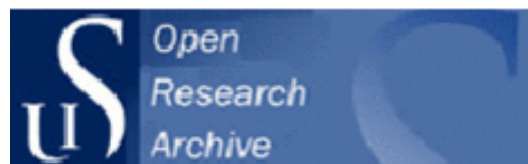




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International fish trade and exchange rates: an application to the trade with salmon and fishmeal

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International fish trade is growing, and fish exports represent an important source of foreign currency for many countries. For a few countries the exports are also an essential part of the economy. We revisit the seminal paper of Richardson (1978) that addresses the issue of exchange rate pass-through in commodity markets, but in a multivariate cointegration framework. The multivariate cointegration framework allows us to test common assumptions like exchange rate pass-through, leading price, central markets, and exogeneity of exchange rates. This approach is particularly suited when studying markets for primary products. We provide empirical examples using salmon imports to Japan and fish meal exports from Peru to Germany.

I. Introduction

International fish trade is growing, and fish exports represent an important source of foreign currency for many countries. For some countries the exports are also an essential part of the economy (United Nations, 2002; Anderson and Martínez-Garmendia, 2003). Due to the importance of relative prices in international trade, the pattern and magnitude of fish trade increasingly depend on exchange rate movements. As for many other primary products, reliable data for several traded fish products are available for prices, but not on quantities. This, in part, explains the popularity of analysing primary product markets using only the information contained in prices. We implement exchange rates into a multivariate cointegration framework. This allows us to test a more comprehensive set of hypotheses on price relationships such as exchange rate pass through and leading prices. It also allows us to test the hypothesis that the export of a key product can influence the exchange rate.

In this study we combine Richardson's (1978) framework for analysing price relationships with the Johansen (1988, 1991) multivariate cointegration procedure. This gives at least two important advantages. In Richardson's framework there is a simultaneity problem because economic theory does not give any indication of the direction of the causality between the prices. This issue is discussed more thoroughly in Goodwin *et al.* (1990a). Such a problem is avoided in the Johansen framework since it is based on a vector autoregressive (VAR) model that allows all variables to be treated as endogenous. Furthermore, one can test for weak exogeneity, and thereby test whether any simpler specifications, including a single equation specification, is appropriate. Exogeneity tests have economic interest as an exogenous price variable can be interpreted as a leading price.¹

¹Leading price corresponds to the central market hypothesis in the geographical dimension.

One can also test the commonly made assumption of exogeneity of exchange rates. Finally, when prices are nonstationary the Johansen procedure is a more reliable method for inference, since one is likely to overreject null hypotheses when nonstationary data are treated as stationary.

Exchange rates have not been an important issue when investigating relationships between prices after cointegration tests became the main econometric tool, as complete exchange rate pass through has commonly been assumed. Some examples of this practice include Ardeni (1989), Baffes (1991), Benson *et al.* (1994), Sauer (1994), Hanninen (1998), Asche *et al.* (1999), Zanas (1999), Indejhagopian and Simon (2000), Swift (2001), Miljkovic *et al.* (2003), Campa and Goldberg (2005) and Asche *et al.* (2007). More recent studies of exchange rates and goods markets have focused more on issues like market power and price discrimination in relation to manufactured goods. This includes most of the literature covering two closely related subjects, exchange rate pass through and pricing-to-market (Knetter, 1989, 1993; Feenstra, 1989; Froot and Klemperer, 1989; Menon, 1996; Yang, 1997). Complete exchange rate pass through combined with constant relative prices, entails perfect commodity arbitrage. The findings of currency changes being completely passed through on prices is, however, mixed in Isard (1977), Richardson (1978) and Giovannini (1988). The related purchasing power parity literature casts even more doubt on this assumption, although the inclusion of tradable and nontradable goods in PPP studies makes the comparison more complicated (Rogoff, 1996; Feenstra and Kendall, 1997). There are several possible explanations why exchange rates are not fully passed through in primary goods markets, even for perfect substitutes. As Goldberg and Knetter (1997) note, an integrated market need not be perfectly competitive since product differentiation or competitive advantage can create opportunities to sell products over marginal costs. Trade restrictions are perhaps even more important sources of inefficiency in commodity markets Goldberg and Knetter, 1999).

