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Price transmission in cross boundary value chains

by

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Abstract

The extent to which demand and supply shocks are transmitted in the value chain is an important topic. As many value chains cross international borders exchange rate pass through is an important element in this context. In this paper a multivariate system that allow us to test different hypothesis with respect to the value chain is specified. This include tests of whether there is a link between the different stages in the value chain, whether the exchange rate pass through is complete and whether price signals are fully transmitted. Different exogeneity assumptions are testable hypothesis, and one can avoid the simultaneity problem associated with the common single equation specifications. Moreover, one can also test whether the exchange rate is determined outside the system, as well as testing for price leadership. An application is provided for the value chain for cod between Norway and Portugal.

Keywords: Value chain, exchange rates, price transmission, cointegration

1. Introduction

Economists have always had an interest in relationships between prices, even though the theory in general includes more variables. This is because data on prices are easier to obtain, and often the only available data for the relationships one wish to study. One form of such relationships is analysis of the value chain. The relationship between two stages in the value chain is well described by the theory of derived demand, where at any point in the chain the demand equation is derived from the profit maximization problem of the agent at the highest level and the supply equation is derived from the profit maximization problem of the agent at the lower level in the chain (Hicks, 1956; Gardner, 1975). However, the data requirements to estimate such relationships often make it impossible to estimate them in practice.[1] Therefore, analysis of just prices at different levels is quite common, at least in the value chain for primary products. Gjølberg and Johnsen (1999) and Goodwin and Holt (1999) provide some recent examples for respectively oil products and beef.

A feature that has not received much attention is that for many products, the value chain may cross international boundaries. However, as shown in the literature on exchange rate pass through and pricing to market, borders will often matter. We will in this paper provide an approach where one can test whether the exchange rate pass trough is perfect in the value chain as well as hypotheses with respect to the relationship between the prices at different levels in the chain. The framework will be similar to the approach used by Richardson (1978) to test for market

[1] Also when analyzing only one link in the chain, as is common in analysis of e.g. import demand, data availability also often create problems. See e.g. Winters (1984) for a powerful critique of the commonly used Armington approach.

integration.[2] However, we will estimate a multivariate system to avoid the simultaneity problem indicated by Richardson (1978) and elaborated by Goodwin, Grennes and Wohlgenant (1990). This is also an advantage if one is interested in price leadership as different hypotheses are then nested within a multivariate system, while simultaneity makes the results from such tests questionable in single equation approaches.[3] The price series are nonstationarity, and the Johansen test (Johansen, 1988; 1991) is therefore the natural approach.

The approach will be applied to the value chain for cod between Norway and Portugal. In addition to the crossing of national borders this value chain is of interest because while cod is consumed in only one product form in Portugal, it is imported processed at different levels. The retail product form of cod in Portugal is dried salted cod or *bacalhau*. However, imports of cod to Portugal are in addition to dried salted cod also wet salted cod and frozen cod, which is processed into dried salted cod in Portugal. Norway and Portugal are the only countries in the world where dried salted cod is produced, although market power is unlikely as the industry consists of many small firms. Hence, this seems to be a competitive industry with trade, but without specialization. There is a world market for frozen cod (Gordon and Hannesson, 1996) and a large European market for wet salted cod (Asche, Gordon and Hannesson, 2002). The Portuguese industry therefore does not have any restrictions with respect to obtaining the main input.[4] Moreover, investigating the imports at different processing levels is of interest since it potentially can give an indication where signals through the value chain are distorted.

[2] Richardson (1978) basically modifies the relationship that is used when testing for market integration domestically by also taking account of the exchange rate. See Doane and Spulber (1993) for a good review of approaches used when testing for market integration.
[3] This is true both when the data are treated as stationary as e.g. in Kinnucan and Forker (1987) and when the data are treated as nonstationary but cointegrated as in Gjølberg and Johnsen (1999).
[4] Spain, Italy and France also import substantial quantities of wet salted cod.

This paper is organized as follows. In the next section we discuss price relationships in the value chain before we in section 3 provide the econometric approach. In section 4 a brief review of the value chain for cod between Norway and Portugal is provided before the data is presented in section 5. The empirical results are reported in section 6, before some concluding remarks are offered in the final section.

