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PRICE TRANSMISSION ANALYSIS: A FLEXIBLE METHODOLOGICAL APPROACH APPLIED TO EUROPEAN HOG MARKETS

The study of spatial price relationships contributes to explain markets performance, their degree of integration or isolation, and the speed at which information is transmited. A great deal of methods have been used to analyze this issue, being the most important: causality tests, impulse-response functions and cointegration. Normally, these techniques have been individually applied. However, a more rich knowledge of markets performance can be extracted when they are jointly applied. In this paper, we try to conjugate these three techniques in a common econometric model. First, Johansen(1988) multivariate cointegration tests are used to determine the number of long-run equilibrium relationships. Cointegration is considered not only as informative about long-run price transmission but also as an essential step in the correct specification of a vector error correction model (VECM) used in the subsequent analysis. Second, Dolado and Lütkepohl (1996) causality tests are used to investigate the lead-lag behaviour among markets. Finally, impulse-response functions are calculated from the VECM estimated in the first stage for evaluating short-run dynamic price linkages. The method exposed is applied to the study of spatial pork prices relationships among seven countries in the EU using weekly data from 1988 to 1995.

1. Introduction

Spatial market integration is related to the free flow of goods and information over space. If no barriers to commodity trade and arbitrage exist, prices at geographically separated locations should be strongly linked. This implies that price shocks in individual markets should evoke responses in others. Markets whose prices are linked are considered to be integrated and global efficient. Nevertheless, market integration is not an absolute issue but a relative one, that is, it is possible to talk about different degrees of market integration which depend on how strictly is considered the theoretical concept and what method of analysis is used. Over time, methods have evolved from a static approach to cointegration, going through dynamic models.

Cointegration has become the most applied method of analysis as far as it takes into account the univariate properties of price series (mostly neglected in earlier methods). Cointegration among prices implies that they are tied up by a long-run equilibrium linkage what seems to match quite closely the concept of market integration. However, recent criticisms addressed to this tool and new emerging questions still unsolved (interpretation of multiple cointegration vectors, perfect transmission hypothesis testing and identification of cointegration space) have reoriented the spatial price analysis to earlier methods, in particular to causality and impulse-response functions.

The objective of this paper is to provide a method that conjugates cointegration, causality and price transmission dynamics in a common modeling framework. From an empirical point of view, we apply this method to the study of spatial pork prices relationships among seven countries in the EU, in the period 1988-1995. The goal is to find out if the institutional efforts made in order to achieve a unified market in the EU have been reflected in the agricultural prices behaviour.

The plan of the paper is as follows. Section 2 discusses the convenience of using a flexible empirical method. Section 3 outlines the econometric techniques used in this analysis to evaluate spatial and dynamic price linkages. The fourth section discusses the data and empirical results. The final section offers some concluding remarks.

2. Spatial Market Integration: Theoretical and Empirical Considerations

Spatial market integration concerns the free flow of goods and information and, therefore, prices, over space. If two markets are integrated, changes in one region's price are transmitted to the other market's price. Efficient arbitrage activities will ensure that price differences between any two regions will not be greater than transfer costs as the Law of One Price (LOP) asserts. Thus, prices in integrated markets are interdependent and move together. A weak version of the

LOP can be interpreted as a significant long-run equilibrium relationship among prices, while a more strict acception requires perfect transmission, that is to say, changes in one market's price should be matched by proportional changes in other markets prices.

Since Ardeni (1989), cointegration has become the most applied method to analyze this issue. However, more recently, it has lost some of its leading role because of the following shortcomings pointed out by Barrett (1996): first, the lack of cointegration may be due to non-stationary transaction costs and not to the lack of market integration; second, negative parameters or estimated values very far from one would mean opposite direction movements of prices and small degree of integration, respectively; and third, cointegrated prices can be compatible with margins sistematically greater than transfer costs. This would imply an absence of rational and efficient arbitrage, as excess profits would be wasted, and, therefore, lack of market integration.