This study focus on relationships between prices but the topic is related to the literature on price discrimination in manufactured goods markets, which during the last decade covers the main bulk of exchange rate pass through studies. The exchange rate pass through literature has evolved with the renewed interest it received following Krugman's (1987) pricing-to-market hypothesis. Early studies like Knetter (1989; 1993) test the hypothesis assuming that products are homogenous using only price and exchange rate data. More recent studies like Goldberg and Knetter (1999) provide more information, but at the cost of higher data requirements. We believe the traditional framework of Richardson (1978) has a role to play in modern analysis, particularly for primary commodity markets like the international fish markets. His approach has similar data requirements as Knetter's (1989, 1993), but it contains different information. In particular, homogenous products need not be assumed, but this is a testable hypothesis together with exchange rate pass-through. Furthermore, one can test for leading prices and the exogeneity of the exchange rate.

Exchange rates can themselves affect international market prices by changing relative prices and thereby influencing trade flows. In particular US dollars are influential due to the importance of the North American market for many commodities (Sachs, 1985; Dornbusch, 1985; Côté, 1987). Trade in fish has grown rapidly during the last decades, where developing countries account for an increasing share. For some of these countries fish exports constitute a major share of total exports (United Nations, 2002; Delgado *et al.*, 2003). Consequently, fish exports may impact exchange rates, making the exchange rate endogenous in the price determination of fish for these countries.

We present two empirical applications of the framework, and have deliberately chosen markets we believe contain homogenous goods.² The first is the Japanese market for imported salmons, where there have been attempts to link declining sockeye prices with increased imports of farmed rainbow trout and coho from Norway³ and Chile. We investigate whether farmed rainbow trout and coho might have displaced wild sockeye in Japan. The other empirical application investigates pricing behaviour of Peru, the world's largest fish meal producer and exporter. In particular, we investigate whether changes in global fish meal demand have opened up for markup pricing for Peruvian fish meal exports to the German market. For both of these applications we investigate a number of hypotheses like exchange rate pass-through, leading price, 'law of one price' and exogeneity of exchange rates in order to disentangle the market relationships.

² There are also some problems when investigating relationships between prices as when testing for cointegration (McNew and Fackler, 1997). In particular, cointegration in itself is neither a sufficient nor a necessary condition for market integration. However, *a priori* information about the market indicates that the conditions for these problems to appear are not present in our context.

³ There are several possible sets of prices that are meaningful to test, including prices from the same exporter to different import markets, prices in one import market from different exporters, and prices in different markets.

The theoretical and methodological aspects of the market integration framework are presented in the next two sections, before we proceed with two empirical applications in the fourth and fifth sections. Concluding remarks follow in the last section.

II Market Integration

Richardson (1978) provides the most general relationship to be estimated in market integration studies. The relationship between two prices are then specified as

$$P_t^1 = P_t^{*2\beta} E_t^\gamma W^\phi e^{v_t} \quad (1)$$

Superscript 1 denotes the price of a good from one producer in his currency, hereafter named the importer's currency, while superscript 2 denotes the price from another producer, hereafter named the exporter.⁴ Superscript * indicates that the price is in the exporters currency, and E is the exchange rate in the importers currency per unit of the exporter's currency. W is transaction costs and v is an error term that captures deviations from the potential long-run relationship. The coefficients β , γ , ϕ are parameters to be determined. In most empirical analyses of the transaction costs W is assumed to be constant so that it can be represented by a constant term, a .⁵ It is also common practice to transform the data to natural logarithms. The long-run relationship to be investigated when transportation costs are assumed constant can then be expressed as

