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Searching For Price Parity in the European Whitefish Market

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Frank Asche
Daniel V. Gordon
Rögnvaldur Hannesson

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Abstract

The purpose of this paper is to test for price parity across different species of whitefish in the European Union. Price parity is defined by a system of cointegrated prices and would be evidence of a single European market for whitefish. Whitefish are of interest because EU fishers receive the largest share of their income from these fish species. Notwithstanding the single market policy of the EU, by establishing national and regional associations to stabilize or increase the local price of fish, fishers operate as if the European market is made up of separate sub-markets with price being determined largely within each sub-market. If whitefish markets were price cointegrated such associations would be largely ineffective. In that case, what are required are regulations that encompass the European market.

* Foundation for Research in Economics and Business Administration, Norwegian School of Economics and Business Administration, Bergen - Sandviken, Norway and Stavanger University College, Stavanger, Norway. E-mail: Frank.asche@tn.his.no

** Department of Economics, The University of Calgary, Calgary, Canada and The Centre for Fisheries Economics, Norwegian School of Economics and Business Administration, Bergen - Sandviken, Norway. E-mail: Dgordon@ucalgary.ca

*** The Centre for Fisheries Economics, Norwegian School of Economics and Business Administration, Bergen - Sandviken, Norway. E-mail: Rognvaldur.hannesson@nhh.no

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I. Introduction

Time series techniques are useful in investigating relationships among prices in primary product markets.[1] The purpose is to define market boundaries and determine any causal relationships that may exist among prices for goods in the same market.[2] If goods are in different markets then the price of the goods can over time move independently having no influence or causation on the other. On the one hand, if goods are in the same market then price movements in one good will call forth a response in the market, either profit maximizing arbitrage on the supply side or substitution of goods on the demand side, that regains the equilibrium relationship among the prices. In this way, by examining the relationships among prices over time, the relevant market can be defined.

Since most price series tend to be nonstationary, statistical efforts focus on the existence of a cointegrating price vector, which, if observed represents a stable long-run equilibrium among the prices (i.e., price parity) and defines market boundaries for the products examined.[3] Tests for a cointegrating price vector are based on the concept of canonical correlations from the theory of multivariate analysis (Johansen 1988, 1993 and Johansen and Juselius 1990). The test procedure is complete in the sense that it defines the exact limiting distribution for the estimator, allowing for tests of linear restrictions on the cointegrating vectors, as well as, estimates of its elements and information about its rank. The purpose of this paper is to exploit the multivariate statistical properties of the Johansen procedure to investigate the relationship among prices for whitefish products in the European Union using price data collected for France, Germany and United

Kingdom. Our interest is to define market boundaries based on long run equilibrium price paths in order to determine the possible existence of a single European market for whitefish.

Our empirical work is focused on whitefish[4] products from which fishers in the EU generate a large portion of their income. In value terms, cod is the most important whitefish species in the EU market. Prices for the different whitefish show substantial month to month variation with a declining trend throughout the 1990s. Fishers have tried to influence the prices received by organizing national and regional associations (producer organizations) with the objective of stabilizing or increasing the price of fish.[5] On occasion, protests against declining prices have erupted in acts of violence directed at imported fish suppliers and vendors. It appears as if fishers perceive the EU market as made up of a number of price segmented or semi-autonomous regional markets. If this were true, prices across regional markets cannot be cointegrated.

On the other hand, if markets in the EU are integrated then prices in different regional markets will follow a similar pattern. What is more, an integrated EU market would imply the need for encompassing regulations rather than piecemeal policies set up by individual countries or regional organizations, which would be largely ineffective. With free trade in goods within the EU, it is expected that national markets should be integrated and that price differentials will be eroded quickly through shifts in supply.[6]

It is worth noting that the cointegrated price system used to define market boundaries is a long run concept. As such, in the short run, prices can vary across countries but cointegration ensures that this variation will not persist and arbitrage forces the recovery of the equilibrium price path for all prices in the system.

It is also possible that regional markets will be integrated across product type. Products such as frozen fillets can be derived from different types of whitefish and processing for final consumption can result in the taste of the original fish being lost (e.g., frozen battered fish sticks). Even if it is possible to discern differences in texture and taste between fillets derived from different types of whitefish, the degree of substitution for frozen fillets of different whitefish species could nevertheless be quite high. The prices of frozen blocks of whitefish used for processing would tend to move together over time as consumers substitute away from the higher priced products and processors respond to profit incentives in processing (Gordon, Hannesson and Bibb, 1993a).

Different products made from the same type of fish may actually have a more distinct identity (e.g., cod fish processed into frozen fillets versus dried or salted). As prices diverge, fish producers are likely to switch to producing the more profitable products, which will force convergence in the prices of the different product forms. Policy regulation for one particular product type will necessarily impact on other products of the same species if markets are integrated.

