Spatial Price Relationships in the Olive Oil Market of the Mediterranean

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Abstract

The study of spatial price relationships helps to explain market performance and the degree of market integration. This paper provides an empirical analysis of the long- and short-run price linkages in the olive oil market of the Mediterranean using Time Series techniques. The empirical results suggest the existence of a stable long-run relationships among prices in Spain, Italy, and Greece. They also suggest that the major producer and exporter (Spain) is the price leader while Greece and Italy are the followers.

Key Words: *Olive Oil Prices, Market Integration, Mediterranean.*

Introduction

The study of price interrelationships in geographically separated markets has held a long interest in applied economic research. The reason is that the strength of price interdependencies indicate the degree of market integration and the efficiency of market performance (e.g. Stigler, 1969; Gupta and Mueller, 1982; Ravallion, 1986; Ardeni, 1989; Goodwin and Schroeder, 1991; Palaskas and Harris-White, 1993; Asche, Salvanes and Steen, 1997). When goods and information flow freely among geographically separated markets, the efficient commodity arbitrage will lead to a spatial equilibrium in which the prices of a homogeneous product will differ only by the transportation costs. In contrast, a low degree of market integration (implying a less than perfect transmission of prices) will result into misallocation of resources and inefficiencies in production and distribution.

The integration of agricultural commodity markets in the EU has been the focus of several works during the last ten years (Bellego, 1992; Gordon, Hobbs, and Kerr, 1993; Zanias, 1993; Sanjuan and Gil, 2001). The topic presents an interest of its own, since following more than three decades of CAP (Common Agricultural Policy) operation, a relevant question is how common is the so-called "common market". The empirical evidence has been mixed. Gordon, Hobbs, and Kerr (1993) found that integration exists among the British, the Irish, and the French lamb markets. Sanjuan and Gil (2001) reached to the same conclusion for the lamp and pork markets in the Netherlands, Italy, Germany, France, Denmark, UK, and Spain. Zanias (1993) examined several agricultural commodities in the EU. He concluded that not enough evidence in favor of market integration exists. More interestingly, according to the results of the latter study the degree of integration is lower in the most intervened markets such as milk and wheat.

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All of the studies mentioned above were concerned with commodities that are of special interest to Northern European countries. To the best of knowledge, there has been no study on agricultural commodities produced in Southern Europe and, in particular, in the EU member states around the Mediterranean Basin.

The present paper focuses on the spatial price interrelationships in the olive oil market. More than 95 percent of olive trees around the World are grown along the coasts of the Mediterranean Sea. Also, 90 percent of the World olive oil consumption takes place in the Mediterranean countries (International Olive Oil Council–IOOC). The EU contributes almost 70 percent of the World supply, while more than 98 percent of the EU production comes from Spain, Italy and Greece.

The common market organization for olive oil has been established in 1966 (Regulation 136/66) and involves import duties and export restitutions which, to a large extent, isolate the domestic market from price fluctuations abroad. Given that Spain, Italy and Greece are by far the largest producers and consumers in the EU, the prices of olive oil in the Community are determined by the supply and demand conditions in those three member states. Therefore, the empirical analysis here relies on price information from Spain, Italy and Greece.

The paper consists of five sections. Section 2 presents the analytical framework (Integration, Cointegration, Law of One Price, Weak Exogeneity, and Short-Run Price Dynamics). Section 2 presents the data (monthly prices for extra virgin and virgin olive oil from 1992 to 1998). Section 4 involves the empirical application along with the relevant statistical tests and the Forecast Error Variance Decomposition, while Section 5 offers conclusions.

Analytical Framework

The empirical investigation of price interdependencies has been pursued by a variety of methods. These include Granger causality (e.g., Gupta and Mueller, 1982), dynamic interaction (e.g. Ravallion, 1986), and long-run equilibria.[1] The realization, however, that most price series exhibit stochastic trends of the random walk type has rendered cointegration analysis as the most commonly employed method for assessing price interrelationships (Ardeni, 1989; Baffes, 1991; Asche, Salvanes and Wessels, 1999; Sanjuan and Gil, 2001). The cointegration approach, proposed by Johansen (1988), allows a researcher to estimate and perform statistical tests on the long-run price linkages, to classify prices into weakly exogenous and endogenous, and to study the short-run price dynamics.