As a result, we consider that it is more appropriate to use a more flexible approach that conjugates cointegration with methods received from the past, as in Goodwin et al.(1996). In this way, the study of spatial price transmission can be extended to evaluate patterns of Granger causality and dynamic features. As markets become more integrated, it is expected that each market employs information from the others when forming its own price expectations. If this takes place, bidirectional causality will be found (Gupta and Mueller, 1982). Likewise, more integration will be accompanied with a greater interdependence among prices, such that every price contributes to explain the evolution of the others. Considering these aspects jointly in one common modeling approach, more information is obtained about the exist linkages among prices and misleading interpretations derived from the use of a single method of analysis are avoided.

The methodological approach consists of three steps: first, Johansen's(1988) multivariate cointegration procedure is used to analyze long-run linkages among prices in a dynamic framework. Moreover, this step is essential in order to identify the proper specification of the Vector Error Correction Model (VECM) that will be used later; second, Granger causality tests, considering non-stationarity and cointegrated series, are applied to find out the direction of lead-lag relationships; and finally, impulse-response functions (IRF) and the decomposition of the forecast error variance (FEV) are used to analyze short-run dynamics.

3. Econometric framework

The starting point is the specification of a Vector Autorregressive Model (VAR) and the use of Johansen's (1988) procedure. Although cointegration is understood as an informative tool by itself, it is rather considered as an essential step in the proper specification of a VECM from which dynamic linkages and Granger causality will be studied.

The Error Correction Model

A k-dimensional VAR model reparameterized in a Vector Error Correction Model (VECM) form can be formulated as:

$$\Delta Y_t = mu + \Psi D_t + \Gamma_1 \Delta Y_{t-1} + ... + \Gamma_{p-1} \Delta Y_{t-p+1} - \Pi Y_{t-1} + \varepsilon_t \qquad [1]$$

where:

Y_t = k×1 vector of stochastic variables (price series for each market);

μ = vector of constants;

D_t = vector of deterministic variables (e.g. seasonal dummies);

Γ_i = k×k matrix of short-run parameters (i=1,...,p);

Π = k×k matrix of long-run parameters;

ϵ_t = vector of disturbances niid(0,Σ).

If price series in Y_t are integrated of order 1 [I(1)], the right and left sides in [1] will be balanced only if price series are cointegrated. In other words, if ΠY_{t-1} is stationary. If series are actually cointegrated, the formulation of a VAR model in differences will be misspecified. Following Johansens's procedure, testing for cointegration consists of testing for the rank of Π (r). If Π is of full rank (r=k), then Y_t is a vector of stationary variables while a rank of zero implies that Π contains no long-run information, and a VAR in differences would be the correct specification to study spatial price dynamics. Finally, if r<k then there are r stationary linear combinations of variables (i.e. r cointegration vectors), which can be interpreted as long-run equilibria among prices and, thus, as the fulfilment of the weak version of the LOP.

Wald Tests of Causality

The idea imbedded in the definition of causality in Granger's sense is that a cause cannot come after the effect. Then, Y_1 will cause Y_2 if the former contributes to improve the predictions of the latter. Granger(1988) showed that cointegration implies Granger causality in at least one direction. However, some inferential problems appear when applying standard Wald tests to cointegrated VAR systems. Toda and Phillips(1993) showed that these tests don't follow the χ^2 distribution as it is the case when using stationary systems.

Nevertherless, if the Wald test is applied over a VAR model obtained from a ECM with the restriction on the number of cointegration vectors imposed, it will have a χ^2 distribution in the following two special cases: first, in bivariate systems, as Lütkepohl and Reimers (1992) have shown; and, second, in multivariate systems that satisfy sufficient cointegration conditions.

Anyway, the approach by Dolado and Lütkepohl(1996) does not require to test for cointegration previously and grants convergence of causality Wald tests to the χ^2 distribution.