$$p_t^1 = \alpha + \beta p_t^{2*} + \gamma e_t + v_t \quad (2)$$

where the relationship is arbitrarily normalized on price.⁶ Note that e in Equation 1 is the exponential function and not a stochastic residual term, while e_t in Equation 2 is the logarithm of the exchange rate. The first hypothesis of interest in this equation is whether there is a relationship between the prices. This corresponds to a test for the null hypothesis that there is no relationship and is given as $H_0: \beta = \gamma = 0$. If the data series are nonstationary, this corresponds to a test of whether the price series are cointegrated, or whether the error term v is stationary. If there is a long-run relationship, the next hypothesis of interest is whether $\beta = \gamma$, given that the parameters are different from zero. If these parameters are equal, we can conclude that the exchange rate pass-through is complete, and one can express the relationship in a common currency.⁷ The final hypothesis of interest is whether $\beta = \gamma = 1$, i.e. whether the relative price is constant or the 'law of one price' holds. When investigating the relationship between prices a simultaneity problem arises because economic theory gives no indication about the direction of the relationship (Richardson, 1978; Goodwin *et al.*, 1990b). Moreover, there are good reasons to expect a leading price or a central market in both directions depending on the market studied, as well as simultaneous systems. In most cases the estimated equations will also contain several lags, as there may be adjustment costs. If one is interested in establishing a leading price, one often runs the regression in both directions. These specifications are problematic as each single equation specification often depends on an exogeneity assumption. In the international trade literature exchange rates are normally assumed to be exogenous as each good makes up a minor share of a country's trade, although one can also argue about this assumption (Richardson, 1978). When one specifies the relationship in a multivariate system these problems can be avoided, and the exogeneity assumptions will be testable hypotheses. In particular, one can test for weak exogeneity, which is both a necessary and sufficient condition for inference (contrary to Granger causality which is neither; see Engle *et al.*, 1983).

III. Econometric Approach

We will investigate the relationships between using the Johansen test (1991). The Johansen test is based on a VAR system. A vector, x_t , containing the N variables to be tested for cointegration, is assumed to be generated by an unrestricted k th order vector autoregression in the levels of the variables;

$$x_t = \Pi_1 x_{t-1} + \dots + \Pi_k x_{t-k} + \Phi D_t + \mu + e_t \quad (3)$$

where each Π_i is a ($N \times N$) matrix of parameters, μ a constant term and $e_t \sim \text{niid}(0, \Omega)$. The VAR system of equations

⁴ However, transportation cost can also be modelled explicitly and can then influence the degree of market integration (Goodwin *et al.*, 1990b).

⁵ Please note that if we rather normalise on the export price, the sign on the exchange rate parameter will be reversed.

⁶ If $\beta = \gamma$, one can write $\beta p + \gamma e$ as $\beta(p+e) = \beta \ln(P^*E)$.

⁷ Virtually all high-valued salmon consumed in Japan is imported, while the low-valued species chum and pink is mostly supplied by domestic fishermen.

in (4) written in error correction form (ECM) is;

$$\Delta x_t = \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \Pi_k x_{t-k} + \Phi D_t + \mu + e_t \quad (4)$$

with $\Gamma_i = -I + \Pi_1 + \dots + \Pi_i$, $i = 1, \dots, k-1$ and $\Pi_k = I + \Pi_1 + \dots + \Pi_k$. Hence, Π_k is the long-run 'level solution' to (3). If X_t is a vector of $I(1)$ variables, the left-hand side and the first $(k-1)$ elements of (4) are $I(0)$, and the last element of (4) is a linear combination of $I(1)$ variables. Given the assumption on the error term, this last element must also be $I(0)$; $\Pi_k x_{t-k} \sim I(0)$. Hence, either x_t contains a number of cointegration vectors, or Π_k must be a matrix of zeros. The rank of Π_k , r , determines how many linear combinations of x_t are stationary. If $r = N$, the variables in levels are stationary; if $r = 0$ so that $\Pi_k = 0$, none of the linear combinations are stationary. When $0 < r < N$, there exist r cointegration vectors – or r stationary linear combinations of x_t . In this case one can factorize Π_k ; $\Pi_k = \alpha\beta'$, where both α and β are $(N \times r)$ matrices, and β contains the cointegration vectors (the error correcting mechanism in the system) and α the factor loadings. Two asymptotically equivalent tests exist in this framework, the trace test and the maximum eigenvalue test. In our empirical applications, the x_t vector contains three data series, the two prices and the exchange rate. We will expect to find one cointegration vector if there is a relationship between the two markets.