2. The value chain

Following in the spirit of Richardson (1978), the relationship between two prices at different stages in the value chain normalized on the higher level or import price can be specified as

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

The superscript *(I)* denotes the import or higher level price in the importers currency, (E^*) denotes the supplier or export price in the exporters currency, E is the exchange rate in the importers currency per unit of the exporters currency, W is processing or marketing costs and v is an error term that captures deviations from the potential long-run relationship. The coefficients a, β, γ, ϕ are parameters to be determined. In most empirical analyses of the value chain W is assumed to be constant so that it can be included in the constant term.[5] Moreover, when analyzing a value chain within a country or assuming perfect exchange rate pass through as in Gjølberg and Johnsen (1999) and Goodwin and Holt (1999), the equation reduces to

$$(2) \qquad P_t^{(I)} = AP_t^{(E)\beta} e^{v_t}$$

where A provides a measure of the markup if the price transmission is perfect (i.e. β=1).

[5] However, there are also exceptions including Kinnucan and Forker (1987) where the prices of different marketing costs such as wages are included as variables on the right hand side.

In empirical analyses it is common practice to transform the data to natural logarithms. The long-run relationship to be investigated can then expressed as

(3) $p_t^I = \alpha + \beta p_t^{E*} + \gamma e_t + v_t$

where the relationship is again arbitrarily normalized on the import price.[6]

The first hypothesis of interest in this equation is whether there is a relationship between the variables at the different levels in the chain so that price changes at one level influence prices at the other level. This corresponds to a test for the null hypothesis that there is no relationship and is given as H_0:β=γ=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 β=γ, given that they 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 β=γ=1, i.e. whether the price signals are perfectly transmitted through the value chain or whether the relative price spread is constant. This is the least likely hypothesis to hold, since it implies that the intermediary's production technology can be represented with a single variable input (Asche *et al*, 2002). However, this can be a reasonable description of the value chain for many primary product as the cost share of the primary input often is very high (Genovese and Mullin, 1998; Asche *et al*, 2002).

When investigating the relationship between prices at two stages in the value chain a simultaneity problem arises because economic theory gives no indication about the direction of the

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[6] Please note that if we rather normalize on the export price, the sign on the exchange rate parameter will be reversed.
[7] If β=γ, one can write β*p*+γ*e* as β(*p*+*e*)=βln*(P*E)*.

relationship.[8] Moreover, there are good reasons to expect price leadership in both directions depending on the market studied, as well as simultaneous systems.[9] The most common specification of the value chain in empirical analysis is to assume that the price at the higher level is a function of the price on the lower level. In most cases the estimated equations will also contain several lags, as there seems to be adjustment costs. However, if one is interested in price leadership one will often run the regression also in the opposite direction (e.g. Gjølberg and Johnsen, 1999). These specifications are problematic as each single equation specification depends on an exogeneity assumption. In the international trade literature exchange rates are normally assumed to be exogenous as each good make 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.

3. Econometric approach

We will investigate the relationships between prices at different stages in the value chain using the Johansen test. The Johansen test is based on a vector autoregressive (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;

$$\mathbf{x}_t = \Pi_1 \mathbf{x}_{t-1} + ... + \Pi_k \mathbf{x}_{t-k} + \Phi D_t + \mu + e_t \tag{4}$$

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;

[8] A discussion of the simultaneity issue in the similar case where one are looking at prices for the same good in different markets can be found in Richardson (1978) and Goodwin, Grennes and Wohlgenant (1990).

[9] The system will be simultaneous if both prices respond to demand and supply shocks. The higher level price will be exogenous if it does not respond to supply shocks, while the lower level price will be exogenous if it does not respond to demand shocks.

$$\Delta \mathbf{x}_t = \sum_{i=1}^{k-1} \Gamma_i \Delta \mathbf{x}_{t-i} + \Pi_K \mathbf{x}_{t-k} + \mu + e_t \tag{5}$$

with $\Gamma_i = -I + \Pi_1 + ... + \Pi_i$, $i = 1,...,k-1$ and $\Pi_K = -I + \Pi_1 + ... + \Pi_k$. Hence, Π_K is the long-run 'level solution' to (4). If $\boldsymbol{x_t}$ is a vector of $I(1)$ variables, the left-hand side and the first (k-1) elements of (5) are $I(0)$, and the last element of (5) 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 case the $\boldsymbol{x_t}$ vector contains three data series, the two prices and the exchange rate. We will expect to find one cointegration if there is a relationship between the two levels in the chain.[10]