Let's consider the following k-dimensional VAR model of order p with series in Y_t in levels:

$$Y_t = mu + \Psi D_t + A_1 Y_{t-1} + ... + A_p Y_{t-p} + \varepsilon_t \qquad [2]$$

Testing for Granger-causality in [2] is equivalent to test for the significance of specific coefficients (Lütkepohl, 1993:39). Consider:

$$Y_t = \begin{bmatrix} Y_{1,t} \\ Y_{2,t} \end{bmatrix} \qquad A_i = \begin{bmatrix} A_{11,i} & A_{12,i} \\ A_{21,i} & A_{22,i} \end{bmatrix} \quad i=1,...,p \qquad [3]$$

where variables in Y_t are divided into two sets, Y_1 and Y_2; and the A_i coefficient matrices are partitioned accordingly. Y_2 does not Granger-cause Y_1 when $A_{12,i} = 0$ (for i = 1,...,p). The general null hypothesis of non-causality is:

$$Ho : R\alpha = 0 \quad \text{against} \quad R\alpha \neq 0 \qquad [4]$$

where:

R : suitable restriction matrix of order $N \times pk^2$;

N : number of restrictions;

α : VEC([A_1 A_2 ... A_p]). The VEC operator transforms the partitioned matrix [A_1 A_2 ... A_p] into a $pk^2 \times 1$ vector, stacking the columns.

Dolado and Lütkepohl(1996)'s approach to test for causality in cointegrated systems consists of specifying a VAR(p+d) model in levels being d the maximum level of integration of individual series. On this model, non-causality hypotheses are tested by imposing the nullity restrictions just on the first p matrices. Therefore, the R matrix becomes of order $N \times (p+d)k^2$.

The Wald statistic for testing H_0 is:

$$W = T\alpha' R' (R \Sigma_\alpha R')^{-1} R\alpha \qquad [5]$$

where T is the number of observations and Σ_α is the variance-covariance matrix of α. Under Ho, W has a Chi-squared distribution with N degrees of freedom.

Dynamics: Impulse-response functions and forecast error variance decomposition

VAR models account for the dynamic interrelationships between a number of variables. This information is summarized in the impulse-response functions(IRF) and the forecast error variance(FEV) decomposition. Both tools are obtained from the conversion of the VAR model defined in [2] into the equivalent moving-average representation:

$$Y_t = \nu + \varphi_0 + \varphi_1 + \ldots = \nu + \sum_{i=0}^{\infty} \varphi_i u_{t-i} \qquad [6]$$

The moving-avarage parameters φ_i are calculated recursively from the A_i parameters in [2]. Their equivalence is given by (Lütkepohl, 1993, p.18):

$$\begin{aligned} \varphi_0 &= I_k \\ \varphi_i &= \sum_{j=1}^{i} \varphi_{i-j} A_j \qquad i=1,2,\ldots \qquad A_j = 0 \text{ for } j>p \end{aligned} \qquad [7]$$

When there is cointegration, the A_i parameters in [2] are obteined from the Γ_i and Π matrices corresponding to the VECM representation according to:

$$\begin{aligned} A_1 &= I_k + \Gamma_1 - \Pi \\ A_i &= \Gamma_i - \Gamma_{i-1} \qquad i = 2,\ldots,p-1 \\ A_p &= -\Gamma_{p-1} \end{aligned} \qquad [8]$$

The IRF simulate over time the effect of a shock in one price on itself and on the other prices of the system. That reaction can be viewed in terms of causality: if a variable responds to a shock in other then the latter causes the former (Lütkepohl, 1993, p.43). Note, however, that they are quite different from the causality tests exposed above, which only allow us to find causality relationships among sets of variables and for the whole period. In stationary systems, responses die out to zero, while this is not necessarily true in non-stationary or cointegrated systems.

The h-step ahead FEV is decomposed into contributions of each variable's innovation in the system. Analysis of FEV provides information about the strength of interrelationships among the variables. Large proportions attributed to one variables's own innovation indicate that this variable is primarily influenced by its own past structure with limited interaction with the others, which can also be interpreted in terms of exogeneity. Moreover, it can be used as a useful complement of Granger causality tests. If the set of variables in Y_1 does not Granger-cause the variables in Y_2, and there is no instantaneous causality between the two groups, then the proportion of Y_2 FEV accounted for by Y_1 innovations will be zero (Lütkepohl, 1993: p.58).