The Johansen procedure allows hypothesis testing on the coefficients α and β , using likelihood ratio tests (Johansen and Juselius, 1990). Provided that the data series are cointegrated and we find one cointegration vector, the rank of $\Pi = \alpha\beta'$ is equal to 1 and α and β are (3×1) vectors. A test of full exchange rate pass through is then a test of whether $\beta' = (1, -b, b)'$ and is distributed as $\chi^2(1)$, while a test for the 'law of one price' is a test of whether $\beta' = (1, -1, -1)'$ and is distributed as $\chi^2(2)$. The factor loadings α are of interest as they contain information about exogeneity (Johansen and Juselius, 1990), and therefore also about leading prices or central markets. If a row in α contains only zeros (or in our case one element since α is a column vector), the price in question will be weakly exogenous, or decided outside of the system. Hence, if the factor loading parameter in the equation for the exchange rate is zero, the data indicate that the exchange rate is decided outside of the system. Furthermore, if the factor loading parameter associated with one of the prices is zero, this price will be determined outside of the system, and will therefore be the leading price. With one cointegration vector, at least one factor loading parameter must be different from zero (Johansen and Juselius, 1990). Also note that only in the case when just one factor loading parameter is different from zero will there be no simultaneity problems if a system is represented with a single equation specification (normalized on the correct variable). On this background we may now proceed with two case studies with application of the market integration framework.

IV. Wild and Farmed Salmon in the Japanese Market

In the first empirical application we address the salmon market, of which there exist a number of studies like Bjorndal *et al.* (1993), DeVoretz and Salvanes (1993), Asche *et al.* (1997), Asche *et al.* (1999), Kinnucan and Myrland (2005). We investigate the price relationships for high valued frozen salmon in Japan.⁸ Until the late 1980s, this flow consisted almost exclusively of wild sockeye salmon from North America, primarily Alaska. However, during the 1980s salmon farming was a growing industry. In the early 1990s, there were considerable growth in production of farmed rainbow trout and coho in Chile and Norway, which was largely exported to Japan. By the late 1990s, the Japanese imports of both farmed rainbow trout and farmed coho were larger than imports of frozen wild-caught North American salmon. Throughout this period, Alaskan fishermen have seen their prices for salmon decreasing. It is therefore of interest to investigate to what extent farmed salmon and trout have become substitutes for wild North American salmon in its principal market, Japan.⁹

After several technological breakthroughs, salmon farming became a viable commercial sector during the 1980s. As the pioneers were European, the preferred species was Atlantic salmon, although operators quickly started farming rainbow trout and (in the Pacific) coho, targeting the Japanese market. The main producers of rainbow trout are Norway and Chile, while Chile is virtually the only producer of farmed coho. These species are suitable for Japanese tradition because of their deep, red flesh. Sockeye is the salmon species with the deepest red colour, traditionally favoured by Japanese consumers. However, sockeye are not as biologically feasible to farm on a commercial basis. In the early 1990s, Japanese imports for the farmed species increased rapidly. Of the imported high-valued species, the market shares in 2000 were 35% for rainbow trout, 34% for farmed coho, and 31% for sockeye. The market share for imported farmed coho and rainbow trout were close to zero as late as 1990. World salmon prices have decreased substantially over the period, which this is primarily due to productivity growth and increased production of farmed salmon (Tveteras, 2000). The objective of this analysis is to ask, given this newly structured market for salmon in Japan, does the presence of farmed salmon in the Japanese market influence prices for wild salmon from Alaska?

⁸ As Atlantic salmon is mainly imported fresh to Japan, and is not considered as one of the 'red-meat' salmon species like rainbow trout, coho and sockeye, we have not included it in the discussion.

⁹ Prior to 1994, all the product categories of interest were not available in the import statistics.