Let **P** be a nx1 vector of prices which follows an unrestricted Vector Autoregression (VAR) of order k in levels

$$P_t = \sum_{i=1}^{k} \Pi_i P_{t-i} + \mu + e_t \tag{1}$$

where Π_i is a nxn parameter matrix, μ is nx1 vector of constants and e_t are i.i.d disturbance terms with zero mean. The Vector Error Correction representation (VECM) of (1) is

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \Pi P_{t-k} + \mu + e_t \ , \tag{2}$$

where $\Gamma_i = -I + \sum_{j=1}^{i} \Pi_j$, i=1, ..k-1, are nxn matrices of short-run parameters; and $\Pi = -I + \sum_{i=1}^{k} \Pi_i$, implying that Π is the long-run level solution (Enders, 1996).

The rank of Π determines how many linear combinations of prices are stationary. If r = n, the variables in levels are stationary; if r=0, none of the linear combinations are stationary. Finally, if 0<r<n there exist r cointegrating vectors (r stationary linear combinations). For n non stationary variables, the maximum possible number of cointegrating vectors is n-1. In case of non stationary variables and provided that r> 0, one can factor Π; $\Pi = \alpha\beta'$, where both α and β are nxr matrices. Matrix β contains the cointegration vectors and matrix α the speed of adjustment parameters (Holden and Thomson, 1992). The number of cointegrating vectors of the system can be determined using the Trace test (Johansen and Juselius, 1990). The largest the number of cointegrating vectors the more stable is the long-run relationship among variables (or equivalently, the higher is the degree of market integration).

The Johansen methodology allows for a wide range of hypothesis testing on the parameters of the Π matrix using the ML statistic computed as $T \sum_{i=1}^{r} (\ln(1-\mu_i^*) - \ln(1-\mu_i))$, where r is the number of cointegrating vectors in the unrestricted model , T is the number of observations, μ_i^* and μ_i are the characteristic roots of the restricted and the unrestricted model, respectively (Enders, 1996; Johansen and Juselius, 1990). The ML follows the χ^2 distribution with degrees of freedom the number of restrictions imposed.

In a spatial market integration analysis there are typically two hypothesis one wishes to test: a) whether the Law of One Price (LOP) holds; and b) whether there exist any weakly exogenous price series. The LOP requires that there are n-1 cointegrating vectors (implying that the price series are pairewise cointegrated) and, in addition, that the slope coefficients in all pair regressions are equal to unity. In other words, when the LOP holds, the matrix of cointegrating vectors can be written as

$$\beta = \begin{bmatrix} 1 & -1 \ldots\ldots\ldots & 0 \\ 0 & 1 \ -1 \ldots & 0 \\ \ldots\ldots\ldots\ldots\ldots\ldots & & \\ & 0 \ \ 0 \ldots\ldots 1 & -1 \end{bmatrix} \quad (3)$$

(Ache, Salvanes, and Wessels, 1999; Lewbel, 1996).

Weakly exogenous prices do not respond to deviations from the long run equilibrium and, in this sense, they lead the remaining prices. With r cointegrating vectors a series, say i, is weakly exogenous when $a_{i1} = a_{i2} = \ldots\ldots = a_{ir} = 0$, suggesting that all parameters in the corresponding row of matrix α are zero (Johansen and Juselius, 1990; von Cramon-Taubadel, 1998).

The existence of cointegration implies that deviations from the equilibrium relationships are stationary. Any shock to one of the variables will result in time paths of the system that will eventually settle down in a new equilibrium. These time paths may provide interesting insights into the short run dynamics. Higher degree of market integration will be naturally accompanied with greater price interdependency in the short-run as each market employs information from the others when forming its own price expectations. The short-run dynamics of the price system can be analyzed via the Forecast Error Variance (FEV) decomposition.