The Johansen procedure allows hypothesis testing on the coefficients α and β, using likelihood ratio tests (Johansen and Juselius, 1990). In our case, it is restrictions on the parameters in the cointegration vectors β which is of most interest. More specifically, in our case there are three data series in the $\boldsymbol{x_t}$ vector. Provided that the data series cointegrate and we find one

[10] One can also model several stages in the value chain in the same system (Goodwin and Holt, 1999). However, we avoid this since the interpretation when also an exchange rate variable is included then is much harder.

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 full price transmission 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 price leadership. 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 therefore be the price leader. With one cointegration vector, at least one factor loading parameter must be different from zero (Johansen and Juselius, 1990). Please also note that only in the case when just one factor loading parameter is different from zero, there will be no simultaneity problems if a system is represented with a single equation (normalized on the correct variable).

4. Background

The exports of cod from Norway date back at least a millennium. Until the 1930s, virtually all cod exported from Norway was either dried salted cod or dried cod. These two product forms had been the two main product forms for centuries, since this was the only known preservation technologies for cod.[11] Moreover, as the drying process removes most of the moisture from the fish, this also makes it lighter, and therefore easier to transport. As preservation technologies and

[11] The main difference between the two product forms is that for dried cod, the raw fish is dried directly, while for dried salted cod, the fish is first salted and then, possibly after some time, dried.

transportation became better in the 1930s, one also started to export wet salted cod, as well as new product forms based on frozen cod.[12] At the global market, frozen cod became the main product form. However, fish produced with traditional preservation methods, dried, dried salted and salted cod still have substantial markets. During the last decade, they made up about 50% of Norway's cod exports.[13] The markets for these products have mainly been in southern Europe and Latin America, with Portugal as the most important market for both dried salted and salted cod.

Fish and seafood is, and has for a long time been an important component of the diet in Portugal, with an average annual gross consumption *per capita* at about 60 kg (FAO, 2000). This makes Portugal the country with the highest seafood consumption in the EU. A substantial part of this consumption (40-50%) is dried salted cod, and this share is fairly stable over time (Dias *et al*, 2001).[14] The changes in international maritime jurisdiction in the late 1970s with the introduction of 200 miles Exclusive Economic Zones (EEC) contributed to the collapse of the Portuguese long distance fleet and the disintegration of many salting and drying plants. From the mid 1980s, most of the cod consumed in Portugal has therefore been imported. Portugal is the world's largest importer of dried salted cod, which outside of Portugal is produced virtually only in Norway. In addition, Portugal is a big importer of salted cod, which is dried in Portugal before consumption by a domestic processing industry. This cod comes from all the larger harvesting nations, i.e. Canada, Iceland, Norway, Russia and small quantities from other places. In the 1990s imports of

[12] In some markets like Spain, salted cod has taken over the market from dried product forms, in some markets like Italy both types of products are consumed, while in other markets like Portugal, dried product forms are preferred.
[13] This share is substantially higher in Norway then for the other main cod suppliers (Iceland, Canada and Russia).
[14] The foundation of dried salted cod consumption in Portugal dates back to the end of the 15th century, when the Portuguese discoveries were in the peak. The cod was caught in the banks of *Terra Nova* (Grand and Georges Banks), where the fish was salted on board, and then dried when it was landed in Portugal.

frozen cod has taken market share from wet salted cod as the Portuguese industry taws, salts and dries this input.

The value chain is therefore somewhat special as the final product, dried salted cod is produced only in Portugal and Norway, while the main input factor, cod, is available from many different sources. Cod is imported not only as a final product, but also at different processing levels as an input for the Portuguese salting and drying industry (import shares are shown in Figure 2). There is little doubt that there is a highly competitive global market for frozen cod (Gordon and Hannesson, 1996), and a large competitive European market for salted cod (Asche, Gordon and Hannesson, 2002). Moreover, although dried salted cod is produced only in two countries, there are many small companies in the industry in both countries giving little scope for market power. Market integration analysis and investigation of substitution relationships between different product forms of cod also indicate that the different cod markets are highly related (Gordon, Hannesson and Bibb, 1993; Asche, Gordon and Hannesson, 2002). This is as expected given that the budget share of the raw fish is high for all product forms (Toft and Bjørndal, 1997).