Although the focus of the study is on whitefish products it is difficult to ignore the substantial increase in salmon imports to the EU during the 1980s and 90s. Earlier research has shown that salmon represents a separate market independent of other fish species (Gordon, Salvanes and Atkins, 1993b). However, with prices of salmon declining steadily over the last years, it is possible that salmon now forms part of an integrated market with whitefish products. Statements from the fishing industry strongly suggest that declining salmon prices have influenced prices of whitefish. A possible price link between salmon and whitefish species can be measured within a cointegration testing procedure.

The paper is organized as follows. In Section II, the statistical procedure used in testing is presented. In Section III, the data and empirical method used in estimation are summarized. The empirical focus is on market delineation both across national markets and within a single national market. Results of testing are reported in Section IV. Section V concludes.

II. Time Series Modelling for Market Integration

Time series tests for market delineation exploit the fact that economic series tend to be nonstationary. A nonstationary series changes overtime in an unstable or unpredictable way and its mean and variance is not well defined. However, it is possible that linear combinations of nonstationary variables may be stationary or cointegrated (Engle and Granger, 1987). If cointegration is observed, there will exist a stable long-run relationship among the nonstationary variables. For market delineation, cointegration implies the existence of price parity and that the products examined belong to the same market (Stigler, 1969). Prices may drift apart in the short run due to random shocks, sticky prices, contracts etc., but in the long run prices will return to the equilibrium path.

The time series approach has some advantages over traditional market demand studies. If the variables of interest in a market demand study are not cointegrated, a standard regression analyses of the variables may lead to incorrect inferences because the true value of the coefficients must be zero. On the other hand, if cointegration is observed, the traditional regression model defines the long run relationship among the prices but an ‘error-correction’ model is necessary to estimate short-run deviations from the equilibrium path (Granger, 1986). As a practical matter, time series procedures are less demanding in terms of data requiring only information on prices and not information on the full set of variables commonly used in demand studies (i.e., quantity, income, etc.).[7] Moreover, with the empirical focus on prices, time series procedures make no distinction between domestic production and foreign imports. This is in contrast to the problems domestic production might cause when estimating import demand functions. For example, in the Armingtion approach, an assumption of weak separability between domestic production and imports is necessary but empirically untenable.

The search for equilibrium price paths begins with an examination of the data generating process that produced the individual price series. Each variable is likely to be nonstationary in level form but can be made stationary by differencing one or more times. The order of integration is determined by the number of times differencing is required to achieve stationarity. The probability distribution of a stationary series is invariant with respect to time, with constant mean and variance. The Augmented Dickey-Fuller (ADF) statistic is used here to determine the order of differencing to achieve stationarity (Dickey and Fuller, 1979; 1981). For each individual price (p_{it}) the ADF statistic is measured from the following regression

$$\Delta p_{it} = \beta_o + \beta T + \sigma p_{it-1} + \sum_{\gamma=1}^{k} \alpha_\gamma \Delta p_{it-\gamma} + \varepsilon_t , \qquad (1)$$

where Δ is the difference operator and T is a time trend. The lag length, k, is set to achieve white noise in the error term (Gordon, 1995). The null hypothesis is that the series is non-stationary against the alternative hypothesis of stationarity. The null hypothesis is tested based on the ratio of σ to its standard error.

It is possible that a linear combination of nonstationary price variables may be stationary. If this is true, there must exist a cointegrating vector that defines the long-run equilibrium relationship and results in a stationary process. For example, consider two price series, x_t and y_t. Each series is nonstationary and integrated of order one (i.e., x_t and $y_t \sim I(1)$) but a linear combination

$$y_t + \Psi x_t = \varepsilon_t \tag{2}$$

may be stationary (i.e., $\varepsilon_t \sim I(0)$). If this is true, ε_t is a white noise stationary process and the cointegrating vector is defined as $[1,\Psi]$. The generalisation to the n variable case is straightforward.

The Johansen test for cointegration is based on a vector autoregressive (VAR) representation. A vector, P_t, containing the N price variables of interest is defined by a vector autoregressive system of equations;

$$P_t = \Pi_1 P_{t1} + \cdots + \Pi_k P_{tk} + \Phi D_t + \mu + e_t, \tag{3}$$

where each Π_i is a (N x N) matrix of parameters, D_t are seasonal dummies orthogonal to the constant term μ and $e_t \sim$ N *iid* $(0, \Sigma)$. The VAR system of equations can be written in error correction form as,

