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IS PRICE TRANSMISSION SYMMETRIC OVER TRANSNATIONAL VALUE CHAINS FOR CODFISH PRODUCTS ?

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Abstract. This paper uses a threshold adjustment methodology to find out whether price transmission over the cod value chain between Norway and Portugal is asymmetric. The basic setting relies on price theory and the relationship between prices in the fish market. Empirical tests of price transmission use a cointegration framework similar to many other non-stationary time series analyses. However, it appears that testing for asymmetric price transmission has not been done so often in the fish market, despite the recent availability of non-linear time series techniques designed to this end. TAR and M-TAR adjustment models can be used in this context. Our results show that while the three price series used in the cod value chain between Norway and Portugal are cointegrated, there is no evidence of asymmetric price adjustment in this market.

Keywords. Asymmetric price transmission, threshold adjustment, cointegration, seafood value chains

Price theory has been used as a framework in analyses of vertical market integration where agent decisions are taken so as to lower transactions costs, attenuate the effects of market power, etc. There are at least two advantages in using this approach. The first is that price data is more readily available than many other forms of data, namely costs data, and analyses can be conducted in chains where only limited information is available. The second is that many industries, particularly primary industries, have a structure where one factor, the primary good, is the main factor in the chain, and therefore influences the use of other factors and also often has a high budget share. However, this comes at the cost that less precise information may be obtained using this approach compared with others based on more intensive datasets.

Of special interest in this context is the study of asymmetric price transmission over a given value chain. This is based on the common feeling that market power is exerted by big retailers to perfectly pass on price increases while mitigating or simply not fully transmitting price decreases, that is, asymmetric transmission of price changes according to the sign (positive or negative) of past variation. It may be a source of distortion in the transmission of information down the marketing chain in response to supply shocks. Thus, an input factor price cut associated with an increased

primary production that is not transmitted to the retail level, will not lead the retail price to equalize the market clearing price and the production will be in excess.
Alternative explanations to asymmetric price transmission in a vertical value chain lie on issues such as inventory holding or the perishable nature of products with a lower supply elasticity. Several studies on this issue have been conducted within the European markets for fresh products such as fresh vegetables or fresh fish. In the latter case, it has been investigated the relation between the characteristics of supply (farmed or wild-caught species) and the results regarding asymmetry of price transmission along the supply chain of fresh fish. Perishable fresh vegetables and wild-caught fish species are more likely to have lower elasticity of supply than the non-perishable and the farmed counterparts. Thus, one would expect that non-perishable vegetables and farmed fish will show less asymmetry than their counterparts due to increased security of supply.
This type of analysis can be extended to the cod value chain between Norway and Portugal. Cod is a wild-caught species that goes through a number of processing actions before reaching the retail market. There are basically three product forms under which the cod is commercialized around the world: frozen, salted non-dried, and dried salted. The latter is the product form that is sold in the retail market in Portugal. Drying and salting are two forms of preservation known since the ancient times. This means that this product can be maintained without further preserving for a long period of time, turning it less perishable than other food products. One would therefore expect a relatively high elasticity of supply and low asymmetry of price transmission for this product at the retail level of the chain. However, since the perishable nature of the product may change for different product forms, there may be variations in the extent of price change asymmetry along the value chain, one hypothesis that is testable in our context.
The empirical analysis of asymmetric price transmission is based on TAR and M-TAR cointegration models carried out on monthly cod price data for Norway and Portugal over the period from January 1988 to December 1999. This methodology overcomes the technical difficulties raised by the non-stationary property of this type of data. Cointegration tests were performed using the Johansen method applied to VAR systems built for the whole structure of the value chain. As usual, where price series are cointegrated the typical VECM transformation can be employed to infer about the nature of the market based on model restrictions. The results obtained do not prove that price transmission in the cod value chain between Norway and Portugal is asymmetric, which is consistent with our prior expectations.
The paper is organized as follows. Chapter 1 describes the basic data and background used to study asymmetric price transmission in the cod value chain. Chapter 2 explains the methodology employed in the empirical analysis of our subject. In Chapter 3 the asymmetric adjustment results are presented and discussed. Chapter 4 contains our concluding remarks.

