate cointegration framework by identifying market integration, sizes, and boundaries of markets and market leaders.

The paper focuses on the German market and the conclusions apply strictly to the trout business in Germany. The conclusions also hold for Danish trout production, since Denmark sells more than half of its exports to Germany and because the majority of German trout imports originate from Denmark. Furthermore, Danish trout farmers produce the same products as their German counterparts, mostly small portion-sized trout with white meat, and to a lesser extent, medium portion-sized trout with red meat, and large salmon trout (trout larger than 1.5 kg with red meat). The Danish trout business, like the German, consists mainly of small-scale firms raising small trout with white meat in freshwater ponds, and to a lesser extent large-scale sea aquaculture, raising medium- and large-sized trout with red meat.

The issue of integration between markets for farmed and capture fish is important, since different developments are taking place in these markets. Supplies of farmed fish are generally increasing, whereas supplies of captured fish are decreasing or stable. If, for example, trout and salmon markets are linked, the price of trout would be negatively affected by the increasing global supply of farmed salmon from Norway, Scotland, Chile, and Canada, but if markets are separate, the price of trout would remain unaffected. In contrast, if trout markets are linked to cod markets, the price of trout might be positively affected by reduced supply of cod from the North Sea, but if these markets are unlinked, cod supply is unimportant. Hence, knowledge of market integration is necessary to assess the potential consequences for the trout business of the introduction of measures such as safeguards and anti-dumping duties on EU imports of Norwegian salmon and of quota restrictions on capture fishing of cod in the North Sea. If trout and salmon markets are integrated, measures applied to Norwegian salmon might be advantageous for the trout business; otherwise, they will have no effect. Conversely, if trout and capture fish markets, like cod, are integrated, the tightening of quota restrictions will cause a gain for the trout business, whereas in the absence of market integration there will be no effect.

The issue is also interesting from a theoretical point of view, since knowledge of market integration can complement demand analysis and provide more information together on cross-price effects and price movements than separately (Asche, Salvanes, and Steen 1997). Furthermore, the correct specification of demand models requires a good understanding of both the size and linkages of relevant markets and market leaders. In the Neo-Classical theoretical tradition, price formation has traditionally been studied empirically by estimating demand equations for certain goods without explicit preassessments of which goods to include. The development of new econometric methods, like the analysis of non-stationary time series, cointegration, tests for the Law of One Price (LOP), and tests for market leaders (weak exogeneity tests) over the last decade provides a framework for identifying market integration and structures before specifying demand systems.

In the economic literature, Guillotreau (2003a,b) analyses the structure of European seafood markets after the revolution in the salmon market. That is, after the market became supplied by farmed salmon besides the traditional capture fish species. This literature and other articles identify sizes and boundaries of European markets potentially supplied by both farmed and wild-caught fish. The main conclusions obtained from the literature, include:

- In the UK, the farmed salmon market is not linked to the markets for captured whitefish, such as cod, saithe, and haddock (Clay and Fofana 1999).

- In Spain, farmed salmon "is at best only a weak substitute for tuna, hake, and whiting, but no significant interaction could be found" (Jaffry *et al.* 2000).
- In France, ambiguous results on the integration of farmed salmon markets and markets for captured whitefish have been obtained in the literature. Gordon, Salvanes, and Atkins (1993) find salmon and whitefish markets separate; whereas Tuncel and Le Grel (1999) find that salmon and whitefish markets are integrated. Further, Tuncel and Le Grel (1999) cannot find close links between trout and whitefish.
- In Finland, farmed salmon trout and farmed and captured salmon are close substitutes, and the price of imported farmed salmon affects salmon trout prices (Asche *et al.* 2001; Setälä *et al.* 2002; Saarni *et al.* 2003). Salmon trout and imported salmon determine the price of wild salmon and sea trout (Setälä *et al.* 2002; Virtanen *et al.* 2005).
- In Germany, farmed trout does not seem to compete closely with other fish species, as it does in other countries (Girag 2002).

Based on these surveys, it is apparent that results concerning market integration in European fish markets supplied by both farmed and captured species are mixed. Markets for farmed salmon and salmon trout are found integrated with wild salmon in Finland. Markets for farmed salmon and captured whitefish are found integrated in France by some, although others contradict the result. Integration between farmed and wild-caught species in Europe are, to the knowledge of the authors, not identified anywhere else, although Asche *et al.* (2005) identify integration between farmed and wild salmon in Japan. These relatively loose links identified would predict that market integration of farmed trout and captured whitefish in Germany is at best very weak. However, such a prediction does not take into account that salmon and trout are sold in different sizes and that the colour of the meat differs. Generally, in Europe trout is sold in three product forms: small portion-sized with white meat, small portion-sized with red meat, and large salmon trout. In Germany, however, small portion-sized trout with white meat predominates. The consequence is that trout and whitefish might be more closely linked than trout and salmon, owing to the white meat of these species and given that whitefish in Germany, such as cod and redfish, are sold in small sizes. This is likely since the stocks of these species in the Northeast Atlantic Ocean supplying Germany are heavily exploited, implying that small fish forms the overwhelming share of catches. Thus, the first hypothesis of this paper is that markets for trout and captured whitefish species are integrated in Germany, owing to small fish being sold and to the white meat of these species.

The above surveys also identify market integration between salmon and salmon trout in Finland, but were unable to identify market integration in France and Germany. Hence, since most farmed salmon sold in Europe, including Germany, originates from large-scale farming in Norway whereas most trout originates from small-scale farming around Europe, the second hypothesis is that markets for farmed trout and salmon remain unlinked in Germany.

Methodology

According to Stigler (1969), a market is defined as "the area within which the price is determined, allowances being made for quality differences and transport costs." Based on this definition, this paper use econometric tests to determine whether the market for a concrete good, trout, forms part of larger markets consisting of several other goods.

Whether the prices of trout and potential substitutes move together over time can be determined by testing the LOP. The LOP is fulfilled if prices of trout and other goods move perfectly over time. Tests can be undertaken for stationary price series in a multivariate set-up by extending the Stigler (1969) bivariate framework and following the Ravallion (1986) *N*-market case by estimating equation (1) for three goods:[1]

$$\ln(p_{1,t}) = A + B\ln(p_{2,t}) + C\ln(p_{3,t}) + \varepsilon_t, \tag{1}$$

where $(p_{1,t})$ is the price of Good 1, $(p_{2,t})$ is the price of Good 2, $(p_{3,t})$ is the price of Good 3, and where $B + C = 1$ implies that the LOP is in force. The regression is only valid for stationary price series. For non-stationary price series, cointegration "is a natural extension" (Asche, Gordon, and Hannesson 2004). Furthermore, regressing price series integrated of different orders may cause spurious correlations. Therefore, it is necessary to confirm that data series are integrated of the same order, determining whether the individual data series is $I(0)$, $I(1)$, or $I(2)$.