4. Empirical Application and Results

Data

Weekly prices for hog carcasses coming from the publication: "Agricultural Markets. Prices" published by EUROSTAT are used. Data cover the period from 1988 to 1995 (418 observations) and are expressed in ECUs/100kg. They correspond to the price received by farmers at the entrance of slaughterhouse. Seven countries from the EU are considered: Netherlands, Italy, Germany, France, Denmark, United Kingdom and Spain. Table 1 shows the geographical distribution of pork production, consumption and the degree of self-sufficiency.

Table 1.- Geographical distribuion of pork production, consumption and degree of self-sufficiency in the EU. 1994.

	Net production		Consumption		Self-sufficiency Index
	Total (000t)	%EU-12	Total (000t)	%EU-12	
Netherlands (Ne)	1928.16	12.73	681.0	4.74	283.0
Italy (It)	1271.53	8.40	1899.0	13.22	68.2
Germany (Ger)	3502.41	23.13	4520.4	31.47	76.6
France (Fr)	2116.83	13.98	2089.0	14.54	101.3
Denmark (Den)	1535.92	10.14	329.0	2.29	467.8
UK	1053.69	6.96	1385.7	9.6	76.1
Spain (Sp)	2104.24	13.89	2123.9	14.78	103.5
EU-12	**15141.86**	**100**	**14363.8**	**100**	**106.1**

Source: Based on EUROSTAT(1995): *Animal Production*.

The seven countries selected represent around 90% of the total meat production and consumption in the EU. The main producer is Germany (23,13%) followed by France, Spain and the Netherlands, with similar shares (around 13-14%). In global terms, the main producers are also the biggest consumers. However, the self-sufficiency index (quotient between production and consumption expressed in percentage) differs among countries. Netherlands and Denmark have always had the greatest surplus, while Germany, Italy and UK show structural deficits. These features of the EU hog sector have estimulated very intense flows of hogs and pork meat among EU countries

The VECM formulation

First, time series univariate properties are examined by using unit root tests. ADF (Said and Dickey, 1984) and KPSS (Kwiatkowski et al., 1992) tests confirm that all series are I(1) (for a more detailed analysis, see Sanjuan (1998)). Therefore, checking for cointegration becomes an essential step in the model specification in order to prevent from spurious regressions.

Model [1] has been estimated for three different systems: system-0, formed by all the price series; system-1, formed by the prices of Netherlands, Italy, Germany and France; and system-2, includes the prices of Denmark, United Kingdom and Spain. System-0 allows to analyze jointly the interaction of every price without omitting any possible linkage. System-1 and system-2 have been defined according to the homogeneity of the commodity. Previous studies have shown that carcasses are much heavier in average in the first group (Sanjuan, 1998). This fact could indicate some degree of market segmentation and could affect prices interrelationships.

The Akaike information criterion (AIC) was used to specify the lag-length in each system. Three lags were selected in each system as residuals appear well behaved at this lag-length (Ljung-Box multivariate tests indicate absence of autocorrelation). In Table 2, the trace statist for testing the rank of cointegration is shown. Four cointegration vectors are found in the complete system, three in system-1 and two in system-2. Multiple cointegrating vectors provide stronger support for the concept of a single price and, therefore, for market integration in the long-run (Goodwin,1992). Moreover, note that in the subsystems the rank equals k-1. That is to say, one common trend leads these subsets of prices and every pair is linked by an equilibrium relationship. This result favours a high degree of integration among subsets of markets in the long-run.

Table 2.- Cointegration rank tests (λ_{TRAZA})

Ho: r= [a]	System 0	System 1	System 2
0	183.12*	91.44*	42.45*
1	124.13*	40.28*	20.49*
2	87.50*	20.05*	3.49
3	58.17*	4.72	
4	31.90		
5	13.40		
6	3.58		

[a] An asterisk indicates rejection of the null hypothesis at 10% significance level.
Critical values are taken from Osterwald-Lenum(1992)

Wald tests of causality

Dolado and Lütkepohl(1996) approach to test for Granger causality has been applied to the complete and partial systems. As all series were I(1), a lag has been added to the VAR in levels and the nullity of the first p lags is tested with the Wald statistic stated in [6]. Results are shown in Table 3.

