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Market Integration and Exchange Rates in Primary Commodity Markets

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Abstract

In most recent studies on international market integration exchange rates have not received much attention. This is in contrasts to the exchange rate pass-through literature where the degree of substitution normally is restricted. We revisit the seminal paper of Richardson (1978) that addresses the issue of exchange rate pass-through together with market integration, but in a multivariate cointegration framework. In addition to standard test like the law of one price and exchange rate pass-through, the multivariate cointegration framework allow us to test common assumptions like 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.

Keywords: Market integration, exchange rate pass-through, law of one price, leading price, exogeneity.

JEL Classification: F14

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1. Introduction

For many primary products reliable data are readily available for prices, for instance from commodity exchanges, but not quantities. This, in part, explains the popularity of market integration tests using only price data. In international trade, exchange rates play an important role due to their influence on relative prices of commodities. Yet, after cointegration tests became the main tool, the role of exchange rates is often disregarded in market integration studies. By omitting exchange rates one loses information about the impact currency movements can have on the international competitiveness of industries. We show that exchange rates can easily be implemented into a market integration framework using a multivariate cointegration analysis. The additional information about currencies' impact on primary goods price movements allows us to test a more comprehensive set of hypotheses on price relationships. It should be noted that the market integration literature focuses on different hypotheses than the exchange rate pass-through literature, including tests for imperfect substitution and leading prices.

In this study we combine Richardson's (1978) market integration framework 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. 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] One can also test the commonly made assumption of exogeneity of exchange rates. The 'law of one price' and exchange rate pass-through are also testable hypotheses in this framework. Finally, when prices are nonstationary the Johansen procedure is a more reliable method for inference, since one is likely to overreject null hypotheses like the 'law of one price' when nonstationary data are treated as stationary.

Exchange rates have not been an important issue in market integration studies using prices data after cointegration tests became the main econometric tool, as it has become common to assume complete exchange rate pass-through. Some examples of this practice include Ardeni (1989), Baffes (1991), Benson *et al.* (1994), Sauer (1994), Hanninen (1998), Zanias (1999), Indejehagopian and

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

Simon (2000), and Asche, Osmundsen and Tveteras (2002).[2] Complete exchange rate pass-through combined with constant relative prices, so that the 'law of one price' holds, 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 cost. Trade restrictions are perhaps even more important sources of inefficiency in commodity markets (Goldberg and Knetter, 1999).

This study focus on market integration, 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

[2] 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).

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. It has similar data requirements as Knetter's approach (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 world prices by changing relative prices and thereby influencing trade flows. In particular U.S. dollars are influential due to the importance of the North American market for many commodities (Sachs, 1985; Dornbusch, 1985; Côté, 1987). Production costs are, however, less likely to change with currency changes since primary goods production usually depends on domestic inputs, contrary to many manufactured goods. The fact that we can rule out direct effects of currency changes on production costs makes it easier to identify what are the effects of currency changes on prices.

We present two empirical applications of the market integration framework, and have deliberately chosen markets we believe contain homogenous goods. The reason is that there is a tendency of rejecting the ‘law of one price’ in earlier market integration studies, and inference might then best be illustrated by being able to maintain the ‘law of one price’ in correspondence with prior beliefs. The first is the Japanese market for imported salmons, where 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.

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 Sections 4 and 5. Concluding remarks follow in Section 6.

2. 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

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

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.[3] A * 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*.[4] 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

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[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.

[4] However, transportation cost can also be modelled explicitly and can then influence the degree of market integration (Godwin, Grennes and Wohlgenant, 1990a).

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

where the relationship is arbitrarily normalized on the import price.[5] 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.[6] 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, Grennes and Wohlgenant, 1990b). Moreover, there are good reasons to expect a leading price or a central market in

[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 $\beta(p+e)=\beta \ln(P*E)$.

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 (Engle, Hendry and Richard, 1983)).

3. Econometric approach

We will investigate the relationships between prices at different stages in the value chain using the Johansen test (1991). The Johansen test is based on a VAR system. A vector, $\boldsymbol{x}_t$, containing the N variables to be tested for cointegration, is assumed to be generated by an unrestricted kth order vector autoregression in the levels of the variables;

$$\mathbf{x}_t = \Pi_1\mathbf{x}_{t-1} + \ldots + \Pi_k\mathbf{x}_{t-k} + \Phi D_t + \mu + e_t \qquad (3)$$

where each Π_i is a $(N \times N)$ matrix of parameters, μ a constant term and ε_t~$niid(0, \Omega)$. The VAR system of equations in (4) written in error correction form (ECM) is;

$$\Delta\mathbf{x}_t = \sum_{i=1}^{k-1}\Gamma_i\Delta\mathbf{x}_{t-i} + \Pi_K\mathbf{x}_{t-k} + \mu + e_t \qquad (4)$$

with $\Gamma_i = -I + \Pi_1 + \ldots + \Pi_i,\ i = 1,\ldots,k-1$ and $\Pi_K = -I + \Pi_1 + \ldots + \Pi_k$. Hence, Π_K is the long-run 'level solution' to (3). If $\boldsymbol{x}_t$ 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 $I(0)$; $\Pi_K x_{t-k}$~$I(0)$. Hence, either $\boldsymbol{x}_t$ 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 $\boldsymbol{x}_t$ 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 $\boldsymbol{x_t}$. In this case one can factorise 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 $\boldsymbol{x_t}$ 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 exchanges 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 (normalised on the correct variable). On this background we may now proceed with two case studies with application of the market integration framework.