This is done by testing the null hypothesis, H_0, of non-stationarity of the individual time series against the stationary alternative. The regression equation used is given in equation (2):

$$\Delta X_t = \pi X_{t-1} + c + \gamma_1 \Delta X_{t-1} + ... + \gamma_{k-1}\Delta X_{t-k+1} + \varepsilon_t, \tag{2}$$

where X_t is the single price series. First, the regression in equation (2) is estimated unrestricted, and afterwards the restrictions in H_0: $\pi = 0$ and $c = 0$ are imposed. The alternative hypothesis is that $\pi, \gamma_1, \ldots, \gamma_{k-1}$ are in the stationary range and c is unrestricted. Based on these regressions, the Dickey-Fuller F-test is calculated (Dickey and Fuller 1981) in equation (3):

$$DF_F = \frac{\dfrac{RRS_r - RSS_{ur}}{2}}{\dfrac{RSS_{ur}}{T - k^*}}, \tag{3}$$

where RSS is the residual sum of squares for the restricted and unrestricted regressions, respectively; T is the number of effective observations (number of observations – number of lags); and k^* is the number of exogenous variables in the unrestricted model.

Based on an $I(1)$ nature of the price series, the Johansen cointegration rank procedure is used and a Vector Autoregressive (VAR) model in Error Correction form is formulated as given in equation (4):

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{k-1}\Delta X_{t-k+1} + \Pi X_{t-1} + \mu + \Psi D_t + \varepsilon_t, \tag{4}$$

[1] A data series is stationary if it moves randomly around a constant mean over time (that is, mean and variance are independent of time) and is non-stationary if the value of the present observation depends on the value of former observations. A stationary data series is said to be integrated of degree zero [*i.e.*, I(0)]. A non-stationary data series is said to be integrated of degree one [*i.e.*, I(1)] if its first differences (the difference between two periods) move randomly around a constant mean over time and integrated of a higher order [*i.e.*, I(z)], where $z \geq 2$ if the value of the present observation depends on the value of former observations.

where $\Delta \mathbf{X_t}$ is a vector of the differenced price series; $\Delta \mathbf{X_{t-k}}$ is a vector of the price series differenced between the present period and period k; $\mathbf{X_{t-1}}$ is a vector of the price series in a basic period; and $\mathbf{D_t}$ is a vector of other deterministic components, such as seasonal dummies and dummies for outliers. $\Delta \mathbf{X_t}$, $\Delta \mathbf{X_{t-1}}$, $\Delta \mathbf{X_{t-k}}$, and $\Delta \mathbf{X_{t-1}}$ are all vectors of the $px1$ dimension, with p being the number of price series. $\Gamma_1 \ldots \Gamma_{k-1}$, Π, μ, and Ψ are all parameters. The matrix Π is the long-run solution to the VAR model and contains the possible cointegrating relationship. The rank of Π determines the number of stationary linear combinations of the variables in $\mathbf{X_t}$. If the rank is less than the number of variables minus one but larger than zero; *i.e.*, one in the case of three variables, a common integrating factor does not exist and it is of no relevance to test the LOP. However, if the rank is exactly the number of variables minus one, two in the case of three variables, a single integrating factor which is common to all the price series exists, and Π can be decomposed into $\alpha\beta'$, where α contains the adjustment coefficients and β the co-integrating vectors. α is of the pxr dimension and β' of the rxp dimension, with r being the rank. In that case, the LOP can be tested.

The Johansen test is used to determine the number of cointegrating vectors, utilising the Trace Test. In this test, the null hypothesis is that there are up to a given number of cointegrating vectors, whereas the alternative hypothesis is that there is exactly one more cointegrating vector. Tests are undertaken in this paper for the constant term being restricted to the cointegration space in order to allow price series to move together over time even though they may have different price levels due to quality differences and transportation costs. Critical values are known from Johansen (1996).

Based on the chosen rank of the number of variables minus one (two in the case of three variables), the LOP is tested using Likelihood Ratio tests of restrictions imposed on β. In the present multivariate set-up, and assuming that the rank is the number of variables minus one, a test of the LOP is a test of whether the columns in the β matrix sum to zero. This implies that the price series are pairwise cointegrated and thus follow a common trend. Given a rank of two and following Nielsen (2005), a test of the LOP with three variables is a test of equation (5):

$$\beta' = \begin{bmatrix} 1 & -1 & 0 \\ 1 & 0 & -1 \end{bmatrix} \qquad (5)$$

In the β' matrix, rows with zero sums correspond to $B + C = 1$ in equation (1). In equation (5), however, price series are nonstationary, where they are stationary in equation (1). The null-hypothesis is that the LOP is accepted. This is tested against the unrestricted alternative of the β matrix. Likelihood ratio test statistics and connected p-values are calculated. The p-values give the probability that H_0 is rejected erroneous (the probability of at type II error, according to Johansen 1996). Hence, the larger the p-value, the larger the probability that the LOP should not be rejected (Dennis 2006). Following the traditional approach, H_0 is accepted when $p > 0.05$ in the present paper.

Cointegration tests and tests of the LOP are undertaken for non-stationary price series in order to determine market sizes and boundaries. When the cointegration test identifies a single integrating factor that is common to all the price series, and the test of the LOP shows that the LOP is in force, the goods analysed are homogeneous, relative prices are constant, and markets are perfectly integrated. If it identifies a single common integrating factor and the LOP is rejected, the markets are partially integrated; since markets, according to Stigler and Sherwin (1985), can "show every level of interdependence from absolute homogeneity to complete independence—the continuity of the conventional criteria of cross-elasticities of demand and supply are enough to suggest that." If markets are partially integrated, the goods will be imperfect substitutes. Where the cointegration test cannot identify one common integrating factor, the goods might be heterogeneous and their markets independent. Therefore, sub-systems for which a single common integrating factor exists are sought by excluding price series one-by-one from the tests until one with a single common integrating factor is identified. Hence, the test of the LOP is used to identify market interdependence, while the cointegration test is used to identify market boundaries.