5. Data

In our analysis we have data on prices and the exchange rate for the period January 1988 to December 1999. The Norwegian ex. vessel prices are from Norges Raafisklag, the Norwegian export price to Portugal in Norwegian kroner from the Norwegian Trade Statistics, and the Portuguese retail prices in Portuguese escudos from the Institute of National Statistics. The exchange rate is from International Financial Statistics. The prices are charted in Figure 1 with the Norwegian prices converted to escudos. As one can see, the price increases substantially at each level in the chain with exception for frozen and salted cod. The main trends in the prices are similar, but there is substantial short-run variation. The main reason for the differences in the price levels is the weight difference due to the different preservation technologies. The difference largely disappear when one take the weight difference into account, as shown in Table 1, where the average of the prices in the data set are shown as well as the average of the prices in live weight equivalent.

The import shares for the different product forms are shown in Figure 2. The share for dried salted cod is relatively stable over the period, while the share of wet salted cod decreases in favor of frozen cod. Frozen cod is a relatively new product in this value chain, and there are a number of zero observations both for the Norwegian export price to Portugal, and for the total imports price to Portugal, particularly early in the period covered by our data set. Since there seems to be a well integrated global market for frozen cod (Gordon and Hannesson, 1996), we therefore use the Norwegian export price to all destinations as a proxy for the world market price. This should be a good measure for the price at which Portuguese importers could purchase frozen cod also in the periods when they actually did not. However, we will therefore impose perfect exchange rate pass through when using this price.

Before we can conduct any empirical analysis we must investigate the time series properties of the data. This is done with Augmented Dickey-Fuller tests, and the results are reported in Table 2. As expected, all data series are nonstationary in levels, but stationary in first differences. These results are independent of the lag length chosen.[15] Hence, all the series seems to be $I(1)$, and cointegration tests is the appropriate tool.

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[15] The lag length in the ADF tests is chosen high enough to make the residuals white noise. The reported test statistics are with six lags.

6. Empirical Results

When reporting the empirical results, we will first look at the hypotheses with respect to the relationships between the prices, before we comment upon the exogeneity tests for all systems. We start with the system containing the retail price in Portugal and the ex vessel price in Norway since this covers the whole value chain. These results are shown in Table 3. The cointegration tests indicate one cointegration vector, and hence price signals are transmitted between the retail and the ex vessel level. The tests for full exchange rate pass through and perfect price transmission is reported in the lower panel of Table 3. As one can see, we cannot reject any of these hypotheses, and can therefore conclude that not only are there full exchange rate pass through in this chain, but price signals is also fully transmitted through the chain.[16] Given these results, one will expect similar results also for the intermediary product categories.

We then turn to the link between the retail price in Portugal and Norwegian export price of dried salted cod. Dried salted cod is the highest processed product form from Norway as this is the finished product, and the margin basically goes to the retailers and transporters. The results are reported in Table 4, and as expected there seems to be one cointegration vector also in this chain. Furthermore, we cannot reject the hypothesis of full exchange rate pass through or the hypothesis of full price transmission. We then look at the link between the Portuguese retail price and the Norwegian export price for wet salted cod, which is an input factor for the Portuguese processing industry. This is reported in Table 5. Also here there is one cointegration vector. However, there is some evidence against full exchange rate price through, as this test is rejected at a 5% level. However, with a *p*-value of 0.454, the evidence is not very strong. Also the hypothesis of full

[16] That price signals are fully transmitted between two levels in the chain implies that the price transmission elasticity is one, as is indicated by our test.

price transmission is rejected at a 5% level although not at a 1% level. Hence, there is some evidence also against this hypothesis. These results are somewhat surprising given the results in the two previous tests. A possible explanation is that wet salted cod is the preferred product form for storage, and hence, that this trade is not fully synchronized with the retail market. However, as the evidence against these hypothesis is not very strong, the price signals seems to be passed through the chain to a large extent. The final product to investigate is frozen cod, which is the least processed product form imported to Portugal. As noted in Section 5, we use the Norwegian aggregate export price for frozen cod in that relationship since there are several periods when Portugal does not import any frozen cod. We therefore express the prices in the same currency, and full exchange rate pass through is accordingly imposed. The cointegration tests are reported in Table 6, and indicate one cointegration vector. A test for full price transmission has a test statistic of 0.285 and with a *p*-value of 0.592 we cannot reject this hypothesis.