4. Wild and farmed salmon in the Japanese market

4.1 Background

In the first empirical application we investigate the price relationships for high-valued frozen salmon in Japan.[7] 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.[8]

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

[7] Virtual all high-valued salmon consumed in Japan is imported, while the low valued species chum and pink is mostly supplied by domestic fishermen.
[8] As Atlantic salmon is mainly imported fresh to Japan, and is not considered as one of the "red-meat" salmons like rainbow trout, coho and sockeye, we have not included it in the discussion.

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. For 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 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?[9]

4.2 Data and empirical results

We use Japanese import data on a monthly basis from January 1994 to December 2000.[10] The data contain import values and quantities for rainbow

[9] There exist a number of studies on the global salmon market like Asche, Bremnes, and Wessells (1999), Bjørndal, Salvanes, and Gordon (1994) and Gordon, Salvanes, and Atkins (1993).
[10] Prior to 1994, all the product categories of interest where not available in the import statistics.

trout, Chilean coho, and North American sockeye, with import unit values in Japanese Yen as prices shown in Figure 1. Prices are in 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.

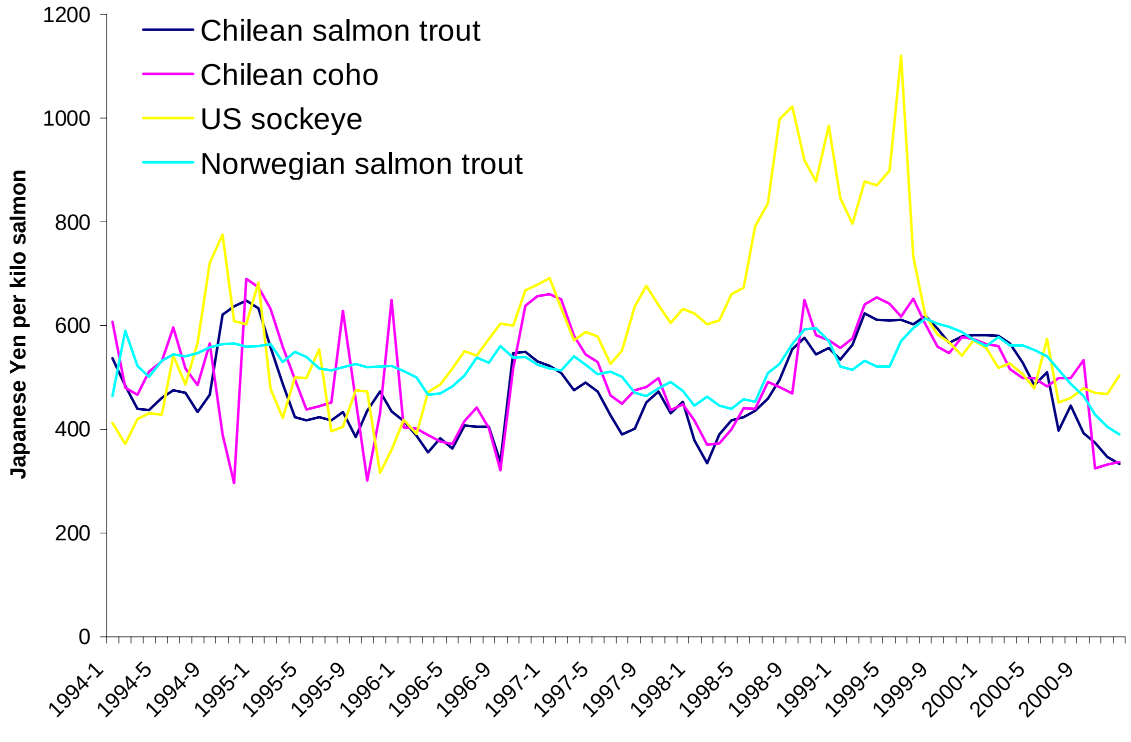

Figure 1. Japanese import prices of salmonid species from January 1994 to December 2000.

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.

Table 1. Augmented Dickey-Fuller tests

Data series; *logs of prices and exchange rates*	Test statistic, levels	Test statistic, first differences
Chilean rainbow trout	-1.6572	-3.9904**
Chilean coho	-1.9779	-5.0158**
US sockeye	-1.9157	-4.6751**
Norwegian rainbow	-2.0012	-3.7414**
trout	-2.7721	-4.9436**
NOK/CLP	0.37624	-5.5569**
USD/CLP		

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

It is well known that cointegration vectors are identifiable only up to a non-singular transformation (Engle and Granger, 1987). To avoid estimation of redundant vectors, the price of Chilean rainbow trout price is included in all reported tests.