The tests of the LOP are undertaken without any identification problems in all cases, due to the fact that the rank condition of Johansen and Juselius (1994) will always be fulfilled. Only multivariate tests are performed in the present paper, partly as the issues are multivariate and partly as it has been demonstrated by Gonzáles-Rivera and Helfand (2001) that bivariate models are "inadequate for capturing the spatial dynamics of price adjustments."

Following the tests of the LOP, tests of weak exogeneity of price series are undertaken to identify causal relationships in integrated markets, thus allowing the identification of market leaders. Given a rank of the number of variables minus one, accepting the test of weak exogeneity of a given price series implies that the price series drive the others without being affected by them. Thus, the price series can be considered the market leader. Weak exogeneity is tested using Likelihood Ratio tests of restrictions imposed as zero rows in α, since this implies that the equation for $\Delta \mathbf{X}_t$ does not contain information about the long-run parameter. Likelihood Ratio test statistics and connected p-values are identified in the same way as described for test of the LOP. The tests on α are performed without maintaining the restrictions on β.

Data

Global supply of rainbow trout was 511,000 tonnes in 2002, consisting of 507,000 tonnes from aquaculture and 4,000 tonnes from capture fisheries (FAO 2002a,b). Chile (22%), Norway (16%), and France (9%) were the largest aquaculture suppliers. The EU-15 production as a whole amounted to 40%.[2] Global trade in the raw material of trout was 183,000 tonnes live weight in 2002 (FAO 2002b). Japan was the main import market (45%), followed by Germany (8%), and Russia (7%). The EU import market was 21% in total. Norway (40%) and Chile (20%) were the main suppliers, followed by Denmark (12%). The EU as a whole supplied 28%, of which a quarter was headed for non-EU countries (Eurostat 2004). Trout was also traded in processed forms like smoked, fillets, and roe, but data on global trade are not available.

The EU market for unprocessed trout was supplied by a domestic production of 206,000 tonnes in 2002. Including unprocessed trout, trout fillets, and smoked trout, internal EU trade in all product forms amounted to 49,000 tonnes (live weight)[3] and imports from and exports to non-EU countries were 13,400 and 14,600 tonnes, respectively. Hence, the EU as a whole is almost self-sufficient, with only 7% traded with non-EU countries, but simultaneously with a quarter traded internally between EU countries. Domestic production in the EU consists of three types of product: red portion-sized trout typically 600–800 grams mainly produced in France, Italy, and

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[2] The EU refers throughout the paper to the 15 member countries before the enlargement with the 10 new members in 2004.

[3] Fillets of trout and smoked trout are converted from product to whole weight using a conversion factor on 1.7. That is, one kilo of fillet or smoked trout corresponds to 1.7 kilo live weight.

Spain (approximately half); white portion-sized trout typically 200–400 grams mainly from Germany and Denmark (one-third); and red salmon trout larger than 1.5 kg mostly from Finland and France (one-sixth) (Eurofish 2004). Larger trout usually originate from sea aquaculture, whereas smaller trout are raised in inland freshwater ponds owned by small-scale firms. Large salmon trout and medium-sized red trout are sold on the global integrated market, where small portion-sized white trout are sold at local markets around Europe. Norway is the main external supplier, which almost only sell large salmon trout.

Red medium portion-sized trout and large red salmon trout are consumed in all EU countries, whereas white portion-sized small trout are mainly consumed in Germany and Italy. The total per capita consumption of all product forms of trout in the EU is approximately 600 grams live weight. Data on the consumption of different product forms of trout are not available, but imports, consisting of fresh (32%), frozen (23%), live (20%), smoked (15%), fresh fillets (6%), and frozen fillets (5%), reveal consumption of a wide range of product forms, although imported unprocessed trout to some extent is used as raw material in filleting and smoking. Smoked trout sales consist of both cold-smoked and hot-smoked fish. Both large and small fish are used for smoked trout.

This paper focuses on the trout market in Germany. In 2002, 24,200 tonnes were raised (Eurostat 2004), of which 85% were small portion-sized (200–400 grams) with white meat (Eurofish 2004). Furthermore, 30,200 and 2,600 tonnes were imported and exported, respectively, making Germany a substantial net importer of trout. Denmark (52%) and Spain (13%) were the largest suppliers. Data on imports of portion-sized white trout, portion-sized red trout, and large salmon trout are not available for 2002, but for 2003 it is known that 80% of German imports of fresh and frozen whole trout consisted of fish smaller than 1 kg; *i.e.*, of portion-sized white and red trout.[4] The per capita consumption, at 650 grams, is near the EU average, but with 85% of domestic production being portion-sized trout with white meat. Considering that 80% of imports are of trout smaller than 1 kg and knowing that Denmark as the main supplier mostly produces portion-sized trout with white meat, it appears that German consumption differs from the rest of the EU by being mostly comprised of small portion-sized trout with white meat.

Owing to data limitations, the present analysis only uses foreign trade data. Total German imports from all supplier countries are included in the analysis on a monthly basis and cover the period January 1998 to December 2003. With no observations missing, the analysis includes 72 observations. Further, owing to data limitations until 2002 it is not possible to study market integration of the three different size classes of trout separately. The implication is that the conclusions only apply to small portion-sized trout with white meat originating from freshwater ponds, since these form the overwhelming majority of trout sales in Germany.

Potential substitutes for trout are chosen according to their importance, their potential for being a substitute for trout (given the colour of their meat and the size of the fish), and to the limits set by the harmonised system of the foreign trade statistics. Potential substitutes are salmon, cod, mackerel, halibut, and redfish (ocean perch). The majority of the German supply of these species is imported. Salmon originates from large-scale sea aquaculture, primarily in Norway, where the potential substitutes originate from capture fisheries in the North East Atlantic Ocean; cod mainly from Norway, Russia, Poland and Denmark; mackerel mostly from Ireland, the Netherlands, and Denmark; halibut from Greenland and Norway; and redfish

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[4] The Harmonised System of the Eurostat foreign trade statistics was changed from 2003 and onward to separate fresh and frozen whole trout into fish above and below 1 kg (1.2 kg gutted).

from Iceland. Salmon is red and sold mainly large sized, where the capture species are white and potentially sold in different sizes. In reality, however, most sales of the capture species are in small portions, owing to the fish stocks being heavily exploited, implying that small fish provide the overwhelming share of catches.