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma_i \Delta P_{ti} + \Gamma_k P_{tk} + \Phi D_t + \mu + e_t, \qquad (4)$$

with $\Gamma_i = -I + \prod_1 + ... + \prod_i$ and $i = 1, ..., k-1$. Hence, Γ_k is the long-run solution to Equation (3). If $\boldsymbol{P}_t$ is a vector of first difference stationary variables, then the left-hand side and the first (k-1) variables on the right-hand side of Equation (4) are stationary, and the last element (e_t) is a linear combination of first differenced variables. It must be true that the error term, e_t is stationary. Hence either $\boldsymbol{P}_t$ contains a number of cointegrating vectors, or Γ_K must be a matrix of zeros. The rank of Γ_K, defined by r, determines how many linear combinations of $\boldsymbol{P}_t$ are stationary. If $r = N$, the variables are stationary in levels, if $r = 0$, there exists no linear combinations which are stationary. When $0<r<N$, there exists r cointegrating vectors, or r stationary linear combinations of $\boldsymbol{P}_t$. In this case, one can factor Γ_K , such that, $\prod_K = \alpha\beta'$ where both α and β are (N x r) matrices, and β contains the cointegrating vectors and α the adjustment parameters.

Johansen shows that it is possible to test for the number of significant vectors, r, using two alternative tests, the Trace test and the Maximum Eigenvalue test. The Trace test (η_r) is a lkelihood ratio test for at most r cointegrating vectors;

$$\eta_r = -T \sum_{i=r+1}^{N} \ln(1 - \hat{\lambda}_i) \qquad (5)$$

where T is the number of o bservations, and the $\hat{\lambda}_i$ are the eigenvalues that solve the eigenvector problem. The Maximum Eigenvalue test (ξ_r), is a test of the null hypothesis of r+1 cointegrating vectors against the alternative hypothesis of r cointegrating vectors;

$$\xi_r = -T \ln(1 - \hat{\lambda}_{r+1}). \qquad (6)$$

We will focus only on bi-variate relationships. The main reason for this is that bi-variate relationships contain the same information as multivariate analysis, and as it saves degrees of freedom we avoid what Hendry (1995) calls the "curse of dimensionality". Bi-variate analysis contains the same information as multivariate analysis because if all variables are pair wise cointegrated, any multivariate system contains only one stochastic trend. In any multivariate system with n variables and one stochastic trend, there will be n-1 cointegration vectors (Stock and Watson (1988). In this case, Johansen and Juselius (1994) show that an exactly identified representation of the system can be defined using bi-variate relationships.

III. Empirical Method and Data

Monthly value and quantity figures for different whitefish species are collected from Eurostat trade statistics for three countries France, Germany and UK. These countries represent by value the most important markets for whitefish products in the EU and provide the most compete and lengthy data series. Monthly price series are obtained by a value quantity transformation and missing observations are interpolated following Gordon and Hannesson (1996).

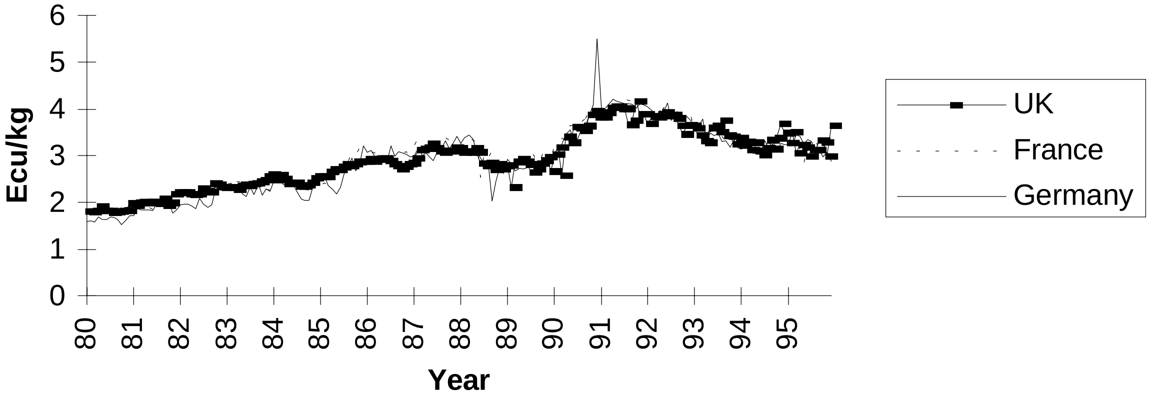
Prices are available for France, Germany and UK for frozen fillets and fresh fillets of cod (January, 1980 to December, 1995), and frozen fillets of saithe (January, 1983 to December, 1995). For France and UK prices are available for frozen haddock fillets (January, 1983 to December, 1995) and for France and Germany prices are available for frozen redfish fillets

(January, 1983 to December, 1995). Finally, for France prices are available for dried salted cod (January, 1983 to December, 1995) and for fresh salmon (January 1983, to December, 1995).