First, causality from one price to the others (and in the opossite direction), is tested in every system. In the complete system only non causality running from Netherlands and Italy is not rejected. The first result seems paradoxical attending to the relevance of this country in the European hog sector; however, it is not supported by results obtained for system-1. In fact, in this system, every price contributes to improve the prediction of the others. More discouraging results about price interdependence are obtained in system-2. Only Danish price seems to cause British and Spanish prices; and British is caused by the other two.

Next, some hypothesis have been tested in the complete system. First, we wonder if prices of both groups of countries are, in fact, independent. The null is rejected in both directions. And finally, we test if main exporter countries lead the formation of European prices or, on the contrary, are the importer ones which exert a greater influence. The null is always rejected. Summing up, feedback between prices is mostly found instead of a radial structure. Prices linkages are multilateral and complex. Moreover, it does not seem to be appropriate to split the system in two so the following stages in this study will be carried out only taking into consideration the complete model.

Table 3.- Dolado-Lütkepohl causality tests

System	CV (5%) [c]	Ho: [a]	W [b]	Ho:	W
System 0 p = 3	$\chi^2_{(k-1)\times p}$: χ^2_{18} = 28.9	Ne ↛ Others	28.28	Others ↛ Ne	69.47*
		It ↛ Others	28.45	Others ↛ It	58.35*
		Ger ↛ Others	75.46*	Others ↛ Ger	34.93*
		Fr ↛ Others	37.92*	Others ↛ Fr	121.70*
		Den ↛ Others	39.10*	Others ↛ Den	75.65*
		UK ↛ Others	44.06*	Others ↛ UK	35.57*
		Sp ↛ Others	29.59*	Others ↛ Sp	73.76*
	$\chi^2_{4\times 3\times p}$: χ^2_{36}= 51.0	System 0 ↛ System 1	115.23*	System 1↛System 0	80.12*
	$\chi^2_{2\times 5\times p}$: χ^2_{30}= 43.8	Den-Ne ↛ Others	64.47*	Others ↛ Den-Ne	94.21*
	$\chi^2_{2\times 5\times p}$: χ^2_{30}= 43.8	Ger-It ↛ Others	104.57*	Others ↛ Ger-It	91.12*
	$\chi^2_{3\times 4\times p}$: χ^2_{36}= 51.0	Ger-It-Fr ↛ Others	111.63*	Others ↛ Ger-It-Fr	93.32*
	$\chi^2_{3\times 4\times p}$: χ^2_{36}= 51.0	Ger-UK-Fr ↛ Others	131.45*	Others ↛ Ger-UK-Fr	65.45*

System 1	$\chi^2_{(k-1)\times p}$	Ne $\nrightarrow$ Others	23.23*	Others $\nrightarrow$ Ne	63.20*
p = 3		It $\nrightarrow$ Others	17.74*	Others $\nrightarrow$ It	17.42*
	$\chi^2_9 = 16.9$	Ger $\nrightarrow$ Others	62.66*	Others $\nrightarrow$ Ger	31.70*
		Fr $\nrightarrow$ Others	26.91*	Others $\nrightarrow$ Fr	100.86*
System 2	$\chi^2_{(k-1)\times p}$	Den $\nrightarrow$ Others	20.23*	Others $\nrightarrow$ Den	6.76
p=3		UK $\nrightarrow$ Others	4.89	Others $\nrightarrow$ UK	27.95*
	$\chi^2_6 = 12.6$	Sp $\nrightarrow$ Others	8.72	Others $\nrightarrow$ Sp	6.84

[a] $\nrightarrow$ means "does not cause to

[b] W: Wald test. An asterisk indicates rejection of the null hypothesis of no Granger causality at the 5% significance level