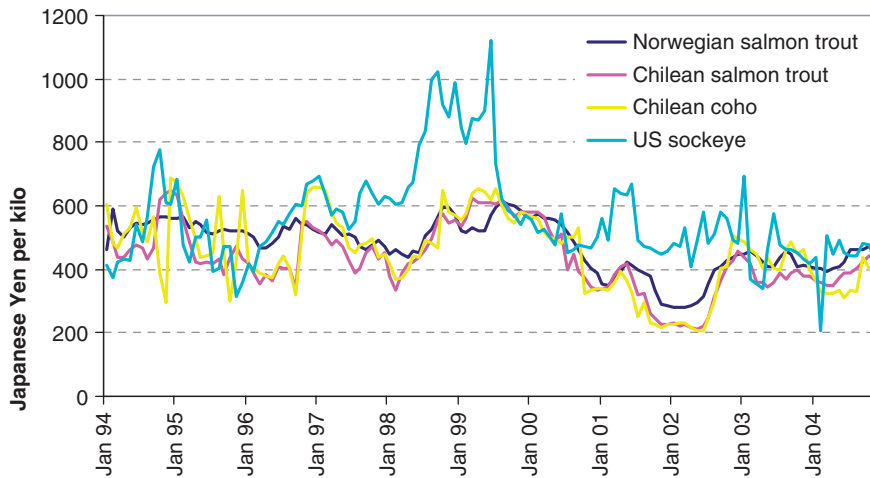


Fig. 1. Japanese import prices of salmonid species, January 1994–December 2004

Table 1. Augmented Dickey–Fuller Tests

Data series; logs of prices and exchange rates	Test statistic, levels	Test statistic, first differences
Chilean rainbow trout	−2.868	−4.996**
Chilean coho	−2.634	−5.856**
US sockeye	−2.499	−7.488**
Norwegian rainbow trout	−2.334	−5.701**
NOK/CLP	−0.692	−4.905**
USD/CLP	−1.221	−5.111**

Note: **indicates significant at a 1% level.

Data and empirical results

We use Japanese import data on a monthly basis from January 1994 to December 2004.¹⁰ The data contains import values and quantities for rainbow trout, Chilean coho, and North American sockeye, with import unit values in Japanese Yen as prices shown in Fig. 1. Prices are changed into their domestic currencies for the cointegration tests. North American sockeye is an aggregate of Alaskan and Canadian sockeye, of which the Canadian catches are a small part. The sockeye fisheries take place in summer, and the exports to Japan throughout the year can therefore be viewed as inventory dissipation of frozen sockeye. Since all coho in Chile is farmed and virtually all production of farmed coho is done in Chile, this variable can also be labelled farmed coho. All production of rainbow trout is farmed, while all North American sockeye are wild caught.

The first step in the analysis is to investigate the time series properties of the data. In Table 1 are the results of the Augmented Dickey–Fuller tests, reporting third lag statistics. The NOK/CLP is the exchange rate between Norwegian Kroner and Chilean Pesos. The null hypothesis of unit root is accepted in levels for the variables, while it is rejected for the first differences indicating that all the variables are $I(1)$. This means that we can proceed with the Johansen tests, which in our framework presupposes that the data are $I(1)$ in order for the hypothesis tests to be meaningful.

It is well known that cointegration vectors are identifiable only up to a nonsingular transformation (Engle and Granger, 1987). To avoid estimation of redundant vectors, the price of Chilean rainbow trout price is included in all reported tests. In Table 2 are the cointegration results for Norwegian and Chilean rainbow trout in the Japanese market. The VAR is specified with three endogenous variables, the respective rainbow trout prices and the exchange rate. Three lags are sufficient to avoid autocorrelated errors. With a trace statistic of 39.04 cointegration is accepted at a 1% significance level.

¹⁰ The beneficial growth effect of fish meal was earlier attributed to an ‘Unidentified Growth Factor’ (UGF). Today it is suspected that a mix of components such as selenium, vitamin B12, methionine and omega-3 fatty acids in fish meal create this beneficial effect, as one has not been able to isolate any single component as the UGF.

Table 2. Cointegration tests between Chilean and Norwegian rainbow trout prices, and exchange rate (CLP/NOK)

Ho: rank = p	Trace test	Critical value
$p = 0$	39.04**	29.7
$p \leq 1$	10.50	15.4
$p \leq 2$	0.47	3.8
LM(12) ^a autocorrelation 0.8606 (0.760) ^b	Full exchange rate pass-through 1.5143 (0.219) ^b	Law of one price 7.2751 (0.026)** ^b
Exchange rate (CLP/NOK) weakly exogenous 0.0005 (0.983) ^b	Chilean trout w/Exchange rate weakly exogenous 3.8132 (0.0508) ^b	Norwegian trout w/Exchange rate weakly exogenous 12.405 (0.000)** ^b

Notes: * and ** indicates significant at a 5% and 1% levels.

^aLM is a Lagrange Multiplier test against autocorrelation up to 12 lags.