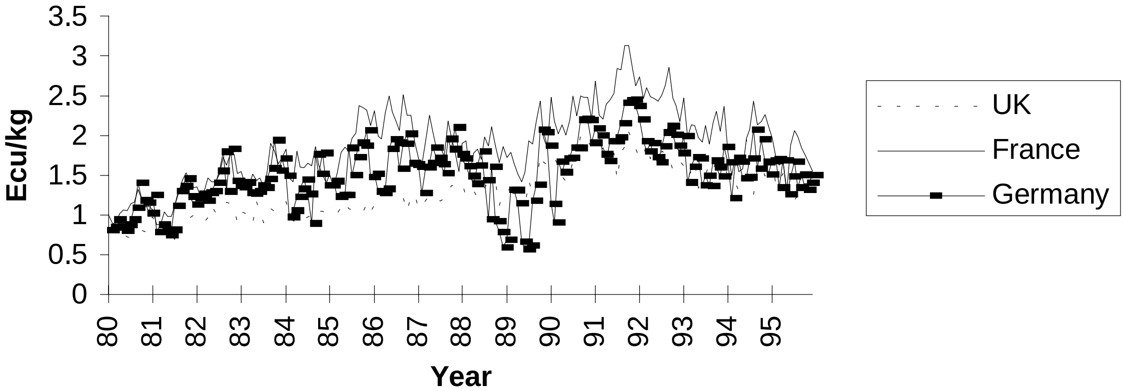
The empirical method is first, to test for market integration across countries using comparable types of fish price data (e.g., fresh cod or frozen saithe, etc.). If markets are integrated by fish type, it must be true that pair wise comparisons for any two countries must also be integrated. Test results are reported for pair wise comparisons for each fish product for each pair of countries. Second, the investigation of market integration continues with an examination of the price relationship within a single national market for similar products derived from different types of whitefish (e.g., frozen fish blocks), and for different fish products derived from the same fish (e.g., fresh, frozen or dried salted cod). France is the single most important fish import country in the EU for which data are most readily available, and will be the focus of the single national market investigation. Finally, for France we measure for price cointegration between salmon and different white fish species and product forms.

The price data used in empirical testing is summarised graphically in Figures 1-3. Figure 1, shows the price data available for the three European countries for cod, saithe, haddock and redfish. In graphs (i) and (ii) of the figure, prices of frozen fillet and fresh fillet of cod are plotted, respectively. Across countries frozen cod prices follow a similar pattern overtime whereas, fresh cod prices show substantially more month to month variation with French prices noticeably higher than either the German or UK. For prices of frozen saithe, haddock and redfish, in graphs (iii), (iv) and (v), respectively, France again appears to maintain the higher price, but across countries prices generally follow a similar pattern. Prices show a declining trend after 1991 for all whitefish products examined.

i) Frozen Cod Fillets



ii) Fresh Cod



iii) Frozen Saithe Fillets

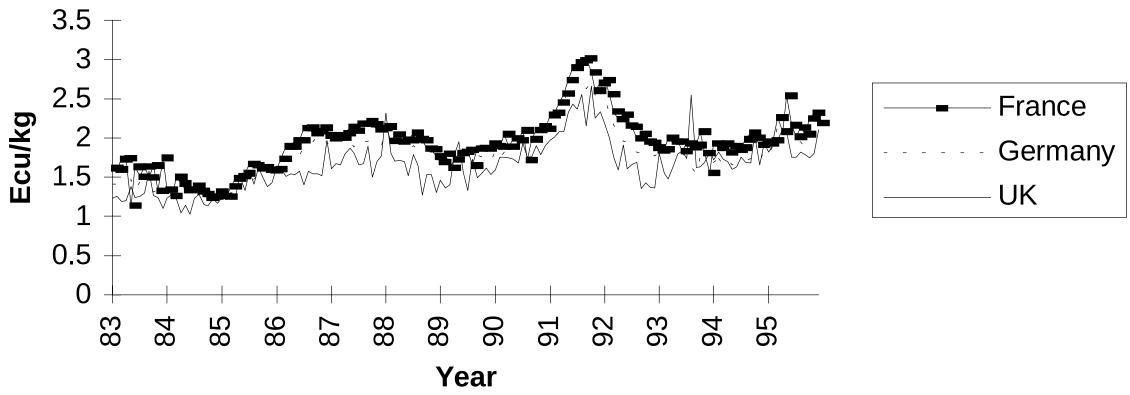
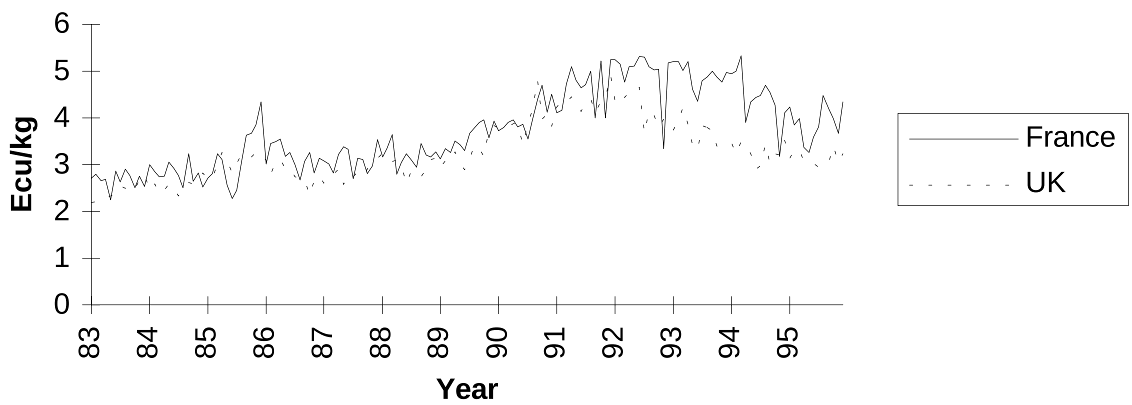