1 Data and Background

The fish and seafood is since long an important component of the diet of the Portuguese population, with an average annual gross consumption *per capita* over 60 kg (lwe). For this reason Portugal holds the first place in the ranking of fish and seafood consumption among the EU countries and the second place within Europe.
The pattern of consumption of fish and seafood in Portugal results not only from the consumption of the most abundant species in national waters (small pelagic such as the sardine and the mackerel) but also, and mostly, from the “traditional taste” for the consumption of dried salted codfish (*Gadus morhua*). This taste created profound roots in the food habits of the Portuguese population since a

long time ago and is perhaps the most marking component of the Portuguese cuisine. This is so obvious that the annual consumption of this species remained at high levels, around 70,000 tones until 1999, despite the abrupt fall of the catches made by the Portuguese fleet [1] due to scarceness and structural changes in the catching rules around the world.
Portugal holds the first place in terms of worldwide import trade of wet salted cod (42%) and the second place along with Brazil on dried salted cod (27%). Norway on the other hand is the major worldwide exporter in all presentations. Between 1988 and 1999 cod imports increased about 10% in quantity live weight equivalent (lwe). This increase was basically due to the explosive growth of frozen cod imports and a moderate increase of dried salted cod imports. The imports of wet salted cod, in turn, decreased 23% over the period. The effect of these variations on the structure of imports was important, with emphasis to the increase in the share of frozen cod (insignificant in 1988 and 21% in 1999), the reduction of the share of wet salted cod (76% in 1988 and 53% in 1999), and the relatively steady state of the share of dried salted cod (23% in 1988 and 26% in 1999). Over the period from January 1988 to December 1999 Portugal imported a total of 457,000 tones of frozen cod (13% of the total), 2,179,000 tones of wet salted cod (60% of the total), and 989,000 tones of dried salted cod (27% of the total). These quantities are expressed in terms of live weight equivalents.
For the national imports of wet salted cod Norway holds the first place as supplying country (40% over the period), but its weight has been decreasing since 1994 in favor of Iceland (24% over the period). In 1999 the national imports of wet salted cod from both countries were rather close (60,000 and 55,000 tones live weight equivalent, respectively). Canada was important until 1992 but is now only residual. The national imports of dried salted cod, on the other hand, come fundamentally from Norway and from Norway via Denmark, respectively with 49% and 27% over the period.
The above picture highlights the role of Norway and Portugal in the worldwide codfish market and helps to understand that this trade is very important in terms of trade balance between both countries. Thus, our tests for asymmetric price transmission will rely on three main price series: ex. vessel prices in Norway, import prices of wet salted cod from Norway, and retail prices of dried salted cod in Portugal. The national series were obtained from data of the Portuguese National Statistics Institute (INE) and the Fisheries Ministry office (DGPA). The data on Norwegian cod production comes from the Norges Rafisklag.
The original national import data series refer to monthly monetary values and quantities for the different presentations/states and countries. The average import prices were then obtained dividing the values of one series by another. The unit price used in this study refers to prices per kg product weight. The conversion factors to live weight equivalent are 3 for wet salted cod and 4.3 for dried salted cod. The values expressed in national currency were converted in euros applying the corresponding exchange rates. Missing prices were obtained using a kernel smoothing interpolation method. For all the series used in this study, the time period considered is from January 1988 to December 1999. A total of 144 data points were then collected.

2 Methodology

There is an extensive literature on price transmission that uses a log-linear functional form to investigate the relationship between non-stationary prices. There are several advantages in using such an approach and we shall also adopt a similar framework. Therefore, the long-run equilibrium relationship between two price series can be written as

$$\ln P_{2t} = \alpha + \beta \ln P_{1t} + \mu_t \tag{1}$$

where P_{1t} and P_{2t} are, respectively, the prices at the upstream and downstream levels. μ_t is a random disturbance that may be serially correlated. The parameter α is a constant and β is the long-run elasticity of P_{2t} with respect to P_{1t}. β gives the magnitude of adjustment of the downstream price to variations of the upstream price. If $\beta < 1$ then, shifts in the upstream price are not fully passed onto the downstream price.