That the exchange rate pass through is high for these products is not surprising, since it is a primary product industry consisting of many small firms. It is more surprising that the price transmission also seems to be complete. However, if one look at Table 1 it is clear from the data that is converted into live weight equivalents that the cost of processing and transporting the fish is low. It therefore does not seem unreasonable to describe the agents at the different levels in this value chain as firms with only one variable input, where the margin must cover marketing and processing costs. Given that there are many small firms and few barriers to entry, exit and entry will adjust capacity, and not substitution of other inputs in the processing and marketing processes.

Let us then turn to the weak exogeneity tests. These are reported in Table 7. If we look at the exchange rate first, we see that the hypothesis that the exchange rate is exogenous cannot be rejected in any of the systems. Hence, as one would expect, there is no evidence that the cod trade influence the exchange rate between the two countries. If we look at the prices the results are not as clear. In the relationships between the retail price and the dried salted and wet salted prices, the retail price is exogenous or price leading and is not influenced by supply shocks for dried salted or wet salted cod. However, in the chain between the retail price and the ex. vessel price the shocks are transmitted in both directions, although there are weak evidence in favor of the ex. vessel price as price leading since the *p*-value is 0.038, and the hypothesis that the ex. vessel price is exogenous is not rejected at a 1% level. The frozen price is exogenous for the retail price. Asche *et al* (2002) indicate that the ex. vessel price in Norway is determined by the world market price for cod. As frozen and frozen fillets of cod is the largest product forms at the world market, these products are therefore likely to be price leading also for the retail price for dried salted cod in Portugal. This is because Portuguese processors have access to the world market for cod, and with the low cost of processing frozen cod to dried salted cod, the global market price will then to a large extent determine the retail price. Other product forms will only be bought to the extent that they are competitive with this price, and will then have to follow this price. That the retail price can influence the dried salted and wet salted cod prices is then possible because this fish then already has been committed to this market, but the Portuguese do not have to buy. Hence, it seems like the price of dried salted cod in Portugal is determined by the world market price for cod.

7. Concluding remarks

The extent to which demand and supply shocks and therefore price information is transmitted in the value chain is an important topic. As many value chains cross international borders, exchange rate pass through is an important element in this context. In this paper a multivariate system that allow us to test different hypothesis with respect to the value chain is specified. We follow the approach used by Richardson (1978) when testing for market integration, but recognize that the data series are nonstationary. This includes tests of whether there is a link between the different stages in the value chain, whether the exchange rate pass through is complete and whether price signals is fully transmitted. By specifying a multivariate system the simultaneity problems that is often present when analyzing relationships between prices are avoided, and different exogeneity assumptions are testable hypothesis. In particular, we can test whether the exchange rate is determined outside the system, as well as testing for price leadership.

We apply this approach to the value chain for cod between Norway and Portugal. This is an interesting value chain not only because it crosses national boundaries, but also because the final product, dried salted cod is produced both in Norway and Portugal and the Portuguese industry depends on imports of less processed cod as input. Moreover, the value added are very low, cod is in this value chain a homogenous nonbranded product, and the industry consists of many small firms. Hence, it is an industry where one would expect the price of the primary product to be the most important factor at all stages in the chain. The empirical results confirm this, as exchange rate pass through seems to be complete for all product forms, as do price transmission. The exchange rates are always found to be exogenous or determined outside of this value chain. When it comes to price leadership the results is somewhat mixed. It seems like price movements at the global market for frozen cod is the main determinant of the price in Portugal, but that retail shocks has influence on cod that has been committed to product forms in this value chain.