Figure 1. Prices of different whitefish species: France, Germany and the UK

iv) Frozen Haddock Fillets



v) Frozen Redfish Fillets

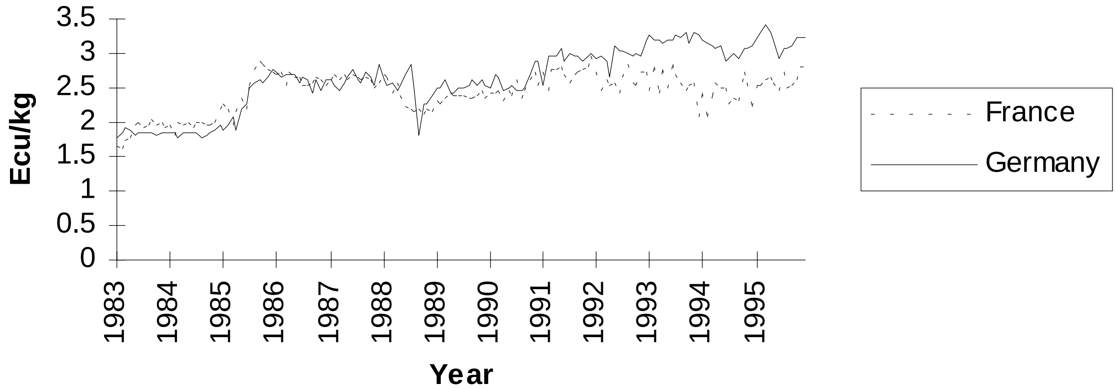


Figure 1. Prices of different whitefish species: France, Germany and the UK (cont'd)

In Figure 2, the prices for France of different product forms of cod (i.e., frozen, fresh and dried salted cod) are graphed for the period 1983-95. Except for a large spike in the price of dried salted cod in the middle of 1985, the prices of the three product forms trend together overtime.[8] Dried salted cod always obtains the highest price followed by the price of frozen cod and, finally, fresh cod, which receives the lowest price of the different product forms.