The analysis is performed for all product forms of trout, except live, frozen fillets, and roe. Live is excluded owing to the absence of imports of potential substitutes, frozen fillets, due to the small amount traded; and trout roe, since it cannot be separated from roe of other species registered as "caviar replacement" in the statistics. Data summary statistics are given in table 1 with prices in nominal terms.

Total German imports of trout amount to 16,177 tonnes worth €71 million. Measured by quantity, frozen trout is the most important item, whereas smoked trout is the most valuable. There are, however, imports of all product forms. Prices are measured in produced weight, and with a conversion factor from produced to live weight of 1.7, the price premium per kilo live weight of fresh fillets over whole fish of only 7%[5] indicates that most fresh whole trout of lower quality are used for fil-

Table 1

Data Summary Statistics on German Import, Tonnes, and €/kg Annual Average 1998–2003

	Quantity[1]	Price
Trout		
Fresh	4,529	3.11
Frozen	6,819	3.14
Fresh fillets	430	5.66
Smoked	4,399	7.61
Total	16,177	4.41
Potential Substitutes		
Fresh salmon	66,087	3.55
Fresh cod	3,726	3.07
Fresh halibut	547	3.17
Fresh mackerel	1,557	1.38
Fresh redfish	15,245	1.68
Frozen salmon	1,681	4.37
Frozen cod	643	3.08
Frozen halibut	4,941	3.45
Frozen mackerel	6,747	1.00
Frozen redfish	2,052	1.84
Fresh fillets of salmon	6,816	6.07
Fresh fillets of cod	3,841	5.79
Fresh fillets of redfish	2,034	5.45
Smoked salmon	9,310	9.37
Smoked halibut	299	12.37
Smoked mackerel	468	2.38

[1] Quantities in produced weight, with a conversion factor from fresh to fresh fillets of trout of 1.7.
Source: Eurostat (2004).

[5] Calculated as (€ 5.66 per kilo)/(€ 3.11per kilo*1.7) = 7%.

lets, and that the highest quality trout is sold whole. The high price of smoked trout compared to the fresh and frozen forms reveals value added, although unprocessed trout is the main cost item in smoked trout amounting to 56% of total turnover in Danish smokehouses in 2002 (Food and Resource Economics Institute 2005).

Salmon is imported to Germany mainly fresh (whole and as fillets) and smoked and consumed in these product forms. Fresh whole salmon is, however, also used for smoking in the German industry. Cod is mostly imported and consumed fresh. Redfish is also dominated by imports and consumed fresh, mackerel by frozen imports, and halibut by frozen whole fish used in German smokehouses. Hence, unprocessed salmon, halibut, and mackerel might be substitutes for trout since they are all raw material for the smoking industry. Excluding frozen salmon, the price levels of salmon and cod are within a range of ±25% of the price of trout.[6] This is also the case for frozen halibut, but the prices of smoked halibut and frozen salmon are above that range. The prices of mackerel and redfish are lower than that of trout.

Results

The presence of unit roots was tested for using Augmented Dickey-Fuller tests in order to ensure that all the data series were integrated of the same order. The tests were undertaken with a constant included in the regression, and both on levels and differences in the logarithms of the price series in nominal terms. The optimal number of lags in the regressions was chosen according to the Schwarz Information Criteria. Test results are presented in table 2.

From the upper part of table 2, it appears that the null hypothesis of unit roots in price levels of trout imported to Germany is accepted for all product forms at the 5% level. Moreover, the null hypothesis of unit roots in the differenced price series is rejected for all product forms, except fresh. This implies that evidence of price series of trout being integrated of the same, first order are only found for frozen trout, fresh trout fillets, and smoked trout. Reliable analyses of the market within which the prices of trout are generated are possible only for these product forms.

Given that only prices of frozen and fresh trout fillets and smoked trout were found I(1), tests of market integration are performed between trout and potential substitutes for these product forms. The reason is that data series integrated of different orders cannot be cointegrated (in the econometric sense). Therefore, market integration between trout and other fish is only possible if the prices of the other fish are also integrated of the first order; *i.e.*, are I(1). The results of the tests are in the lower part of table 2. It appears that potential substitutes for frozen trout are salmon, cod, mackerel, and redfish, with the null hypothesis of non-stationarity in levels and differences, respectively, all accepted and rejected.

Price series of trout and other fish, identified as I(1), are shown in figure 1 over the entire time period in Euros per kilo.

From figure 1, it appears that prices increase with processing. Smoked fish is more expensive than fresh fillets, which are more expensive than fresh and frozen whole fish. Furthermore, the price of trout is higher than mackerel and redfish, on the same level as cod, and less than halibut and salmon. Since all the price series shown in the figure were found integrated of order one, cointegration methods must be used for estimation.

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[6] The reason for the high price of frozen salmon in relation to fresh remains unclear. The frozen salmon is of the same origin as fresh, with 82% of frozen salmon originating from Norway and Scotland. A potential explanation of the high price of frozen salmon is that it supplies a niche market in Germany.

Table 2
Unit Root Tests (Augmented Dickey-Fuller Tests with Constant)[1]

	H_0 of Non–stationarity:	
	Price Levels	Differenced Prices
Trout		
Fresh	–1.97 (12)	–1.58 (12)
Frozen	– 0.87 (12)	–4.69 (12)***
Fresh fillets	–1.67 (12)	–2.77 (12)**
Smoked	–1.38 (12)	–2.94 (12)***
Potential Substitutes		
Frozen salmon	–1.50 (12)	–2.88 (12)***
Frozen cod	–2.25 (12)	–2.88 (12)***
Frozen halibut	–1.91 (12)	–1.84 (12)
Frozen mackerel	–1.84 (12)	–3.14 (12)***
Frozen redfish	–1.70 (12)	–2.77 (12)**
Fresh fillets of salmon	–1.13 (12)	–1.94 (12)
Fresh fillets of cod	–2.72 (10)**	–4.27 (10)***
Fresh fillets of redfish	–1.70 (12)	–2.24 (12)
Smoked salmon	–1.85 (12)	–2.05 (12)
Smoked halibut	–1.44 (12)	–2.82 (12)**
Smoked mackerel	–2.58 (12)**	–3.27 (12)***

[1] The critical values are known from MacKinnon (1991) and are –3.43/–2.86/–2.57, respectively, at 99%, 95%, and 90% levels. ***/** = significance at 1 and 5% levels. "." indicates that unit root tests are not performed, owing to the absence of I(1) for the corresponding product form of trout. Numbers in parentheses indicate the number of lags chosen by the Swartz Information Criterion.

