PRICE FOUNDED TESTS FOR MARKET INTEGRATION:

FISH MARKETS IN FRANCE

by

Frank Asche*

Daniel V. Gordon**

Rögnvaldur Hannesson*

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* Department of Economics and Centre for Fisheries Economics, Norwegian School of Economics and Business Administration, Bergen - Sandviken, Norway.
** Department of Economics, The University of Calgary, Calgary, Canada and Centre for Fisheries Economics, Norwegian School of Economics and Business Administration, Bergen - Sandviken, Norway.

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Abstract

This paper discuss the relationship between traditional parametric tests for market integration such as causuality tests and tests of the Law of One Price and cointegration tests for market integration. We show that cointegration tests are a natural extension of the traditional methods taking into account that prices are nonstationary, and not an alternative approach. By using the Johansen test, one can both test for causality and provided that prices are cointegrated, for the Law of One Price. An empirical analysis is provided for the whitefish market in France.

I. Introduction

What constitutes a market is an important question in many contexts, as virtually all microeconomic analysis is based on some definition of a market. While the concept of a market is unproblematic in theory, it is often difficult to define empirically. However, the importance of defining a market empirically can be seen in a number of cases, including antitrust cases, antidumping cases and price supporting schemes. One of the most common approaches to investigate market integration empirically is to test the relationships between prices over time. Empirical approaches include tests for the Law of One Price (LOP), tests for causality, correlation analysis and cointegration tests.

In this paper, we will focus on the parametric approaches. The Law of One Price is the relationship with the longest history, but is also the most restrictive condition for market integration. However, that goods are not perfect substitutes, or that e.g. transportation costs prevent markets from being perfectly integrated, indicates that the LOP might be a too strong relationship. This has led to extensions in two directions: As the adjustment may take time, one has allowed the Law of One Price to hold only as a long-run relationship (Ravallion 1986; Goodwin, Grennes and Wohlgenant, 1990). Further, if markets are not perfectly integrated, the relationships between prices need not be proportional. Hence, one has used causality tests to delineate markets, or to find market boundaries (Horowitz, 1981; Ravallion, 1986; Slade, 1986).

Recently, since most price series tend to be nonstationary, cointegration tests have become the tool of choice when investigating relationships among prices.[1] Using cointegration test has mostly been regarded as a new approach to investigate market integration, although some of the papers in this tradition, and particularly the early ones, are motivated by the LOP.[2] This interest in the LOP has diminished, mainly because of the difficulties in testing hypothesis on the parameters when using cointegration tests, as the preferred tool, the Engle and Granger test (Engle and Grange, 1987), does not allow such tests. This has led to the looser notion that the long-run relationship implied by cointegration is sufficient for market integration.

In this paper we will emphasize the similarities between LOP/causality tests and cointegration test as tools to investigate market integration. In fact, by using appropriate tests for cointegration, one can show that the two approaches provide the same information. What should determine the choice of tool is the characteristics of the underlying data; if the prices are stationary, LOP/causality tests should be used, while if prices are nonstationary, cointegration tests should be used.

In most studies using cointegration tests to investigate market integration, the Engle and Granger test has been the preferred tool, although some recent exceptions exist. This test has several weaknesses. The most important in a market delineation context are that one cannot test hypothesis on the estimated parameters and that the estimates of the cointegration vectors are dependent on the choice of dependent variable. In fact, in some cases the conclusion will depend on the choice of dependent variable (Goodwin and Schroeder, 1990; Zanias, 1993; Doane and Spulber, 1995). In general, it is well known that these problems can be avoided by using the Johansen test (Johansen, 1988), and we will here exploit this in the context of market integration.

An empirical analysis is carried out for whitefish products in France, from which fishermen in France derive a large portion of their income.[3] Fishermen have also organized regional associations, producer organizations (PO's), for the purpose of influencing fish prices of particular species with the objective of stabilizing the price of fish and fishermen's income.[4] To what extent this will be possible depends on to what extent markets are integrated across product type. Moreover, there is already evidence that prices of frozen cod fillets in different regional markets (France, Germany, UK and USA) are integrated (Gordon and Hannesson, 1996). To find that prices of frozen cod fillets are related to other whitefish products might therefore suggest an integrated market for whitefish not only in France, but also globally.