^bp-values in parentheses.

Table 3. Cointegration tests between US Sockeye and Chilean rainbow trout prices, and exchange rate (USD/CLP)

Ho: rank = p	Trace test	Critical values
$p = 0$	32.13*	29.7
$p \leq 1$	11.8	15.4
$p \leq 2$	0.5086	3.8
LM(12) ^a autocorrelation 0.758 (0.908) ^b	Full exchange rate pass-through 11.412 [0.001]** ^b	Law of one price 22.466 (0.000)** ^b
Exchange rate (USD/CLP)US sockeye w/exchange rate (USD/CLP) exogenous in system	US sockeye w/exchange rate (USD/CLP) exogenous in system	Chilean rainbow trout w/exchange rate (USD/CLP) exogenous in system 7.591 (0.006)** ^b
1.786 (0.181) ^b	8.421 (0.004)** ^b	

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

^aLM is a Lagrange Multiplier test against autocorrelation up to 12 lags.

^bp-values in parentheses.

With a test statistic of 1.5143, the complete exchange rate pass-through hypothesis cannot be rejected. The test can be interpreted as whether changes in the exchange rate between Chilean pesos (CLP) and Norwegian kroner (NOK) are fully reflected in the price relationship, so that changes in exchange rate do not change the relative prices in the long run. With a p -value of 0.026 the joint hypothesis of complete exchange pass through and the 'law of one price' is rejected at a 5% but not at a 2.5% significance level. Hence, the markets for these two products are highly integrated even though there is some evidence against the hypothesis of full market integration. The final test statistics in Table 2 address the question of exogeneity. These tests indicate that Chilean rainbow trout is the leading price, which is not surprising as their production is almost twice the size of the Norwegian production. Furthermore, as expected the exchange rate is exogenous.

In Table 3 we examine the relationship between Chilean rainbow trout and US Sockeye. Figure 1 shows that the main trend in the wild sockeye price tracks the prices of the farmed species except for in a period during 1998/99. The divergence in this period must be seen in relation to a dramatic fall in sockeye catches in 1998, when they dropped to a level that was only 40% of what it was 2 years earlier. The trace test gives one cointegration vector at a 5% significance level, and indicates that wild salmon is integrated with the farmed rainbow trout. Both the hypothesis of complete exchange rate pass-through and the 'law of one price' are rejected on a 1% significance level.

Table 4. Cointegration tests between Chilean coho and Chilean rainbow trout

Ho: rank = p	Trace test	Critical value
$p = 0$	43.83*	15.4
$p \leq 1$	5.54	3.8
LM(12) ^a autocorrelation 0.6965 (0.8726) ^b	Law of one price 0.0737 (0.7860) ^b	
Chilean rainbow trout weakly exogenous (priceleader)	Chilean coho weakly exogenous (priceleader)	
0.0115 (0.9148) ^b	29.305 (0.0000)** ^b	

Notes: * indicates significant at a 5% level.

^aLM is a Lagrange Multiplier test against autocorrelation up to 12 lags.

^bp-values in parentheses.

Hence, while the markets are integrated, there is evidence against full market integration between sockeye and trout. Neither Chilean rainbow trout nor US Sockeye are found to be the leading price, indicating a joint influence on each other. While it is surprising that we can reject the hypothesis of complete exchange rate pass through, these results most likely reflect the strong dynamics in the sockeye supply due to seasonality in the landings as well as the fact that rainbow trout and coho has displaced sockeye in the Japanese market during the 1990s. Sockeye had a 90% market share at the end of the 1980s, but during the 1990s it has been reduced to approximately a third of the market. Alaskan sockeye suppliers are disadvantaged by the seasonal nature of the fisheries, while Chilean producers are able to provide high-quality rainbow trout throughout the year. This is a part of the reason why there is some evidence against a fully integrated market, as large variations in the supply of sockeye is likely to influence the unit price relative to the prices of rainbow trout, even though they are substitutes.