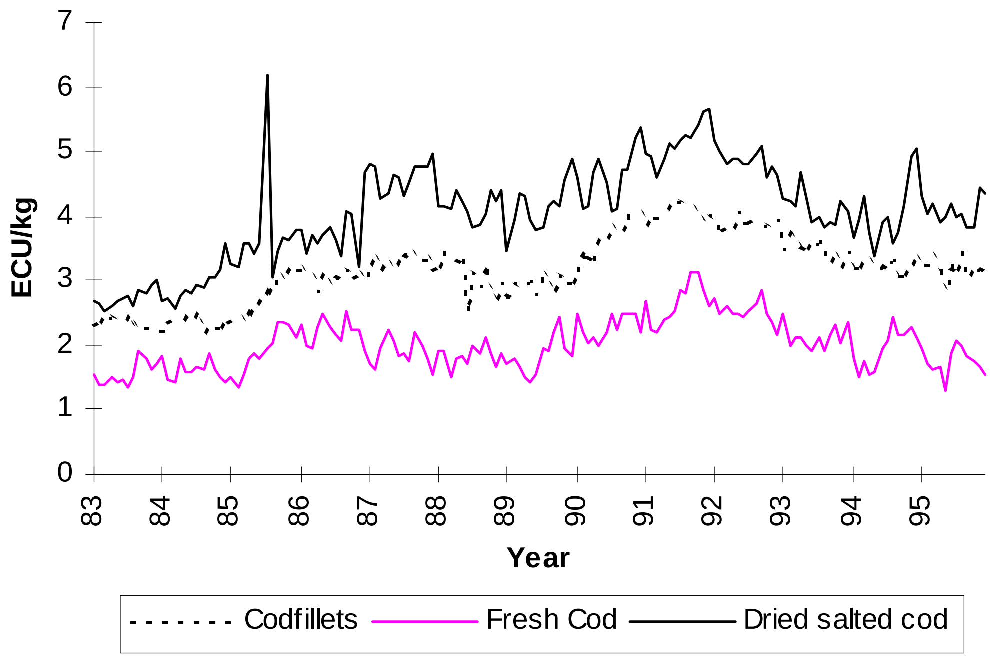


Figure 2. France prices of different product forms - Cod, 1983-1995

In Figure 3, the price of salmon for France is shown for the period 1983-95. Also, for comparison, we graph the corresponding price movements for cod, haddock, redfish and saithe. Prior to 1990, salmon prices were noticeably higher than for whitefish products and showed a trend opposite to the movement in whitefish prices. However, during the 90s the prices of salmon and whitefish products appear to move together, which may indicate an integrated market after 1990.

In searching for market integration, the first priority is to examine each price series for evidence of stationarity. In Table 1, the results of the ADF test for individual prices are reported. The null hypothesis is that each price series is stationary in first differences against the alternative of stationary in level form. The ADF statistic is calculated from Equation (1) without a trend line reported in column two and including a trend reported in column three. Evidence of stationarity in first differences, at the 5% level, is observed if the ADF statistic is greater than -2.879 without trend and greater than -3.439 with trend. Except for the price of fresh cod in Germany, the ADF statistic, with and without a trend line, shows fish prices to be first difference stationary. For the exception, the ADF without trend rejects first difference stationary, however, the with trend results show first difference stationary. Keeping this result in mind, we conclude that all fish prices examined are first differenced stationary and proceed with tests for market boundaries.

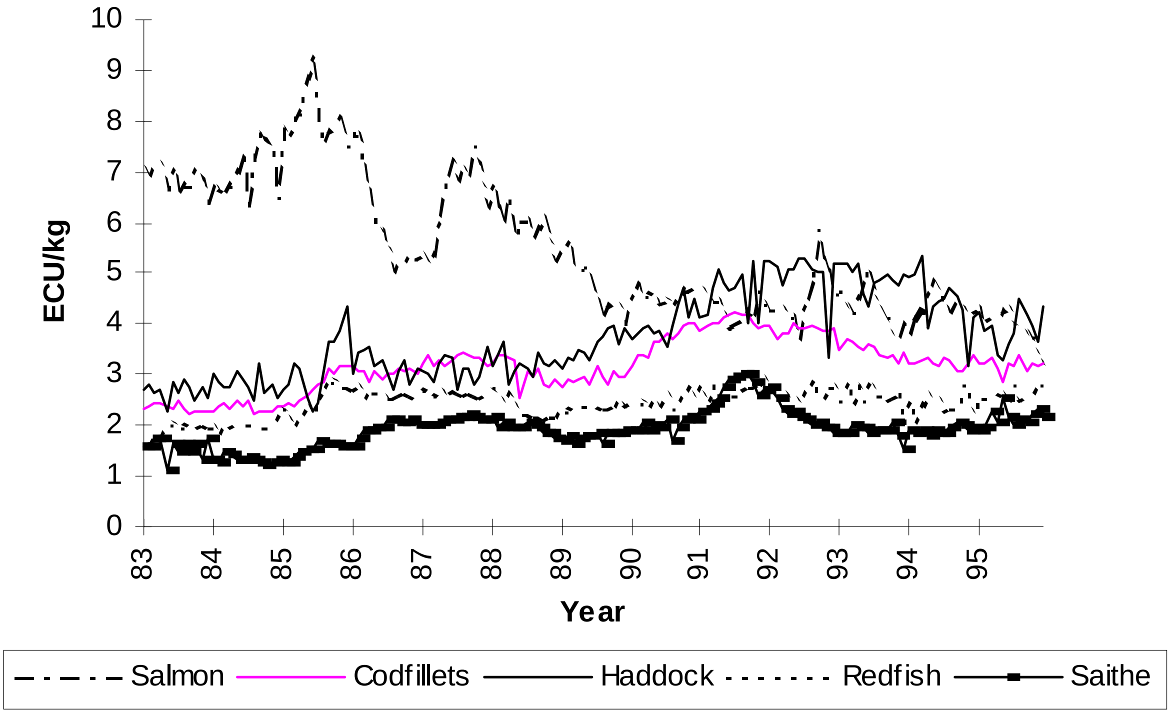


Figure 3. France, prices of salmon and whitefish species, 1983-1995

Table 1: Tests for Unit Roots in Prices of Different WhiteFish Species and Salmon in Germany, France and U.K.