The threshold methodology applied here uses the estimated OLS residuals of the long-run relationship between prices to assess whether there are different adjustment speeds for positive and negative variations in the upstream price. Thus, the methodology focuses on the OLS estimate of ρ in the following relationship:

$$\Delta\mu_t = \rho\mu_{t-1} + \varepsilon_t \tag{2}$$

where ε_t is a white noise disturbance and the residuals from (1) are used to estimate (2). Equation (2) is used as the basis for the Dickey-Fuller test. However, the DF test and its extensions are misspecified if adjustment is asymmetric, and similarly for cointegration tests. An alternative way of specifying equation (2) that allows for different adjustment processes for positive and negative variations is then

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1-I_t)\rho_2\mu_{t-1} + \varepsilon_t \tag{3}$$

where I_t is the Heaviside indicator function such that

$$I_t = \begin{cases} 1 & \text{if } \mu_{t-1} \geq 0 \\ 0 & \text{if } \mu_{t-1} < 0 \end{cases} \tag{4}$$

The model specification illustrated in equation (3) is called the threshold autoregressive (TAR) model [2]. It allows for different coefficients for positive and negative variations. A sufficient condition for the stationarity of μ_t is $-2 < (\rho_1, \rho_2) < 0$ [3]. If $\rho_1 = \rho_2$ then the adjustment is symmetric, which is a special case of (3) and (4). Equation (3) can also contain lagged values of $\Delta\mu_t$.

An alternative adjustment specification is to allow the decay to depend on the previous period change in μ_{t-1}, which is called the momentum threshold autoregressive (M-TAR) model. Thus, equation (4) is replaced by

$$I_t = \begin{cases} 1 & \text{if } \Delta\mu_{t-1} \geq 0 \\ 0 & \text{if } \Delta\mu_{t-1} < 0 \end{cases} \tag{5}$$

In equation (4) the Heaviside indicator depends on the sign of the level of μ_{t-1}. Thus, if μ_{t-1} is above its long-run equilibrium value, the adjustment is $\rho_1\mu_{t-1}$, and if μ_{t-1} is below its long-run equilibrium value, the adjustment is $\rho_2\mu_{t-1}$. In equation (5), the adjustment is now allowed to depend on the sign of the change of μ_{t-1} in the previous period.

The TAR model is designed to capture asymmetrically "deep" movements in the series of the deviations from the long-run equilibrium, while the M-TAR model is useful to capture the possibility of asymmetrically "steep" movements in the series [2]. For example, in the TAR model if $-1 < \rho_1 < \rho_2 < 0$, then the negative phase of μ_t will tend to be more persistent than the positive phase. On the other hand, for the M-TAR model, if for example $|\rho_1| < |\rho_2|$ the model exhibits little

decay for positive $\Delta\mu_{t-1}$ but substantial decay for negative $\Delta\mu_{t-1}$. This means that increases tend to persist but decreases tend to revert quickly toward the attractor.
Finally, we can perform a number of statistical tests on the estimated coefficients in order to ascertain whether the variables are cointegrated and, in such case, if the adjustment is symmetric or not. The relevant tests are H_0: $\rho_1 = 0$ and H_0: $\rho_2 = 0$, for which we obtain the sample values of the *t*-statistics; and H_0: $\rho_1 = \rho_2 = 0$, for which we obtain the sample values of the *F*-statistic. These values are compared with the appropriate critical values in [2] and [4] to determine whether the null hypothesis of a unit root can be rejected. If the alternative hypothesis is accepted, it is possible to test for asymmetric adjustment, since ρ_1 and ρ_2 converge to a multivariate normal distribution [2]. The restriction that adjustment is symmetric, i.e. H_0: $\rho_1 = \rho_2$, can be tested using the usual *F*-statistic.

3 Results

The methodology for assessing asymmetric price transmission in the cod value chain presented in the previous Chapter was applied to the dataset described in Chapter 1. Firstly, we have run ADF tests for assessing non-stationarity in the log price series. The results are given in Table 1. The number of lags was chosen automatically using the Schwarz criterion (SIC). The resulting residuals follow a white noise process. The results are presented for the variables in levels and in first differences.
For all the variables, the test in levels does not allow us to reject the null hypothesis that there is a unit root, independently of the inclusion of a constant or a constant and a deterministic trend in the ADF regression. However, the null hypothesis of a unit root is significantly rejected at the 1% level by the tests for the variables in first differences. This means that the price variables are integrated of first order. In this way, cointegration procedures seem to be required to perform tests on these series.