The paper is organized as follows. In Section II, the Johansen time series procedure and the statistical test for the Law of One Price are presented. In Section III, the data is described and the empirical results reported. Section IV concludes.

II. Time Series Modeling of Market Integration

Relationships between prices has a long history in economics, and early economists like Cournot and Marshall used the relationship between prices to define a market as early as the in the 19th century. In relation to international trade, Cassel (1918) seems to be the earliest reference. Also more recent definitions are often based on the relationship between prices. For instance, Stigler (1969, p. 85) defines a market as "the area within which the price of a commodity tends to uniformity, allowance being made for transportation costs". Based on these market definitions, there exists a large empirical literature investigating market integration by analyzing relationships between prices. These approaches have their deficiencies, and certainly provide less information then partial equilibrium models of markets where demand and supply equations are specified. However, since price data are available to a much larger extent than quantity data, price analysis will be possible in many cases were analyses using other approaches are not.

In most studies of market integration, tests are performed on the logarithms of prices, and throughout this paper we will proceed under this assumption. With stationary price series, the test for market integration with the least restrictive assumptions is the causality test for market boundaries used by Slade (1986).[5] Given time series of two prices, p_t^1 and p_t^2, a causality test is performed by first running the regression[6]

(1) $$p_t^1 = a + \sum_{i=1}^{m} b_i p_{t-i}^1 + \sum_{i=0}^{n} c_i p_{t-i}^2 + e_t$$

The lag length is chosen so that e_t is a white noise error term. One concludes that p_t^2 causes p_t^1 if one must reject the null hypothesis that all c_i parameters are zero. Economic theory does not give any guidance to the choice of dependent variable, and the tests are therefore mostly done twice, with both prices as dependent variables. If there is no causation in any of the equations, the goods are not in the same market. Sometimes one might also find that one price causes the other while the opposite does not hold. This is an interesting result, and may occur e.g. when there is one central market that affects regional markets, but where none of the regional markets are big enough to affect the central market.

Equation (1) nests the LOP. If the restriction $\sum b_i + \sum c_i = 1$ holds, one can conclude that the LOP holds as a long-run relationship, while if $c_o = 1,\ c_i = 0$ and $b_i = 0,\ \forall i > 0$ holds, LOP holds instantaneously.[7] Hence, the LOP is a more restrictive test than causality.

Testing for LOP as a static (or instantaneous) relationship is probably the most common test for market integration, and is carried out by regressing one price on the other (and a constant term), and testing whether the parameter on the price equals one.[8] This static relationship also provides the first illustration of the relationship between tests for the LOP and cointegration tests for market integration, as the simplest of the cointegration tests, the Engle and Granger test (Engle and Granger, 1987) is carried out on the same static equation. However, the cointegration test is concerned with the time series properties of the residuals in this regression and not the parameter values. The price series are found to be cointegrated if the residuals are stationary. It is of interest to note that if data series are nonstationary but cointegrated, the error terms in a static regression must be serially correlated (Engle and Granger, 1987). This implies that for nonstationary prices, there must be some dynamic adjustment for the prices. Hence, a static representation of the LOP cannot be correct when prices are nonstationary.[9]

When using the Engle and Granger test, one cannot test hypothesis on the parameters (the cointegration vector). Hence one cannot test the restriction for LOP using this method.[10] However, note that it is the same basic relationship between prices one are concerned with and that estimates are provided for, both when using static models and later, when more complicated dynamic models are used in relation to the Johansen test.

This leads us to the Johansen test (Johansen, 1988) for cointegration, which is formulated in terms of a VAR for the data series in question. In contrast to what is the case with the Engle and Granger test, one can also test hypotheses on the parameters in the cointegration vector. Furthermore, since the test is carried out in a system, one need not normalize on any of the prices. Given a vector, P_t, containing the variables of interest, in our case the two prices, the Johansen test is carried out in the following VAR;

$$(2) \qquad P_t = \sum_{i=1}^{k-1} \Pi_i P_{t-i} + \Pi_k P_{t-k} + \mu + e_t \,,$$

where each Π_i is a ($N \times N$) matrix of parameters, μ is a constant term and $e_t \sim iid\ (0,W)$. The system of equations can be written in error correction form as;

$$(3) \qquad \Delta P_t = \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \Gamma_K P_{t-k} + \mu + e_t$$

with $\Gamma_i = -\mathrm{I} + \Pi_1 + \ldots + \Pi_i$ and i=1,…,k-1.