Based on the I(1) nature of selected price series, cointegration tests, as well as tests for the LOP and weak exogeneity, were undertaken between different fish species for each of the product forms. The species were selected on the basis of table 1. For example, market integration was tested between frozen trout, salmon, cod, redfish, and mackerel. Tests were undertaken using a strategy starting with 12 lags (one year) to search for a model without any misspecification problems and with a rank of the number of variables minus one. The misspecification tests included autocorrelation, normality, and autoregressive conditional heteroscedasticity (ARCH) tests, and conclusions on the presence and absence of misspecification problems were obtained at the 5% significance level.[7] The analysis initially included trout and all other fish (as given in table 1) and was carried out by removing lags, by including and excluding 11 centred seasonal dummies, and by introducing dummies for outliers. When a model with a rank of the number of variables minus one without misspecification was found, it was chosen, and the LOP and weak exogeneity were tested. If such a model could not be found, price series were excluded one by one, and the searches were repeated until such a model was found. Test results are

[7] The tests used were the multivariate LM test for first and fourth order autocorrelation in the residuals, a multivariate test of normality of the Shenton-Bowman type (Doornik and Hansen 1994), and univariate LM tests for autoregressive conditional heteroskedasticity with degrees of freedom = number of lags.

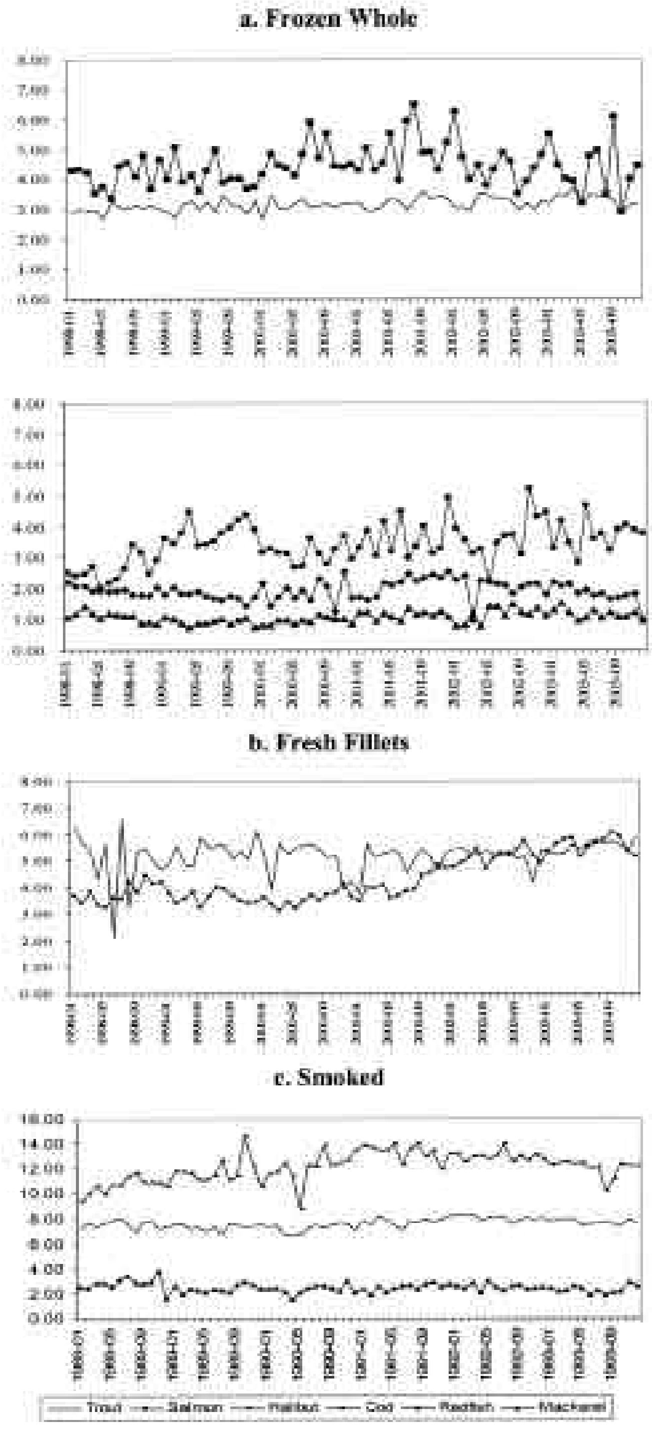

Figure 1. Monthly Import Prices of Trout and Potential Substitutes, €/kg

reported only where a rank of the number of variables minus one without misspecification could be found and only for the largest number of price series included. That is, results for tests with a reduced number of price series are reported only if higher degrees of market integration were found. Results of cointegration tests and tests of the LOP; *i.e.*, of whether price series move perfectly together over time, are shown in table 3.

In table 3, the first line represents the test for cointegration between German import prices of frozen trout, salmon, cod, and mackerel. A common integrating factor is identified, accepting a 10% significance level (the rank is 3 in the model with four price series). The test of the LOP is, however, rejected. Replacing mackerel with redfish, the second test gives the same result. A common integrating factor is identified at the 5% level, but the LOP is rejected. Hence, there is weak evidence that the German import market for frozen fish is neither perfectly integrated, nor can any of the price series be excluded. The German import markets for frozen trout, salmon, cod, mackerel, and redfish are partially integrated. Excluding both mackerel and redfish and testing only trout, salmon and cod also identifies a common integrating factor. The rank is 2, although only at the 10% level. Given this rank, the LOP was tested and accepted with $p = 0.07$. This is weak evidence that the markets for frozen trout, salmon, and cod are perfectly integrated. Taking the former tests into account, there is weak evidence that this perfectly integrated market is partially integrated with the markets for frozen mackerel and redfish.

The presence of perfect market integration between trout and cod and of partial market integration between trout, redfish, and mackerel are as expected, owing to all species being of small size with white meat. The results point to trout being a part of the European frozen whitefish market where integration is determined by the white colour of the meat, the small size of the fish, and that these species are considered inferior by German consumers. The presence of perfect market integration between trout and salmon, which are both farm raised, with trout being small and white and salmon being red and large, is against the *a priori* expectation. The reasons remain speculative, but might include that only a small share of salmon is sold frozen. Such sales might include the lowest quality salmon competing in the discount shops with other fish species and that frozen salmon, as an inferior product, might be produced on the basis of small fish.