Table 1
Augmented Dickey-Fuller Tests

Product	**Constant**		**Constant and trend**		**lags**
Levels:					
Retail Portugal	-0.308		-0.946		2
Wet salted import Norway	-0.971		-1.506		2
Ex. vessel Norway	-1.461		-1.843		0
First Differences:					
Retail Portugal	-5.566	**	-5.702	**	1
Wet salted import Norway	-13.633	**	-13.644	**	1
Ex. vessel Norway	-13.204	**	-13.196	**	0

** significant at the 1% level
Critical value is -3.477 at the 1% level (test statistic with constant)
Critical value is -4.024 at the 1% level (test statistic with constant and trend)

We shall now proceed with the cointegration analysis of the logarithmic transformations of the price series. Being bivariate tests, we shall consider as many VAR systems as the relevant price combinations. The VAR model was specified with two lags in the system. The results of the bivariate Johansen tests are based on the VECM form of the system with no deterministic trend, and are presented in Table 2.

Table 2
Bivariate Johansen Tests

Price 2	**Price 1**	**Rank = *p***	**Eigen value**	**Trace**		**Max**	
Retail Portugal	Ex. vessel Norway	p==0	0.1907	31.479	**	30.042	**
		p==1	0.0101	1.437		1.437	
Retail Portugal	Wet salted import Norway	p==0	0.2186	36.981	**	35.018	**
		p==1	0.0137	1.963		1.963	
Wet salted import Norway	Ex. vessel Norway	p==0	0.2851	49.476	**	47.653	**
		p==1	0.0128	1.823		1.823	

** significant at 1%. Critical values are 24.60 and 12.97 for the Trace test and 20.20 and 12.97 for the Max test

The column rank = p identifies the null hypothesis of each cointegration test performed. Here, $p = 0$ corresponds to the null hypothesis that there are no cointegrating vectors, that is, the cointegrating rank is zero, and $p \leq 1$ corresponds to the null hypothesis that there is at most one cointegrating vector, that is, the cointegrating rank is less than or equal to one. The next column reports the eigenvalues for each hypothesis. The last two columns present the results of the trace and maximum eigenvalue test statistics.

In all cases, the null hypothesis that there are no cointegrating vectors ($p = 0$) is rejected at the 1% significance level. On the other hand, the null hypothesis that there is one or none cointegrating vector ($p \leq 1$) cannot be rejected at the 5% significance level, thus indicating cointegration relationships for all pairs of variables.

We now use the threshold methodology as described in Chapter 2 in order to verify whether price adjustment over the value chain is asymmetric. Three OLS equations were estimated in the same sequence as shown in Table 2. The variables named Price 2 are, in each case, the dependent variables, and those named Price 1 are the explanatory variables. The OLS residuals obtained from each simple regression model were then used to estimate the thresholds. Table 3 summarizes the results for the relevant tests of the null hypotheses that: 1) $\rho_1 = 0$ and $\rho_2 = 0$, 2) $\rho_1 = \rho_2 = 0$ and 3) $\rho_1 = \rho_2$. Notice that the third test only makes sense when the two previous tests conclude the rejection of the null hypothesis. That is, if the ρ coefficients estimated for the threshold are significantly different from zero, then the regression is non-trivial and testing for symmetry makes all the sense.

Table 3
Threshold Cointegration Tests

	Model	Asymmetry		Statistics	Symmetry
		ρ_1	ρ_2	p value ($\rho_1 = \rho_2$)	
Retail – Ex. vessel	TAR	-0.099	-0.289	0.049	-

	M-TAR	-0.121	-0.222	0.294	yes
Retail – Wet salted	TAR	-0.607	-0.562	0.773	yes
	M-TAR	-0.694	-0.448	0.111	yes
Wet salted – Ex vessel	TAR	-0.793	-0.721	0.667	yes
	M-TAR	-0.838	-0.686	0.364	yes

The results of the first two tests allowed us to conclude that the null hypothesis is rejected in all cases except for $\rho_1 = 0$ in the first bivariate model. There is however evidence of non-trivial coefficients in all cases. For the symmetry tests, the null hypothesis is rejected in all cases except, again, the first one. These results seem to corroborate our prior expectations that there is no asymmetric price transmission over this particular value chain.

4 Conclusions

This paper employs a threshold adjustment methodology to inquiry the asymmetric nature of price adjustment in the cod transnational value chain between Norway and Portugal. Although the series are all cointegrated, there is no evidence of asymmetry in price transmission. Evidence exists however on differences in terms of size of margin that can be interpreted as a consequence of the uncertainty in the conditions of supply.

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