Here, Γ_K is the long-run solution to Equation (3).[11] If ΔP_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 error term, e_t is by assumption stationary. Hence, either 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 P_t are stationary. If $r=N$, the variables are stationary in levels; if r=0, there exist no linear combinations which are stationary. When $0<r<N$, there exist r cointegrating vectors, or r stationary linear combinations of P_t.

The cointegration test has a direct relationship to the causality test. Two data series will be cointegrated only if there exists a statistically significant linear relationship between them. However, if there is a statistically linear relationship between two data series, there must also be a causal relationship. Indeed, Granger who originally introduced the concept of causality (Granger, 1969), notes that cointegration implies causality (Granger, 1986).

When data series are cointegrated, one can factor Γ_K, such that, $\Gamma_K = \alpha\beta'$, where both α and β are $(N\times r)$ matrices. The matrix β contains the cointegrating vectors and α the adjustment parameters. Both matrices, or in our case vectors, are of interest. The adjustment parameters (or factor loadings) are closely related to the concept of weak exogeneity, since if all adjustment parameters are zero in one equation, this variable is weakly exogenous for the long-run parameters in the remaining equations (Johansen and Juselius, 1990). However, this implies that the parameters on the levels variables in the system are zero in this equation, and hence, that the other variables cannot in the long-run cause this variable. For there to be no causality, also the short-run parameters on the other variables must be zero.[12] The test for weak exogeneity do therefore provide a test for no long-run causuality. Further, since the α matrix cannot have zero rank when a cointegration relationship has been found, at least one of the parameters will be different from zero.

The matrix β contains the long-run parameters in the system. These are of interest when one will test the LOP. Johansen and Juselius (1990) show that any linear restrictions on the cointegrating vector can be tested using a likelihood ratio test. For the LOP to hold, the restriction that the cointegrating vector is (1,-1) must be valid. As this is only a long-run relationship, whether the LOP holds in the short run must be tested on the short-run parameters. This can be done in a normal error correction model if it is of interest.

III. Empirical Analysis

Monthly value and quantity figures for different whitefish species were collected from Eurostat's trade statistics for France. Monthly price series were obtained by a value quantity transformation and missing observations were interpolated following Gordon and Hannesson (1996). Prices were collected for frozen cod fillets, fresh cod, frozen saithe fillets, frozen haddock fillets, frozen redfish fillets and dried salted cod.

The price data used in empirical testing are summarized graphically in Figures 1 and 2. In Figure 1, the prices of frozen fillets from cod, haddock, redfish and saithe are shown for the period 1983-1995. There appears to be a common trend, although the price levels differ with the perceived quality of the different species. In Figure 2, the prices for different product forms of cod (i.e., frozen fillets, fresh and dried salted cod) are graphed for the period 1983-95. Also here the prices of the three product forms appear to trend together over time. 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.

When investigating market integration, the first priority is to examine each price series for evidence of stationarity, to choose the appropriate tool. In Table 1, the results of the ADF test for individual prices are reported. The null hypothesis is that each price series is nonstationary. 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. For all prices, we cannot reject the null hypothesis of nonstationarity. When proceeding with testing for market integration we therefore use cointegration tests.[13]

Since market integration is most interesting as a long-run relationship, we will in the following focus on the long-run relations. We will split the analysis into two parts; fillets from different species and different product forms of cod. The results from the cointegration tests for frozen fillets from different species of whitefish are reported are reported in Table 2.[14] In all cases, the null hypothesis of no cointegration vectors can be rejected. However, the hypothesis of one or fewer cointegration vectors cannot be rejected, and we must therefore conclude that all pairs of prices are cointegrated. The results for different product forms of cod are reported in Table 3. Also here we must conclude that all pairs of prices are cointegrated. These results show that the market for whitefish is robust across fish species and product forms, as all prices are cointegrated.[15] Hence, all whitefish products and species are competing in the same market, as there are causal relationships between all of the prices.

The last column of Table 2 reports the results for the test of the Law of One Price for the different whitefish species. The Law of One Price holds for cod and haddock, cod and saithe, and haddock and saithe, but the test fails whenever redfish is used in pairwise testing. The last column of Table 3 reports the tests of the Law of One Price for the different product forms of cod. The relative prices of the different forms of cod are maintained over time, or in other words, the Law of One Price holds for the different product forms of cod in France. Hence, when using this stricter definition of market integration, redfish is not a part of the market. Accordingly, the market for the species apart from redfish is more closely related, as the LOP holds here.