Finally, as a control measure we examine whether Chilean coho and rainbow trout prices are integrated in the Japanese market. Given our prior knowledge of coho and rainbow trout as being closely related, it is as expected that we find these prices to be cointegrated. With a trace statistic of 48.83, as reported in Table 4, the test indicates one cointegration vector at a 1% significance level. The test for the 'law of one price' is not rejected with a test statistic of a *p*-value of 0.7860 implying that the relative prices of Chilean coho and rainbow trout are constant in the long run. From the weak exogeneity test we can infer that rainbow trout is the leading price, reflecting the increasing market share and preferred quality of rainbow trout in the Japanese market. In the concluding section follows a discussion concerning implications for Alaskan fishermen of these results.

V. The Fish Meal Market – FOB Peru, C&F Hamburg

Background

In the second empirical application we look at whether increased production of high-quality fish meals has opened up for markup pricing of Peruvian exports to Germany, as it has reduced the availability of standard quality meals that Germany purchases. The Hamburg price is one of the most widely quoted fish meal prices, reflecting that Germany is a large fish meal importer. Peru, on the other hand, has a unique role in the fish meal market as it accounts for over 50% the global fish meal exports in 2000. With such strong position it is not unnatural to suspect Peru of having some degree of market power in the market for marine protein meals. Moreover, fish meal is one of Peru's most important export products. Traditionally fish meal was almost entirely used as a protein input in feeds for poultry and pigs. The fish meal consumption pattern has, however, changed with the expansion of intensive aquaculture production, and in 2002 a total of 34% of the global fish meal supply went to aquaculture feeds (Barlow, 2002). The majority of the fish meal imports to continental Europe represent the traditional use of fish meal, as a protein source in pig and poultry feeds. This is certainly the case for Germany where large parts of the imports are re-exported to middle and central Europe, countries that do not have any industrial aquaculture to speak of. Increased production of premium quality fish meal destined to aquaculture feed producers has potentially provided Peruvian fish meal producers the opportunity to exert market power over buyers of standard quality fish meal, as less of this quality is available. Market power will, however, depend on whether demand for standard quality fish meal is inelastic, and also whether arbitrage opportunities are possible.



Fish meal makes up a valued high protein input in the feeds of simple-stomached animals due to its favourable balance of amino acids, its vitamin B-content, and its positive effect on growth, particularly in the early stages of growth (United Nations, 1983). Despite the special characteristics of fish meal it is also clear that fish meal is used as a protein input where alternative protein sources are available. Vukina and Anderson (1993) show that there is a strong relationship between the fish meal and soybean meal markets. If fish meal can easily be substituted with vegetable protein sources like soybean meal, there is little room for markup pricing. This might well be the case considering that pig and poultry feed producers operate with least cost formulas where many feed ingredients are interchangeable.

Data and empirical results

One way to approach the question of market power in pricing strategies is by testing for exchange rate pass-through of exporter to importer price. Preferably, one should use the exporter's marginal costs, but such data are seldom available, and then price data is an alternative. Incomplete pass-through signals markup pricing since it implies that price is not constant relative to marginal costs. Price adjustments relative to marginal cost imply that there either is a markup, or that price is below marginal costs, although the latter money-losing strategy is not plausible in the long run. We use Peruvian FOB fish meal price and Hamburg C&F fish meal price in own currencies for standard quality meal in addition to the exchange rate between Peruvian Nuevo Soles (PEN) and Euro (EUR). The dollar equivalent prices are shown in Fig. 2. As we can see there have been dramatic price movements in the data period spanning from January 1994 to December 2001. The high prices in the middle of the period relates to the El Niño weather phenomenon in 1997/98, which drastically reduced the industrial fisheries and thereby fish meal production. The Peruvian and Hamburg prices are converted from US Dollar to Peruvian Nuevo Soles and Euro respectively. Oilworld Ista Mielke has provided the Hamburg fishmeal price data, while the Peruvian FOB prices are from International Fishmeal and Fish Oil Organisation.

Table 5 shows the results from the Augmented Dickey–Fuller unit root tests, indicating that all three series are $I(1)$. Next, Table 6 reports the cointegration tests together with the other tests performed in this system. Three lags are sufficient to avoid dynamic misspecification, and the trace test indicates that the series are cointegrated on a 1% significance level with a trace statistic of 39.7. The test for complete exchange rate pass-through cannot be rejected with a p -value of 0.35. This indicates that Peruvian fish meal producers do not have any market power to speak of in the German market for marine protein meals. The ‘law of one price’ cannot be rejected on a 5% significance level, indicating full market integration.