[c] p = number of lags in the system; k= number of variables in the system

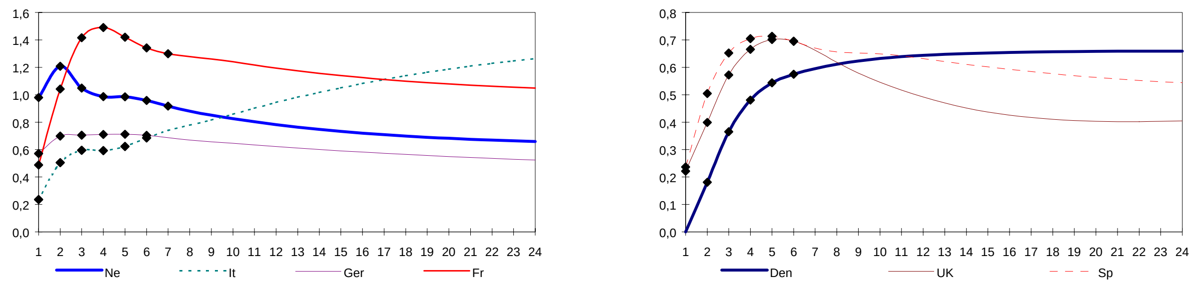
Short-run dynamics

The VECM estimated for the complete system has been transformed into its equivalent VAR in levels following the equivalence between parameters showed in [8] and IRF and FEV decompositions have been calculated. The Choleski decomposition was used to transform the covariance matrix of innovations to an identity matrix. This decomposition depends upon the way variables are ordered. In this paper, series are ordered basing on the degree of self-sufficiency shown in Table 1. Thus, prices are ordered as: Denmark, Netherlands, Spain, France, Germany, UK and Italy. Alternative orderings were considered but results were quite consistent.

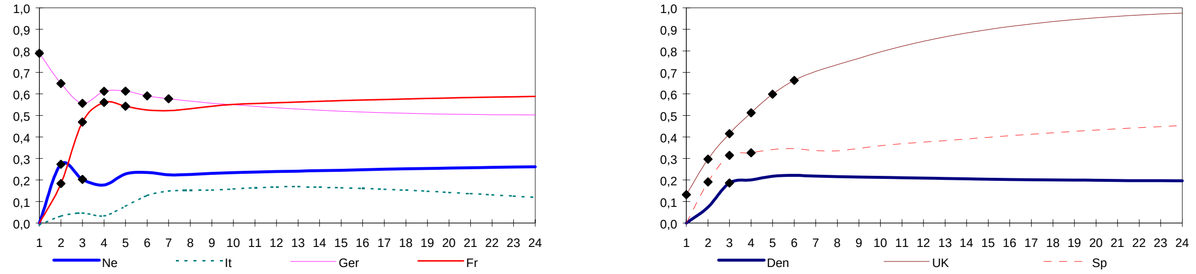
In Figure 1 the most relevant impulse-response functions are displayed. Significant responses at 5% level are marked with a black rhomb. The standard deviation of responses have been calculated following Lütkepohl(1993, p.97-101; 360). Responses of each variable have been normalized by the standard deviation of each variable's innovation. Thus, responses can be interpreted as percent changes in the standard error which allows to compare the size of reactions.

Figure 1.- Ortogonalized and normalized responses. System 0 (k=7; p=3; r=4)