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Figure 1. Prices in the Norway-Portugal value chain for cod

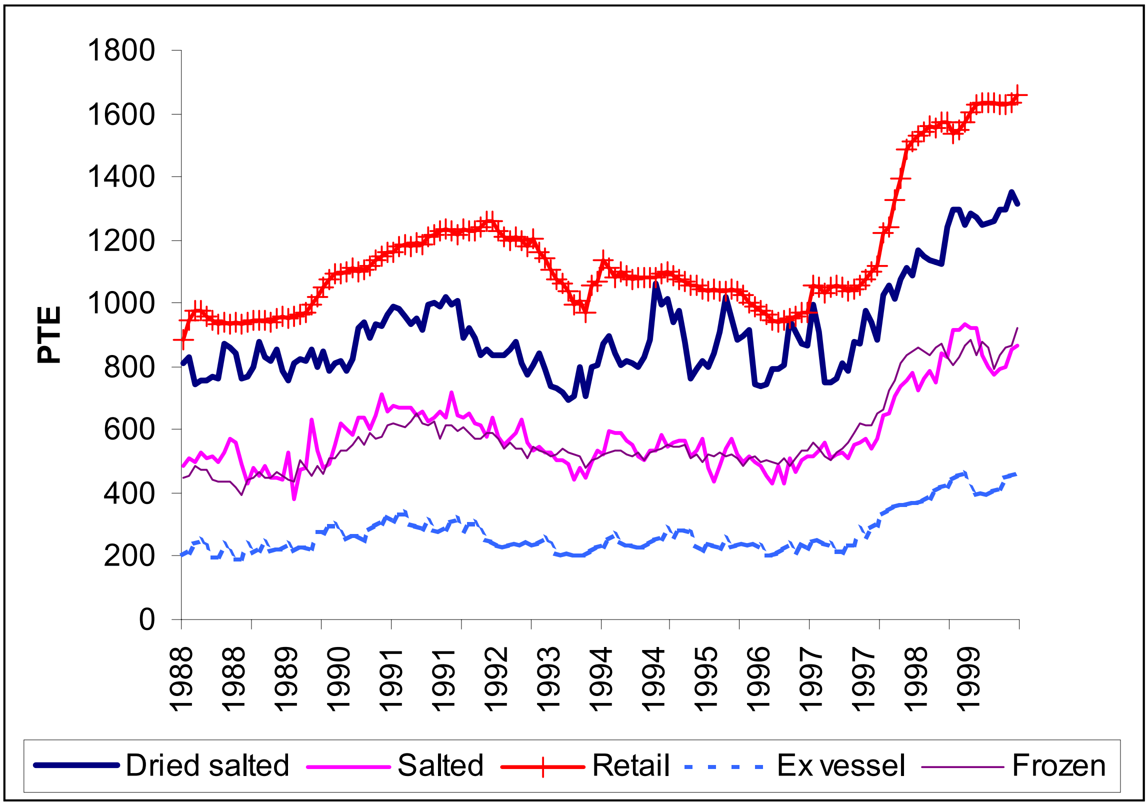

Figure 2. Import shares for cod by product form to Portugal

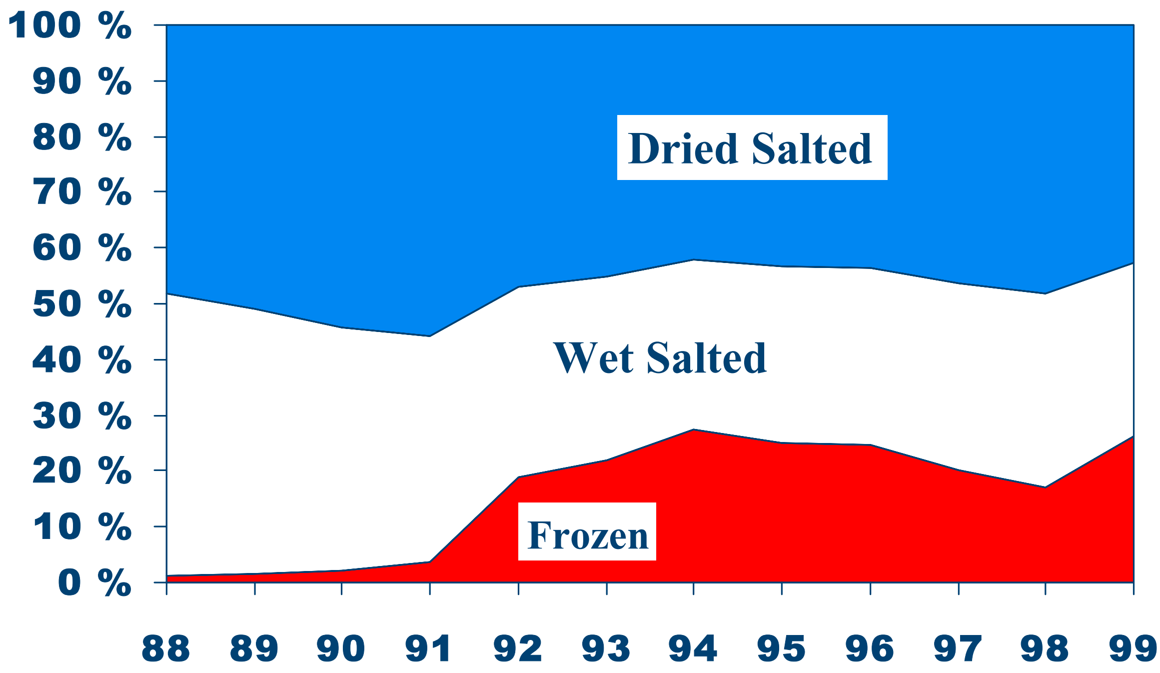

Table 1. Average prices, actual and in live weight equivalents (LWE)

Product form	Actual	LWE
Ex. Vessel	272.83	181.88
Wet salted	589.55	196.51
Frozen	579.29	192.68
Dried salted	910.98	211.86
Retail	1146.49	

Table 2. Dickey-Fuller tests

Data series	Test statistic, levels	Test statistic, first differences
Retail	-0.931	-3.280*
Ex. vesssel	-0.722	-5.903**
Dried salted	-0.822	-5.172**
Wet salted	-1.092	-5.074**
Frozen	-0.845	-4.177**
Exchange rate	-1.090	-5.916**

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

Table 3. Cointegration tests, Ex. vessel price

Ho:rank=p	Max test	Critical values	Trace test	Critical value
p == 0	23.31*	22.0	36.04*	34.9
p <= 1	9.31	15.7	12.73	20.0
p <= 2	3.42	9.2	3.41	9.2

LM(12)[a]	Full exchange rate pass through	Perfect price transmission
1.179 (0.142)[b]	0.389 (0.532)[b]	2.346 (0.309)[b]

* indicates significant at a 5% level

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

[b] *p*-values in parenthesis

Table 4. Cointegration tests, Dried salted cod

Ho:rank=p	Max test	Critical values	Trace test	Critical value
p == 0	23.09*	22.0	37.30*	34.9
p <= 1	11.13	15.7	14.21	20.0
p <= 2	3.08	9.2	3.07	9.2