IV. Concluding Remarks

The purpose of this paper was to explore the relationships between traditional parametric tests and cointegration tests for market integration using prices, and to define market boundaries for whitefish species and product forms within France. We show that traditional approaches like causality tests and tests for LOP provide the same information as cointegration tests. The difference is only that the approaches are suitable for data with different characteristics. If the prices are stationary, LOP/causality tests should be used, while if prices are nonstationary, cointegration tests should be used. However, to obtain all the information of interest when prices are nonstationary, the Johansen cointegration test should be used. In contrast to what is the case with the Engle and Granger test, this test allows hypothesis testing on the cointegration parameters.

The empirical results indicate that there is one whitefish market in France. The market includes both similar product forms made from different fish species, and for different product forms made from the same fish species. Moreover, the relative prices of the different product forms of cod (frozen, fresh and dried salted) are consistent with The Law of One Price, and same holds for the relationships between frozen fillets from different species with exception of redfish fillets. Together with the results of Gordon and Hannesson (1996), which indicate a world market for frozen cod fillets, this also provides support for the hypothesis that there is a global market for whitefish.

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Table 1. Dickey-Fuller tests

Product	Test Statistic	Test statistic with trend	No. of lags
Frozen cod fillets	-2.515	-1.732	12
Fresh Cod	-2.229	-1.207	12
Frozen Haddock fill.	-1.967	-1.337	4
Frozen Redfish fillets	-2.389	-2.423	4
Frozen Saithe fillets	-1.744	-2.186	1
Dried salted cod	-2.795	-2.751	2
Fresh salmon	-2.44	-2.10	6

* indicates significant at a 5% level. Critical values can be found in MacKinnon (1991).

Table 2. Bivariate Johansen tests for cointegration for frozen whitefish fillets

Variables	H_0:rank = p	Max test	Trace test	Law of One Price
Cod fillets and	p == 0	33.94*	38.9*	0.822
Haddock fillets	p <= 1	4.96	4.96	
Cod fillets and	p == 0	35.27*	41.3*	13.369*
Redfish fillets	p <= 1	6.03	6.03	
Cod fillets and	p == 0	31.09*	35.44*	0.098
Saithe fillets	p <= 1	4.34	4.34	
Haddock fillets	p == 0	17.38**	25.47*	4.842**
and Redfish fillets	p <= 1	8.08	8.08	
Haddock fillets	p == 0	21.11*	27.60*	0.001
and Saithe fillets	p <= 1	6.48	6.48	
Saithe fillets and	p == 0	35.69*	43.42*	12.614*
Redfish fillets	p <= 1	7.72	7.72	

*indicates significant at a 1% level and ** indicates significant at a 5% level.

Table 3. Bivariate Johansen tests for cointegration between product forms of cod

Variables	H_0:rank = p	Max test	Trace test	Law of One Price
Cod fillets and	p == 0	31.05*	36.39*	0.174
Fresh cod	p <= 1	5.34	5.34	
Cod fillets and	p == 0	34.10*	38.49*	0.004
dried salted cod	p <= 1	4.39	4.96	
Fresh cod and	p == 0	26.15*	33.40*	0.152
dried salted cod	p <= 1	7.25	7.25	

*indicates significant at a 1% level and ** indicates significant at a 5% level.