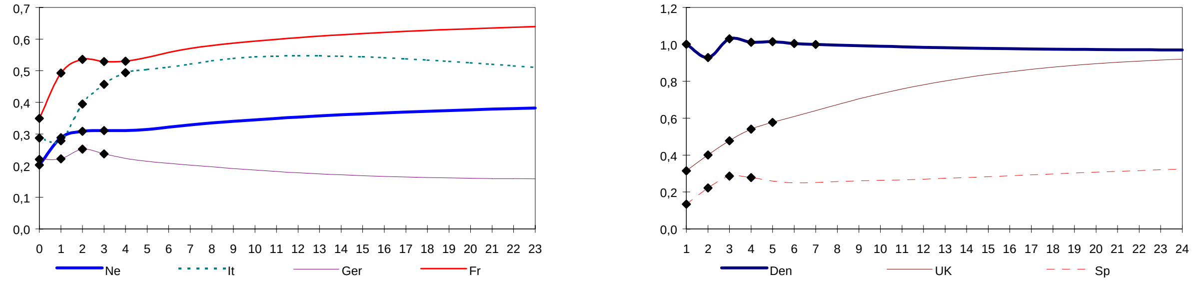
a) Shock in Netherlands price



b) Shock in Germany price



c) Shock in Denmark price



In general terms, the following results are obtained: first, positive shocks provoke also positive responses as was expected according to theoretical postulates; second, in contrast to stationary systems, responses do not die out as the time horizon from the shock increases. In fact, prices are attracted to their long-run equilibrium. Finally, responses to Denmark, Netherlands and Germany prices shocks are significant during longer periods than other prices shocks (results are not presented here). This fact awards the important role of these markets in the price formation process of this industry in the European Union.

Responses to shocks in Ducth and Danish prices are very similar. Reactions are very short-run in nature, significant during, at least, three weeks (reaching five weeks in some cases) and its magnitude ranges between 20 and 70 per cent of the initial shock. Denmark and Netherlands are the main exporters in the EU. Both represent around 60% of total hog and pork meat trate within the EU. So, it is expected that prices of their customers are very sharply influenced by shocks suffered by these two markets. On the other hand (and not shown here) these markets react inmediately and very intensively to other prices' shocks in an attemp to keep market shares. Shocks to Germany prices, however, are not responded son intensively by all series, and just the British price shows a more durable reaction.

FEV decompositions for alternative forecast horizons, ranging from 1 to 24 weeks, are shown in Table 4. Prices of the more important net exporter countries can be considered as the most exogeneous in the system. The percentage of Netherlands and Denmark FEV attributed to its own error exceeds 70% and 60%, respectively, at all reported horizons. The most endogeneous variable in the system is the French price. Its own innovation only explains around 8% of its FEV. Other prices are situated in an intermediate position. Among them, it is noticeably the relative high exogeneity of British prices (more than 50% of its FEV is attributed to its own past innovations).

Innovations in Dutch prices are the main factor explaining other prices FEV (apart from their own past), and becomes more important as the time horizon increases. For instance, 22 and 55% of Danish and French price FEV, respectively, is attributed to Netherlands price innovations after six months. Only the British price FEV is explained in a greater extent by innovations in other prices, mainly by Danish and German prices (both represent around 16% of its FEV).

Although Dutch prices are the most exogeneous it is not independent from the others, even in the short-run. Significant proportions of its FEV are explained, mainly by Danish price innovations (its direct competitor) but also by its customer markets prices: Germany, France and Spain. A similar pattern is found in Denmark price FEV. The only difference is the higher influence of British price variations. This result is consistent with the veryfied trade relationships that link both countries: Denmark is the main meat pork provider of United Kingdom (40% of total imports come from Denmark).

Table 4.- Forecast error variance decomposition. System 0 (k=7;p=3;r=4)