Steen *et al.* (1999) studied the integration of European salmon and whitefish markets with mixed results. The finding of perfect integration of salmon and cod markets suggests that salmon and whitefish markets may also be perfectly integrated. This is, however, only on the frozen fish market. Sales of salmon and cod in Germany contribute only 2% and one-sixth, respectively, of fresh sales. No evidence of market integration between fresh salmon and whitefish is provided.

The test for cointegration between smoked trout, halibut, and mackerel also identify a common integrating factor, with a rank of 2 obtained at the 5% level. The test of the LOP reveals Likelihood Ratio test statistics of 5.14, corresponding to a p value of 0.08. Thus, the LOP is accepted and the German import markets for smoked trout, halibut, and mackerel are shown to be perfectly integrated. Testing for cointegration between fresh fillets of different fish species revealed no common integrating factor. Hence, integration of these markets could not be identified.

The presence of market integration for smoked fish reveals linkages between the trout markets and markets for capture fish. Smoked trout forms part of the same market as halibut and mackerel. Hence, the market for farm-raised trout forms part of the same market as capture fish. Furthermore, for smoked fish no evidence was found for the two farm-raised species, trout and salmon, being part of the same market. This implies that the smoked trout market is more closely connected to markets for capture fish than for farm-raised salmon, as expected. Reasons for this result in-

Table 3
Johansen Tests for Cointegration and Tests of the LOP — Prices of Trout and Substitutes in Germany

	Model[2]	Johansen Test								LOP Tests	
		Eigenvalue				Trace Test[3]				LR	p
Price Series[1]		1	2	3	4	p=0	p<=1	p<=2	p<=3		
Frozen T–S–C–M	12	0.72	0.53	0.28	0.13	***148.31	***72.99	***28.04	*8.02	52.20	<0.01
Frozen T–S–C–R	D/6	0.39	0.21	0.25	0.04	***69.18	***44.61	**21.71	2.54	13.05	<0.01
Frozen T–S–C	4	0.23	0.18	0.09	.	**36.95	*19.40	6.14	.	5.43	0.07
Smoked T–H–M	DD/12	0.40	0.24	0.12	.	**54.21	**23.63	7.36	.	5.14	0.08

[1]T is trout, S is salmon, C is cod, M is mackerel, R is redfish, and H is halibut.
[2] D = dummy introduced to correct for outlier observations. For frozen redfish 2000.10, 2002.03, and 2003.12; for smoked halibut 1999.10 and 2000.05; and for smoked mackerel 1998.11, 1998.12, and 2000.04. The numbers measure the lags at which the estimations are undertaken. The degrees of freedom are calculated as number of effective observations minus number of variables multiplied by number of lags minus number of deterministic components. The lowest degree of freedom is in the first test with ((72-12)-4*12-0) = 12. Hence, the degree of freedom is sufficient both in this and the other three tests.
[3]***/**/* = significance at 1, 5, and 10% levels. Critical values known from Johansen (1996).

clude similarities between trout, mackerel, and halibut (small white fish) and dissimilarities between trout and salmon (small white and large red, respectively), consumer perception of trout as bulk, that farm-raised trout was an established market one to two decades before salmon and that salmon has been subject to continued introduction and subsequent removal of import limitations, minimum import price schemes, safeguards, and anti-dumping duties.

Tests for weak exogeneity identify market leaders, and the results of such tests are presented in table 4. The tests are based on the test for cointegration in table 3, from which each line continues.

The tests for weak exogeneity of frozen trout, salmon, cod, and mackerel do not provide evidence of any of the price series being weakly exogenous. When mackerel is replaced by redfish in the tests, salmon prices are found weakly exogenous, with an LR statistic of 6.56 and a *p* value of 0.09. Excluding both mackerel and redfish, cod and trout are weakly exogenous, with p values of 0.12 and 0.06, respectively. Hence, for frozen fish, the market leaders are, as expected, found among trout, salmon, and cod, which all form part of the perfectly integrated market. The test of weak exogeneity of smoked trout, halibut, and mackerel revealed that only smoked mackerel is the market leader. This is against *a priori* expectations, since the quantities of mackerel sold form only about 10% that of trout (table 1). The reason for this remains a matter of speculation, with the prices of substitutes among other fish and food products sold in larger quantities revealed in the price of smoked mackerel, as one possible explanation.

Discussion

In this paper, the size and boundaries of the trout markets in Germany were identified and substitutes and market leaders found. Only a few substitutes for trout were identified. Frozen trout were perfectly integrated with salmon and cod, and partially integrated with mackerel and redfish, whereas smoked trout were perfectly integrated with halibut and mackerel. In the frozen market trout, cod, and salmon were identified as market leaders. Substitution for fresh whole and fresh fillets of trout was not identified. Thus, the linkages between trout and other fish are, in general, few, although the trout market in some product forms is linked to both markets for farmed salmon and markets for capture fish like cod, halibut, mackerel, and redfish. Hence, market integration between trout and capture fish is greater than that between trout and farmed salmon. This is as expected, the main reason being that most trout imported to Germany are small portion-sized with white meat, originating from freshwater ponds, which is more similar to capture species in size and colour than to farmed salmon.

The implications of these findings are two-fold, covering economic modelling and policy issues. These are discussed below. Before this, however, qualifications to the methods and results are considered in order to assess the reliability of the methods applied and the validity of the results obtained.

A potential problem with the analysis is that the conclusions are obtained for mixed sizes of trout. Hence, it is neither taken into account that trout are traded in different sizes and colours, nor that these might be headed for different market segments. This problem, although present, is limited, since the overwhelming amount in Germany is sold as small, portion-sized white trout. Thus, conclusions in this paper only hold for this market segment. The implication of the possible absence of other product forms in the statistics might have meant that market integration for small, portion-sized white trout was found to be tighter.

Another potential problem is that the conclusions on smoked fish are obtained

Table 4
Test of Weak Exogeneity — Prices of Trout and Substitutes in Germany

Price Series[1]	Weak Exogenous Tests											
	Trout		Salmon		Cod		Mackerel		Redfish		Halibut	
	LR	*p*	LR	*p*	LR	*p*	LR	*p*	LR	*p*	LR	*p*
Frozen T-S-C-M	34.20	<0.01	18.42	<0.01	26.25	<0.01	12.81	0.01	.	.	.	.
Frozen T-S-C-R	17.77	<0.01	6.56	0.09	14.69	<0.01	.	.	16.69	<0.01	.	.
Frozen T-S-C	5.75	0.06	8.66	0.01	4.32	0.12	.	.	.	.	.	.
Smoked T-H-M	8.94	0.01	.	.	.	.	0.82	0.66	.	.	17.71	<0.01

[1]T is trout, S is salmon, C is cod, M is mackerel, R is redfish, and H is halibut.

for mixed cold- and warm-smoked products. Since trout are traded as both cold- and warm-smoked products and that these might be headed for different market segments, is not taken into account. This problem, although present, is limited, if cold- and warm-smoked products are substitutes. Provided that they are not substitutes, warm-smoked trout and warm-smoked salmon might be substitutes. Cold-smoked trout and cold-smoked salmon might be substitutes as well.