	Test Statistic	Test Statistic with Trend
Frozen Cod Fillets		
Germany	-2.18	-2.05
France	-2.52	-1.73
U.K.	-1.87	-2.07
Fresh Cod		
Germany	-3.14*	-3.13
France	-2.23	-1.21
U.K.	-2.13	-0.89
Frozen Saithe Fillets		
Germany	-1.74	-2.19
France	-1.56	-1.68
U.K.	-2.25	-2.89
Frozen Haddock Fillets		
France	-1.97	-1.34
U.K.	-1.48	-1.47
Frozen Redfish Fillets		
Germany	-1.57	-2.14
France	-2.39	-2.42
Salmon		
France	-0.67	-2.78
Dried Salted Cod		
France	-2.44	-2.10

NOTE: *statistically significant at the 5% level. Critical values at 5% level -2.91 without trend and -3.499 with trend.

IV. Test Results for Cointegration

In Table 2, cointegration test results are reported for different species and product forms of whitefish in pair wise testing across different European countries. There are eleven separate pair wise tests reported in the table. The purpose is to determine if the same type of fish species and product forms are price integrated across national markets (i.e., the existence of a European market for whitefish). The first column of the table shows product and fish type, and the countries used in pair wise testing. Columns two and three show the value of the calculated statistics for the Maximum Eigenvalue and Trace Test for testing the null hypothesis that there exists no cointegrating vector. Columns four and five repeat the tests under the null hypothesis that there exists less than or equal to one cointegrating vector.

In all pair wise country tests, the null hypothesis of no cointegrating vector (Rank = 0) is rejected at the 1% level and conversely the null hypothesis of less than or equal to one cointegrating vector (Rank $\leq$ 1) cannot be rejected at the 1% level. These results show empirical evidence that the prices of different fish species and product forms across countries do not represent separate or independent prices but rather form part of a European system of fish prices. At least in terms of the countries examined here, market boundaries for whitefish in the EU extend beyond individual country boarders.

The French whitefish market is the largest in Europe with substantial quantities of imported product. For this reason and the fact that the price series are more complete for the French market relative to Germany or UK, we focus additional cointegration testing on this market. In Table 3, the bivariate Johansen cointegration test results for a similar product derived from different species of whitefish and for three different products forms of cod (i.e., frozen, fresh and dried) are reported.

TABLE 2:
Bivariate Johansen Test for Regional Integration for Comparable WhiteFish Species

Prices	Null Hypotheses[a)]			
	Rank = 0		Rank = 1	
	Max[b)]	Trace[c)]	Max	Trace
Frozen Cod				
Ger/Fra[d)]	79.83*	84.93*	5.09	5.09
Ger/U.K.	74.52*	84.93*	5.51	5.52
Fra/U.K.	71.92*	76.96*	5.08	5.08
Fresh Cod				
Ger/Fra	46.41*	57.62*	11.21**	11.21**
Ger/U.K.	40.75*	48.63*	7.88	7.88
Fra/U.K.	36.44*	44.45*	8.01	8.01
Frozen Saithe				
Ger/Fra	89.03*	91.70*	2.67	2.67
Ger/U.K.	60.22*	63.17*	2.95	2.95
Fra/U.K.	84.07*	90.62*	5.45	5.45
Frozen Haddock				
Fra/U.K.	45.40*	52.16*	6.76	6.76
Frozen Red Fish				
Ger/Fra	55.02*	61.04*	6.01	6.01

NOTE: [a)]The null hypothesis is that the number of cointegrating vectors is equal to zero or one
[b)]Maximum Eigenvalue Test
[c)]Trace Test
[d)]Ger is Germany, Fra is France, U.K. is United Kingdom
*statistically significant at the 1% level
**Statistically significant at the 5% level

TABLE 3: Bivariate Johansen Test for Different Product Forms of Cod: France

Prices	Null Hypotheses[a)]			
	Rank = 0		Rank = 1	
	Max[b)]	Trace[c)]	Max	Trace
Frozen Cod/ Fresh Cod	31.05*	36.39*	5.34	5.34
Frozen Cod/ Dried Cod	34.10*	38.49*	4.39	4.39
Fresh Cod/ Dried Cod	26.15*	33.40*	7.25	7.25

NOTE: [a)]The null hypothesis is that the number of cointegrating vectors is equal to zero or one
[b)]Maximum Eigenvalue test
[c)]Trace Test
*statistically significant at the 1% level
**Statistically significant at the 5% level

The purpose is to establish whether the prices of different whitefish and the prices of different product forms of cod are part of the same market. Evidence of cointegration across the different whitefish species and product forms will indicate that the EU whitefish market extends not only across countries but also across different whitefish species and product forms. In other words, the entire fish market is well integrated both vertically and horizontally.