FEV in:	Weeks ahead	Standard Error	Percentage of forecast error explained by innovations in:						
			Den	Ne	Sp	Fr	Ger	UK	It
Den	1	0,021	100	0	0	0	0	0	0
	4	0,046	84,04	8,45	0,22	3,02	1,70	1,28	1,26
	12	0,089	66,61	18,84	0,84	3,63	2,51	4,41	3,12
	16	0,105	63,86	20,54	0,91	3,76	2,50	5,02	3,38
	24	0,130	60,97	22,31	0,96	3,93	2,43	5,75	3,60
Ne	1	0,033	4,09	95,90	0	0	0	0	0
	4	0,075	6,04	85,91	2,50	2,03	2,80	0,04	0,65
	12	0,122	8,69	77,78	5,98	2,74	4,20	0,19	0,39
	16	0,137	9,96	75,06	7,01	2,66	4,75	0,20	0,33
	24	0,160	12,10	70,81	8,31	2,45	5,72	0,21	0,37
Sp	1	0,031	1,81	5,59	92,59	0	0	0	0
	4	0,074	4,05	21,94	67,42	0,231	4,31	0,48	1,54
	12	0,119	5,24	32,55	50,81	0,129	8,41	2,08	0,76
	16	0,133	5,91	34,02	45,68	0,156	10,11	3,47	0,61
	24	0,156	7,33	34,73	38,20	0,352	13,32	5,52	0,51
Fr	1	0,018	12,21	23,82	3,45	60,50	0	0	0
	4	0,059	8,72	51,92	4,03	29,04	5,31	0,16	0,79
	12	0,103	10,89	57,65	8,39	12,85	8,96	0,87	0,35
	16	0,118	11,92	56,90	9,38	10,42	9,95	1,13	0,28
	24	0,141	13,57	54,95	10,55	7,80	11,40	1,45	0,25
Ger	1	0,035	4,83	32,57	0,31	0,10	62,17	0	0
	4	0,070	5,38	44,98	3,94	2,04	42,74	0,04	0,86
	12	0,120	4,49	44,87	11,87	1,63	35,87	0,53	0,71
	16	0,136	4,24	43,87	14,27	1,39	34,78	0,86	0,56
	24	0,162	3,94	41,87	17,06	1,08	33,88	1,71	0,42
UK	1	0,019	9,89	4,90	2,11	1,62	1,74	79,71	0
	4	0,059	8,35	10,47	2,28	3,57	5,79	67,20	2,31
	12	0,124	10,91	9,36	1,69	4,32	11,90	59,06	2,72
	16	0,146	12,66	8,17	1,56	4,22	14,13	56,56	2,67
	24	0,181	15,48	6,80	1,55	3,95	17,41	51,98	2,79
It	1	0,021	8,25	5,54	0,78	3,70	0,01	4,44	77,25
	4	0,058	6,89	13,35	0,14	2,86	0,05	1,61	75,06
	12	0,103	11,25	25,35	0,46	1,92	0,72	7,26	53,00
	16	0,122	11,52	30,64	1,13	1,53	0,83	10,11	44,20
	24	0,157	10,83	38,52	2,88	1,04	0,77	13,94	31,98

[a] h: prediction time horizon (weeks)

5. Concluding remarks

In this paper an attemp is done to conciliate different analytical tools used isotately in the past to study spatial price transmission. In contrast to other studies in this area, it has been considered that a deeplier knowledge of markets performance can be obtained when considering the linkages among prices from a broad perspective that includes the long-run, causality and short-run dynamic relationships. The method proposed has been applied to examine European hog markets. In particular, weekly prices received by farmers in seven countries: Netherlands, Italy, Germany, France, Denmark, United Kingdom and Spain, in the period 1988-1995, are considered.

European hog prices show a high degree of interdependence in the long-run. These relationships are more explicit when spliting the whole system into two, according to the homogeneity of the product. Second, information contained in any series contributes to improve the predictions of the others as causality tests results show. No radial structure in the price formation proccess is discovered given that bidirectional causality is mostly found. Finally, dynamic elements of spatial market linkages have been investigated. Shocks to the more important countries from the perspective of intra-EU trade (Netherlands, Denmark and Germany price), are quikcly and intensively transmited to the rest of countries, being the magnitude and the duration of the effect greater in the first two cases. Moreover, in those countries, prices are more exogeneously determined as their forecast error variance is primarily explained by their own past innovations. However, they are not independent from the others. In fact, the prices in these markets are very sensitive to each other and to their customer markets prices. In global terms, Netherlands price innovations exert the greatest influence on the evolution of any other European price, explaining significant proportions of any other price forecast error variance.

Results provide empirical evidence about the efficiency of European hog markets, pointing out a high degree of integration in terms of price transmission. The removal of trade barriers, with the aim of achieving the Unified European Market by 1993, has provoked intense flows of hog and meat pork through the EU and, therefore, has introduced efficency in the price transmission mechanism. Likewise, the low incidence of intervention measures considered by the Common Agricultural Policy (CAP), have also contributed to the synchronism of hog price evolution across the EU. Neverthérless, in order to assess the existence of a single market, further analysis about differences among the levels of prices and their convergence should be performed, although the absence of data about transport costs constitutes an unsolvable handicap.

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