The implications for economic modelling suggest that pre-tests for market integration should be performed before traditional estimation and analysis of demand are carried out (Lewbel 1996; Asche, Bremnes, and Wessells 1999; Nielsen 2005). The reason is that goods can only be substitutes if they, to some certain extent, form part of the same market. Otherwise, cross-price effects are absent, since purchasers consider the goods separate. For non-stationary price series, as in the present paper, cointegration tests and tests for the LOP in that set-up is a suitable tool for revealing market delineation (Asche, Gordon, and Hannesson 2004). The advantage of testing for market integration is that knowledge of market sizes and boundaries is obtained, and the determination of price elasticities can be based on a more reliable and consistent statistical basis; *i.e.*, the researcher knows which substitutes to include in demand analyses.

Furthermore, the results obtained above, indicating that the markets for farmed and capture fish are integrated, raise the issue of whether demand on such markets is modelled consistently in ordinary (price exogenous) or inverse (quantity exogenous) demand systems. *A priori* the causality in demand is expected to depend on whether the market is supplied from capture fisheries or fish farms. The reason for the supply source being decisive for the direction of causality relates to control. Fish farms can organise their production as they wish and can choose to sell when market conditions are favourable. Fishermen do not have this opportunity, since they have to fish when bio-economy, weather, and fisheries management allows. Hence, markets dominated by farmed fish give the expectation of preference of ordinary demand. On first-hand markets dominated by capture fish, it is expected that inverse demand is preferred. These expectations follow from the existing literature, where markets for farmed fish are typically modelled in ordinary demand systems (DeVoretz and Salvanes 1993; Bjørndal, Salvanes, and Gordon 1994; Asche 1996). In first-hand markets for capture fish, however, inverse demand systems are preferred (Ioannidis and Whitmarsh 1987; Barten and Bettendorf 1989; Burton 1992; Jaffry, Pascoe, and Robinson 1999). This leaves the question on how to approach demand analysis on markets supplied by both farmed and captured fish. One obvious answer is to test for whether demand should be modelled in ordinary or inverse demand systems. For non-stationary data, this can be done in a cointegration framework given a reasonable rank by using a standard test for weak exogeneity of quantities and prices, respectively, following Johansen (1996). Another answer is to model demand (and supply) in mixed demand systems where "some but not all goods are available in predetermined quantities" (Moschini and Vissa 1993). In such systems, demand functions can be modelled in a simultaneous equations framework.

The policy implication of the general finding of few linkages between trout and other fish is that the prices of trout are formed at its own sub-markets, without being severely affected by developments in markets for other fish. This conclusion is obtained for trout as a whole, where sub-markets might include small portion-sized white trout, medium portion-sized red trout, and large salmon trout. Small portion-sized white trout raised in freshwater ponds, however, dominate the market. This implies that conclusions apply only to that segment of the trout business. Thereby, income in that industry remains relatively unaffected by prices of other fish species. Thus, the gradual increase in supply of Norwegian salmon in Europe, for example, has had limited effect on income in that segment of the trout business. This is also the case for the EU trade measures on salmon, such as minimum price schemes, safeguards, and anti-dumping duties, which also have limited effect on income in the industry. The gain of the industry of such measures on imported salmon is small. Despite the general finding of relative separate trout markets, some linkages are identified. German imports of frozen farmed trout and salmon are perfectly integrated, implying that the prices of frozen trout are affected by developments in the frozen salmon market. It should, however, be remembered that German imports of frozen salmon form only 2% of the import of fresh salmon. That is, German imports of frozen salmon are small, and since it was not possible to identify linkages between fresh trout and salmon, developments in the frozen salmon market drive the trout markets only to a limited extent.

Although only for some product forms, linkages are also identified between farmed trout and capture fish like cod, halibut, redfish, and mackerel, the reason being that most of these fish are white and sold relatively small, *i.e.*, the consumer's perceive trout and these fish as similar. The implication is that if the prices of the capture fish rise, the price of trout follows. Hence, to the extent that fisheries management affects prices of capture fish, the price of trout is also affected. For example, reduced quotas on cod in the North Sea and the Baltic Sea over the period might have caused a modest upward pressure on the price of trout. The implication is that the part of the trout business operating with freshwater ponds should focus more on developments of captured fish markets than on markets for farmed salmon. The finding of market integration between markets for farmed and captured fish raise the question of how general the result is. Provided that markets for farm-raised and captured fish are linked, the continued development of aquaculture can reduce the pressure on capture fish stocks, since consumers can choose between captured and farm-raised fish. Provided that markets are unlinked, however, aquaculture does not affect capture fisheries. The present finding of market integration between trout and capture fish shows that aquaculture reduces the pressure on capture fish stocks in some instances, but the finding is only presumed valid for some fish markets, not all, since in several cases farmed fish are large, where capture fish are small, owing to the heavy exploitation of several fish stocks worldwide.

References

Asche, F. 1996. A System Approach to the Demand for Salmon in the European Union. *Applied Economics* 28:97–101.

Asche F., H. Bremnes, and C. Wessells. 1999. Product Aggregation, Market Integration and the Relationships between Prices: An Application to World Salmon Markets. *American Journal of Agricultural Economics* 81:568–81.

Asche, F., D. Gordon, and R. Hannesson. 2004. Test for Market Integration and the Law of One Price: The Market for Whitefish in France. *Marine Resource Economics* 19:195–210.

Asche, F., A.G. Guttormsen, T. Sebulonsen, and E. Sissener. 2005. Competition between Farmed and Wild Salmon: The Japanese Salmon Market. *Agricultural Economics* 33(3):333–40.

Asche, F., J. Hartmann, A. Fofana, S. Jaffry, and R. Menezes. 2001. *Vertical Relationships in the Value Chain: An Analysis Based on Price Information for Cod and Salmon in Europe*. Report No. 48/01 from the Centre for Fisheries Economics. Bergen, Norway: Institute for Research in Economics and Business Administration.