In columns two and three of Table 3, the calculated value of the Maximum Eigenvalue and Trace Test, respectively, are listed for the null hypothesis of no cointegrating vector. In all cases, the null hypothesis can be rejected at the 1-% level. In column four and five, the test is repeated for the null hypothesis that there is less than or equal to one cointegrating vector. In this case, the null hypothesis can not be rejected at the 1-% level for either the Maximum Eigenvalue or Trace Test. These results show that the market for whitefish is robust across fish species and product forms. Whereas, cointegrated markets across countries is driven by arbitrage on the supply side cointegration across fish species and product forms is most probably driven by demand side factors where consumers substitute across fish species and product forms.

To determine whether salmon is an important factor in the EU whitefish market, the price of imported salmon is introduced into the equation and pair wise testing against the different prices of whitefish species are performed. The French fish prices included in the pair wise tests represent fresh salmon, frozen cod, fresh cod, dried cod, and frozen saithe, haddock and redfish. The results are reported in Table 4. In column one of the table the different fish species used in testing are listed. Columns two and three show the value of the calculated statistics for the Maximum Eigenvalue and Trace Test for testing the null hypothesis that there exists no cointegrating vector. Columns four and five repeat the tests under the null hypothesis that there is less than or equal to one cointegrating vector.

The value of the test statistics reported in column two and three do not allow us to reject the null hypothesis of no cointegrating vector for all pair wise tests using either the Maximum Eigenvalue or Trace Test statistics. In other words, salmon does not form a cointegrated system with any of the different whitefish species and product forms. For completeness we repeat the test under the null hypothesis of less than or equal to one cointegrating vector. For the results to be consistent the calculated values of the statistic should not allow us to reject the null of less than or equal to one cointegrating vector. For all pair wise tests the results show that the null cannot be rejected. These results are consistent with a conclusion of no evidence of a cointegrated system that includes salmon and whitefish species. The increased supply of salmon on the French market is an interesting development in the fish industry but the data and model used in this study shows no evidence of declining salmon prices influencing the prices of whitefish in the EU market.

TABLE 4: Bivariate Johansen Test for Salmon and Different WhiteFish Species: France

	Null Hypotheses[a]			
Prices	Rank = 0		Rank = 1	
	Max[b]	Trace[c]	Max	Trace
Salmon/ Frozen Cod	8.48	11.16	2.67	5.34
Salmon/ Fresh Cod	16.51**	18.52	2.01	2.01
Salmon/ Dried Cod	12.53	14.80	2.26	2.26
Salmon/ Saithe	8.06	9.99	1.93	1.93
Salmon/ Haddock	15.39	17.45	2.06	2.06
Salmon/ Red Fish	10.79	13.48	2.69	2.69

NOTE: [a]The null hypothesis is that the number of cointegrating vectors is equal to zero or one
[b]Maximum Eigenvalue test
[c]Trace Test
*statistically significant at the 1% level
**Statistically significant at the 5% level

V. Concluding Comments

The purpose of this paper is to define market boundaries for whitefish species and product forms within the European Union. The Johansen cointegration testing procedure offers a statistical testing method to investigate whether the different fish prices form a long-run equilibrium relationship. In bivariate testing, the empirical results show evidence of a robust and integrated EU whitefish market. The extent of the market includes not only different species of fish across national borders but also for similar product forms made from different fish species, and for different product forms made from the same fish species.

Given the single market policy of the EU the results of this paper may not be surprising. Within the fishing industry, however, there is serious debate as to the cause of price determination of different fish species. The abundance of imported salmon on the EU market and the subsequent decline of whitefish prices are seen as evidence of causal relationship but, in fact, the data show no evidence of cointegration between the prices of salmon and whitefish species. In other words, the price of salmon and the prices of whitefish are determined independently. What is clear, is that policies designed to better the lot of fishers in the EU must recognize the single EU market for whitefish when implementing regulations. Moreover, the single EU market for whitefish leaves no scope for influencing the long run prices of whitefish by regional associations.

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ENDNOTES

[1] See, Ardeni, 1989; Beck, 1994; Benson, et. al. 1994; Goodwin and Schroeder, 1990; Gordon, Salvanes and Atkins, 1993; Doane and Spulber, 1995; Sauer, 1995; Bose and McIlgrom, 1996; Gordon and Hannesson, 1996; Asche, Salvanes and Steen, 1997.

[2]Stigler (1969) defines market as "the area within which the price of a good tends to uniformity, allowances being made for transportation costs," (p. 85).

[3] For stationary prices, causality tests provide the same information. For an application of causality tests for market integration, see Slade (1986).

[4] Whitefish include the species cod, haddock, redfish and saithe.

[5] Hatcher (1997) describes some of the functions of fisheries organization in the UK.

[6] Fresh fish might be the exception, because of problems of storage.

[7] Of course, by excluding most demand variables from the analysis, time series modelling is silent on measuring the statistical characteristics of such variables.

[8] The spike is most certainly an outlier, possibly due to a data collection error. A similar outlier can also be found in the German import price for frozen cod fillets. We found that the empirical results were not significantly affected by removing the outliers from the data set.