Although Peru does not seem to have market power we would expect the major fish meal producer to have a leading price role in the price relationship. The weak exogeneity tests confirm our expectations by rejecting the hypothesis of weak exogeneity of the Hamburg price while accepting exogeneity for the Peruvian FOB price. Also here, the exchange rate is exogenous.

VI. Concluding Remarks

Studies of relationships between prices are of interest in primary product markets, in particular, because price series often are the most available form of data. In this study we use Richardson's (1978) framework in combination with the Johansen cointegration test. This allows for an array of hypotheses tests on price relationships, including explicit tests of exchange rate pass-through. The Johansen test is formulated in a VAR system where all variables are allowed to be endogenous. One can therefore avoid the simultaneity problem in Richardson's single equation specification. Moreover, in the multivariate cointegration framework one can test for exogeneity. Exogeneity tests opens up for tests of hypothesis like leading prices and exogeneity of exchange rates. These hypotheses are instrumental in understanding what mechanisms drive prices, but have in the literature mostly been assumed rather than tested. The approach differs from the pricing-to-market literature in that homogenous products need not to be assumed, as is required for the data intensive approaches in that literature.

Table 5. Augmented Dickey–Fuller tests

Data series; logs of prices and exchange rates	Test statistic, levels	Test statistic, first differences
Peruvian FOB fishmeal	-2.2560	0.36059**
Hamburg C&F fishmeal	-2.2724	-2.9522*
PEN/EUR	-1.8606	-5.2435**

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

Table 6. Cointegration tests between Peruvian fob and Hamburg C&F fishmeal prices, and exchange rate (PEN/EUR)

Ho: rank = p	Trace test	Critical values
$p = 0$	39.7**	29.7
$p \leq 1$	11.49	15.4
$p \leq 2$	2.98	3.8
LM(12) ^a autocorrelation 1.0361 (0.4205) ^b	Full exchange rate pass-through 0.87342 (0.3500) ^b	Law of one price 5.8369 (0.0540) ^b
Exchange rate (PEN/EUR) exogenous in system 0.9862 (0.3207) ^b	Hamburg C&F price w/exchange rate (PEN/EUR) exogenous in system 0.86401 (0.3526) ^b	Peruvian FOB price w/exchange rate (PEN/EUR) exogenous in system 1.1594 (0.2816) ^b

Notes: ** indicates significant at 1% level.

^aLM is a Lagrange Multiplier test against autocorrelation up to 12 lags.

^bp-values in parentheses.

Our first empirical application is on the Japanese market imports of high-valued frozen salmon. Alaskan fishermen have experienced declining prices for their sockeye exports to Japan, a development that has been associated with the increasing exports of frozen farmed rainbow trout and coho to the Japanese market. The tests indicate that wild sockeye, farmed rainbow trout, and farmed coho constitute an integrated market, although there is evidence against constant relative prices for sockeye as this is rejected at a 1% significance level. Since the findings implies that the prices of wild-caught sockeye are closely related those of farmed rainbow trout, the prospects for Alaskan fishermen of experiencing an increase in sockeye prices are small. On the contrary, prices will likely continue to decrease, as production costs for farmed salmon are declining.

The application to Peruvian fish meal exports to Germany represents the ‘classical’ exchange rate pass-through setting, where one uses the exporter’s and the importer’s price to measure the degree of pass-through. In combination with exogeneity test of the Peruvian fish meal price relative to the Hamburg fish meal price, we examine whether Peru is a price leader with leverage to conduct markup pricing in continental Europe. Once again the test for complete exchange rates pass-through is not rejected, and neither is the hypothesis of constant relative prices. The results indicate that Peruvian fish meal producers have little or no market power despite its formidable position with around 50% of global fish meal exports. They are also supportive of the privatisation that has taken place of the Peruvian fish meal industry, in that there seems to be limited market power to be gained from a national monopoly. These findings correspond with the view that it is generally difficult to conduct markup pricing in primary goods markets. As expected, the exogeneity tests for the exchange rates confirm the commonly made assumption that exchange rates are exogenous to the trade in individual commodities. This is true even for fish meal in Peru, which is a product with a significant share of total exports and with fairly volatile prices.

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