LM(12)[a]	Full exchange rate pass through	Perfect price transmission
1.317* (0.037)[b]	0.081 (0.775)[b]	0.768 (0.681)[b]

* indicates significant at a 5% level

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

[b] *p*-values in parenthesis

Table 5. Cointegration tests, Wet salted cod

Ho:rank=p	Max test	Critical values	Trace test	Critical value
p == 0	25.19*	22.0	37.39*	34.9
p <= 1	9.35	15.7	12.2	20.0
p <= 2	2.84	9.2	2.84	9.2

LM(12)[a]	Full exchange rate pass through	Perfect price transmission
0.862 (0.814)[b]	4.070* (0.043)[b]	7.881* (0.019)[b]

* indicates significant at a 5% level

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

[b] *p*-values in parenthesis

Table 6. Cointegration tests, frozen cod cod

Ho:rank=p	Max test	Critical values	Trace test	Critical value
p == 0	19.96*	15.7	21.28*	20.0
p <= 1	1.32	9.2	1.32	9.2

LM(12)[a]	Perfect price transmission
1.152 (0.245)[b]	0.286 (0.593)[b]

* indicates significant at a 5% level

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

[b] *p*-values in parenthesis

Table 7. Exogeneity tests from Multivariate systems [a]

Exogenous price	Retail	Exchange rate	Exogenous variable
Ex. vessel	6.805** (0.009)	0.389 (0.532)	4.269* (0.038)
Dry salted	0.886 (0.346)	0.164 (0.685)	10.433** (0.001)
Wet salted	1.898 (0.168)	0.257 (0.612)	15.667** (<0.001)
Frozen	16.473** (<0.001)		0.039 (0.842)

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

[a] *p*-values in parenthesis