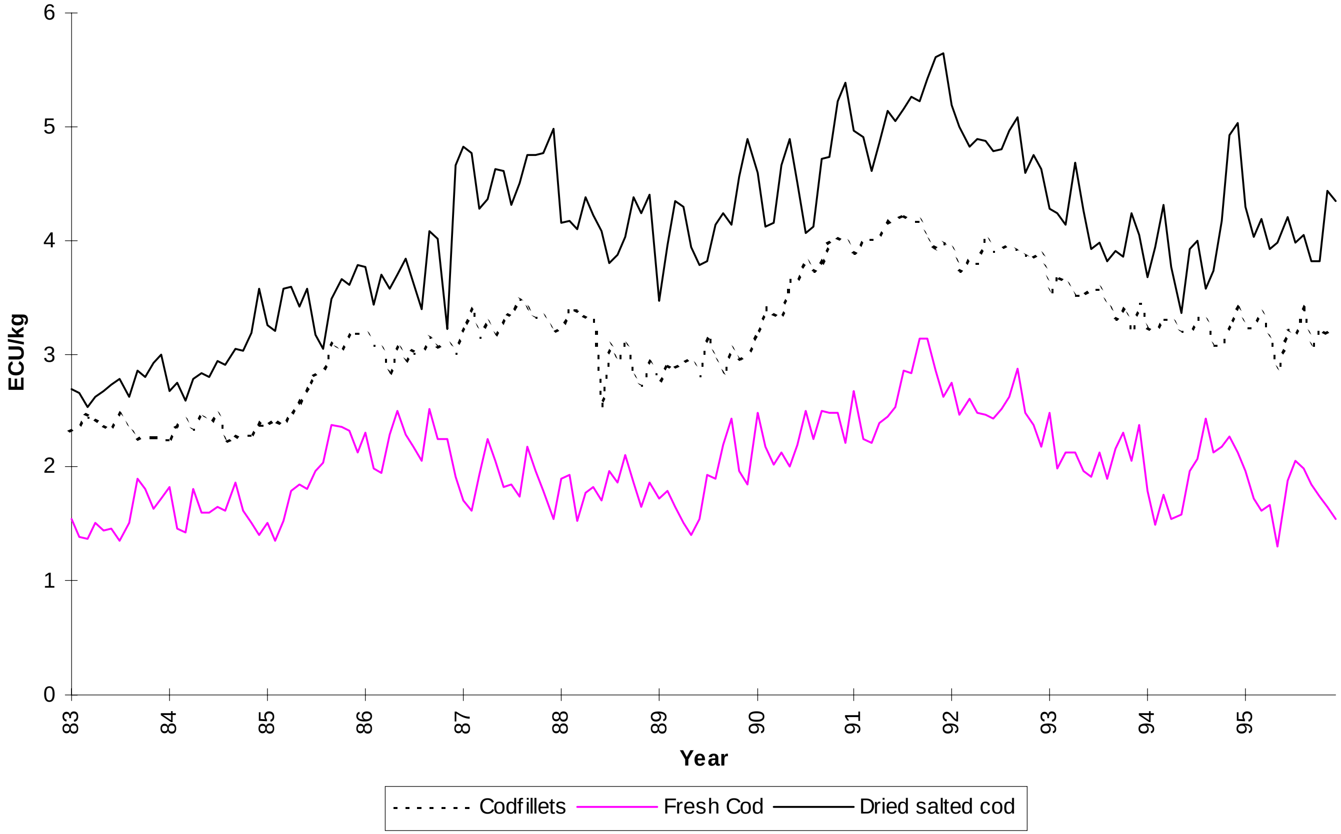

Figure 2. Import prices of different product forms of cod to France, 1983-1995

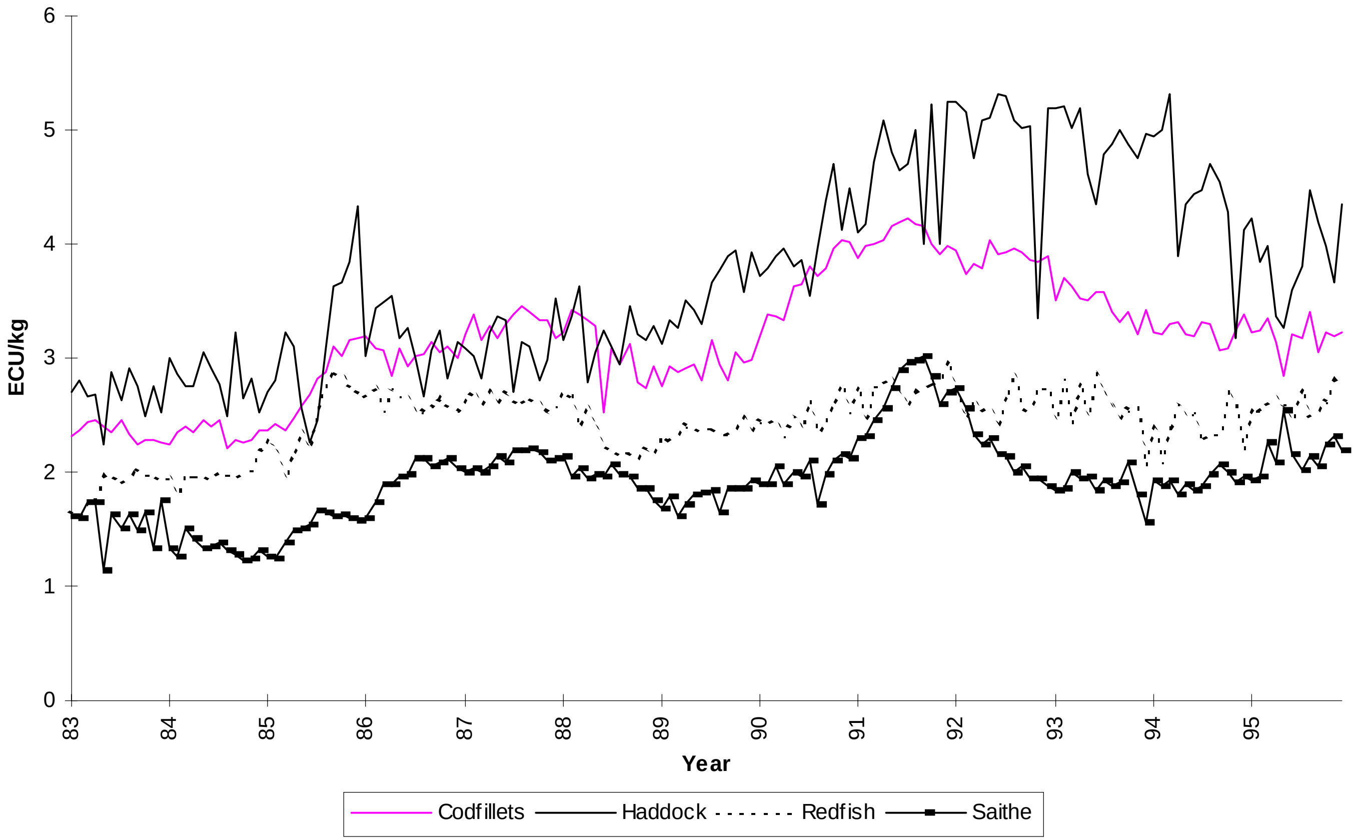

Figure 1. Import prices of frozen fillets from different whitefish species to France, 1983-1995

ENDNOTES

[1] See e.g. Ardeni (1989), Goodwin and Schroeder (1990), Baffes (1991), Gordon, Salvanes and Atkins (1993), Zanias (1993), Doane and Spulber (1995), Sauer (1995), Bose and McIlgrom (1996), Gordon and Hannesson (1996), Asche, Salvanes and Steen (1997).

[2] Papers referring to the LOP includes Ardeni (1989), Baffes (1991) and Doane and Spulber (1995). Ardeni and Baffes also tries to impose a stronger restriction than price proportionality in their studies, by imposing price equality (except for a stationary error term).

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

[4] The only opening in the treaty of Rome for allowing collusion between producers is the possibility to establish producer organizations in agriculture and fisheries. The purpose of a producer organization is to stabilize supply and the producers' income, and it is meant to benefit both consumers and producers. It is not allowed to extract excessive profits.

[5] Slade's analysis is an extension of Horowitz (1981), who assumes more restrictive dynamics.

[6] In some cases, exogenous variables that represent common trends for the prices are also included.

[7] Ravallion (1986) discusses in more detail the interpretation of different restrictions on the dynamic process.

[8] See e.g. the analysis of Isard (1977) and Richardson (1978).

[9] However, a static regression of the prices may of course provide a (super) consistent estimate of the long-run parameters.

[10] One might, however, impose the restriction that a=0 and b=1, and test the difference of the two prices for stationarity (Baffes). If the strict version of the LOP holds, this difference should be stationary.

[11] Note that there is only a constant term, no trend term in (3). To keep this specification in the cointegration tests, this restriction must be imposed (Johansen and Juselius, 1990).

[12] If all the short-run parameters are zero, the variable will be strongly exogenous.

[13] Lag length in the Dickey-Fuller tests are chosen by finding the highest significant lag. It should be noted that the results are insensitive to what lag length is chosen.

[14] Lag length in the Johansen test were set by minimizing Schwartz' information criterion.

[15] It might here be noted, although it is not reported, that the different product forms of cod cointegrate with the prices also of all the other frozen fillets, not only for frozen fillets from cod