We start by investigating the relationship between Norwegian and Chilean rainbow trout. The results are reported in Table 2, and a specification with three lags are sufficient to avoid autocorrelated errors. With a trace statistic of 29.84 cointegration is accepted at a 5 percent significance level. With a test statistic of 1.7007, the complete exchange rate pass-through hypothesis cannot be rejected. The 'law of one price' hypothesis cannot be rejected, as one would expect for a homogenous commodity. 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.

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	29.84*	29.7
p <= 1	12.94	15.4
p <= 2	3.529	3.8
LM(12)[a] autocorrelation	Full exchange rate pass-through	Law of one price
1.2673 (0.1161)[b]	1.7007 (0.1922)[b]	3.3857 (0.1840)[b]
Exchange rate (CLP/NOK) weakly exogenous	Chilean trout w/Exchange rate weakly exogenous	Norwegian trout w/Exchange rate weakly exogenous
0.32931 (0.5661)[b]	2.4902 (0.1146)[b]	7.3281 (0.0068)** [b]

* indicates significant at a 5% level

[a] LM is a Lagrange Multiplier tes t against autocorrelation up to 12 lags

[b] *p*-values in parentheses

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 1998/1999. 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. The hypothesis of complete exchange rate pass-through cannot be rejected with a *p*-value of 0.3504, but with a *p*-value of 0.0207 the 'law of one price' hypothesis is rejected on a 5 % significance level, but not on a 1% level. Hence, while the markets are integrated with exchange rate changes being passed through, there is some evidence against full market integration between sockeye and trout. Still, there is little doubt that the markets are highly integrated. Also here Chilean rainbow trout is found to be the leading price. These results most likely reflect that rainbow trout has displaced sockeye in the Japanese market during the 1990s. Sockeye had a market share at about 90% 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 explains the leading price role of rainbow trout and can also be a part of the reason why the 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. Again the exchange rate is exogenous.

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 <= 1	11.8	15.4
p <= 2	0.5086	3.8

LM(12)[a] autocorrelation	Full exchange rate pass-through	Law of one price
1.3213 (0.0888)[b]	0.87194 (0.3504)[b]	7.7554 (0.0207)* [b]
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**
0.11434 (0.7353)[b]	5.8495 (0.0156)* [b]	2.6713 (0.1022)[b]

* and ** indicates significant at a 5% and 1% level
[a] LM is a Lagrange Multiplier test against autocorrelation up to 12 lags
[b] *p*-values in parentheses

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 statitistic of 27.95 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 0.1832 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.

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

Ho:rank=p	Trace test	Critical value
p == 0 p <= 1	27.95** 3.181	15.4 3.8
LM(12)[a] autocorrelation 1.2704 (0.1592)[b]	Law of one price 1.7715 (0.1832)[b]	
Chilean rainbow trout weakly exogenous (priceleader) 0.62151 (0.4305)[b]	Chilean coho weakly exogenous (priceleader) 21.185 (0.0000)** [b]	

* indicates significant at a 5% level
[a] LM is a Lagrange Multiplier test against autocorrelation up to 12 lags
[b] *p*-values in parentheses

5. The fish meal market – FOB Peru, C&F Hamburg

5.1 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 a 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 (FAO, 1983).[11] 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.

[11] 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.

5.2 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 Figure 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.[12]

[12] Oilworld Ista Mielke has provided the Hamburg fishmeal price data, while the Peruvian FOB prices are from International Fishmeal and Fish Oil Organisation.

Figure 2. Peruvian FOB and Hamburg C&F fishmeal prices for standard quality meal with 64/65% protein content from January 1994 to December 2001 (IFFO/Oil World).

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.

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**

* 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 <= 1	11.49	15.4
p <= 2	2.98	3.8

LM(12)[a] autocorrelation	Full exchange rate pass-through	Law of one price
1.0361 (0.4205)[b]	0.87342 (0.3500)[b]	5.8369 (0.0540)[b]

Exchange rate (PEN/EUR) exogenous in system	Hamburg C&F price w/exchange rate (PEN/EUR) exogenous in system	Peruvian FOB price w/exchange rate (PEN/EUR) exogenous in system
0.9862 (0.3207)[b]	0.86401 (0.3526)[b]	1.1594 (0.2816)[b]

* and ** indicates significant at a 5% and 1% level
[a] LM is a Lagrange Multiplier test against autocorrelation up to 12 lags
[b] *p*-values in parentheses

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

6. Concluding remarks

Market integration studies 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 for market integration in combination with the Johansen cointegration test. This framework allows for an array of hypotheses tests on price relationships, including explicit tests of exchange rate pass-through. After cointegration techniques became popular, it has become a matter of practice to assume full exchange rate pass-through in market integration studies. 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 make tests of hypothesis like leading prices and exogeneity of exchange rates possible. These hypotheses are instrumental in understanding what mechanisms drive prices, but have in the literature mostly been assumed rather then 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.

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 with full exchange rate pass-through, although there is some evidence against the ‘law of one price’ for sockeye as this is rejected at a 5% but not at a 1% significance level. Wild Alaskan sockeye appears to be a price follower in this market. Since the findings implies that the prices of wild-caught sockeye follow 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 salmons 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 ‘law of one price’. 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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