Asche, F., K.G. Salvanes, and F. Steen. 1997. Market Delineation and Demand Structure. *American Journal of Agricultural Economics* 79(February):139–50.

Barten, A., and L. Bettendorf. 1989. Price Formation of Fish – An Application of an Inverse Demand System. *European Economic Review* 33:1509–25.
Bjørndal, T., K. Salvanes, and D. Gordon. 1994. Elasticity Estimates of Farmed Salmon Demand in Spain and Italy. *Empirical Economics* 4:419–28.
Burton, M. 1992. The Demand for Wet Fish in Great Britain. *Marine Resource Economics* 7:57–66.
Clay, P., and A. Fofana. 1999. *Delineation of the UK Seafood Markets*, Scottish Agricultural Station, Management Division Working Paper No. 3.3, Aberdeen, Scotland, UK.
Dennis, J.G. 2006. CATS in RATS – Cointegration Analysis of Time Series, version 2, Estima, www.estima.com
DeVoretz, D., and K. Salvanes. 1993. Market Structure for Farmed Salmon. *American Journal of Agricultural Economics* 75:227–33.
Dickey, D.A., and W.A. Fuller. 1981. Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica* 49(July):1057–72.
Doornik, J.A., and H. Hansen. 1994. *An Omnibus Test for Univariate and Multivariate Normality.* Working Paper, Nuffield College, Oxford University, UK.
Eurofish. 2004. *Fish Info Network Market Report on Trout*, August 2004. Report available at www.eurofish.dk/
Eurostat. 2004. *New Cronos Database*, database available at http://epp.eurostat.cec.eu.int/
Food and Agricultural Organisation of the United Nations. 2002a. *Yearbook of Fishery Statistics—Aquaculture Productions*. Rome, Italy: FAO.
___. 2002b. *Yearbook of Fishery Statistics—Commodities*. Rome, Italy: FAO.
Food and Resource Economics Institute. 2005. Economic Situation of the Danish Fishery 2005. Report available at www.foi.kvl.dk/
Girag, S. 2002. *An Analysis of the Farmed Trout and Seabream Supply Chains in the Main EU Markets – Denmark, France, Germany, Greece, Italy, Spain and the UK*. Report prepared for the EU Commission under the Perspectives for Plant Protein Use in Aquaculture Programme PEPPA, Q5RS-2000-30068, France. www.girafood.com
Gonzáles-Rivera, G., and S.M. Helfand. 2001. The Extent, Pattern, and Degree of Market Integration: A Multivariate Approach for the Brazilian Rice Market. *American Journal of Agricultural Economics* 83(August):576–92.
Gordon D., K. Salvanes, and F. Atkins. 1993. A Fish is a Fish is a Fish? Testing for Market Linkages on the Paris Fish Market. *Marine Resource Economics* 8:331–43.
Guillotreau, P., ed. 2003a. *Prices and Margins along the European Seafood Value Chain.* EU-Funded Salmar project - Final report. Les Cahiers de l'Artemis-Organisations et Stratégies Industrielles N° 4. Nantes, France: Université de Nantes.
___. 2003b. How does the European Seafood Industry Stand after the Revolution of Salmon Farming: An Economic Analysis of Fish Prices. *Marine Policy* 28:227–33.
Ioannidis, C., and D. Whitmarsh. 1987. Price Formation in Fisheries. *Marine Policy* 11:143–45.
Jaffry S., S. Pascoe, and C. Robinson. 1999. Long Run Price Flexibilities for High Valued UK Fish Species: A Cointegration Approach. *Applied Economics* 31:473-81.
Jaffry, S., S. Pascoe, G. Taylor, and U. Zabala. 2000. Price Interactions between Salmon and Wild Caught Fish Species on the Spanish Market. *Aquaculture Economics and Management* 4(3):157–67.
Johansen, S. 1996. *Likelihood-Based Inference in Cointegrated Vector*

Autoregressive Models. Oxford, UK: Oxford University Press.
Johansen, S., and K. Juselius. 1994. Identification of the Long-Run and the Short Run Structure: An Application of the ISLM Model. *Journal of Econometrics* 63:7–36.
Lewbel, A. 1996. Aggregation without Separability: A Generalized Composite Commodity Theorem. *American Economic Review* 86:524–61.
MacKinnon, J.G. 1991. *Critical Values for Cointegration* Tests, *Long–Run Economic Relationships.* R. Engle and C.J.F. Granger, eds., pp. 267–76. Oxford, UK: Oxford University Press.
Moschini, G., and A. Vissa. 1993. Flexible Specification of Mixed Demand Systems. *American Journal of Agricultural Economics* 70(1):1–9.
Nielsen, M. 2005. Price Formation and Market Integration on the European First-hand Market for Whitefish. *Marine Resource Economics* 20:185–202.
Ravallion, M. 1986. Testing Market Integration. *American Journal of Agricultural Economics* 63(1):102–09.
Saarni, K., J. Setälä, A. Honkanen, and J. Virtanen. 2003. An Overview of Salmon Trout Aquaculture in Finland. *Aquaculture Economics and Management* 7(5-6):335–43.
Setälä, J., P. Mickwitz, J. Virtanen, A. Honkanen, and K. Saarni. 2002. *The Effect of Trade Liberation to the Salmon Market in Finland*. Proceedings of the Eleventh Biennial Conference of the International Institute of Fisheries Economics and Trade, August 19-22, Wellington, New Zealand.
Steen, F., F. Asche, P. Clay, S. Jaffry, L. Le Grel, S. Pascoe, and M. Tuncel. 1999. *The Implications for Fisheries Management Systems of Interactions between Farmed and Wild Caught Species*. SNF Report No. 59. Final Report from the FAIR Project CT96-1814. Bergen, Norway.
Stigler, G.J. 1969. *The Theory of Price.* London, England: MacMillan.
Stigler, G.J., and R.A. Sherwin. 1985. The Extent of the Market. *Journal of Law and Economics* 28:555–85.
Tuncel, M., and L. Le Grel. 1999. *Market Delineation of Aquatic Products in France*. Report No. 4 from the LEN-CORRAIL, University of Nantes, France.
Virtanen, J., J. Setälä, K. Saarni, and A. Honkanen. 2005. Finnish Salmon Trout-Discriminated in the European Market. *Marine Resource Economics* 20:113–19.