Lutkepohl and Reimers (1992) extended the FEV decomposition methodology to cointegrated systems. The contribution, in percentage terms, of an innovation in variable m to the h-step ahead FEV of variable j is defined as

$$\omega_{jm,h} = \sum_{l=0}^{h-1} \theta_{jm,l}^{2} / MSE_j(h) \text{, h= 1, 2, ... ,} \tag{4}$$

where $\theta_{jm,l}$ is the response of variable j to a unit shock in variable m, l periods ago and $MSE_j(h)$ is the jth diagonal element of the mean squared error matrix of the optimal h-step ahead forecast of the p_j process.[2]

The Data

The data for the empirical application are obtained from the *Agricultural Markets: Prices*, published by the European Commission. They cover the period 1992:1 to 1998:12 (84 observations), are expressed in ECUs per 100 kg and correspond to the prices received by producers at the factory gate for olive oil in bulk.

Olive oil is classified into different grades according to relevant decisions of the IOOC. Here, two grades are considered. Namely, the extra virgin (acidity less than 1) and the virgin (acidity from 1.01 to 2). The choice of the grades has been dictated by the availability of published price information in all three countries. Separate analysis of price interdependencies is conducted for each of the two grades.[3]

Figure 1 presents the evolution of prices (in logarithms) for extra virgin olive oil in the three countries. The price in Italy exceeds those in Spain and Greece in all periods. This must be attributed to the fact that Italy is the deficit region, importing every year substantial quantities from Spain and Greece which are net exporters (surplus regions). On average, the price of extra virgin in Italy has been almost 20 percent higher than that in Spain and almost 15 percent higher than that in Greece. Since 1996, there is a considerable decrease in the prices of virgin olive oil reflecting the fact that the increase in consumption have not kept up with the increase in supply (due to new plantations in Spain and to irrigation and other technological improvements in all three countries).

Figure 2 present the evolution of prices (in logarithms) for virgin olive oil. Although the price in Italy is higher, the price spreads are narrower compared to those for extra virgin. In particular, the price in Italy is, on average, 9 percent higher than that in Spain and 10 percent higher than that in Greece. Again, the prices in all countries exhibit a pronounced downward trend since 1996 for the reasons given above.

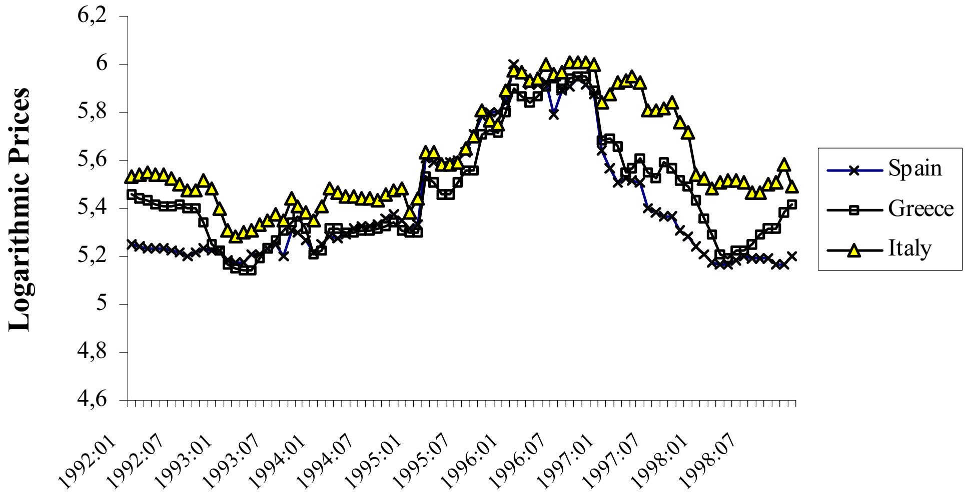

Figure 1. Prices of Extra Virgin Olive Oil (in Logs)

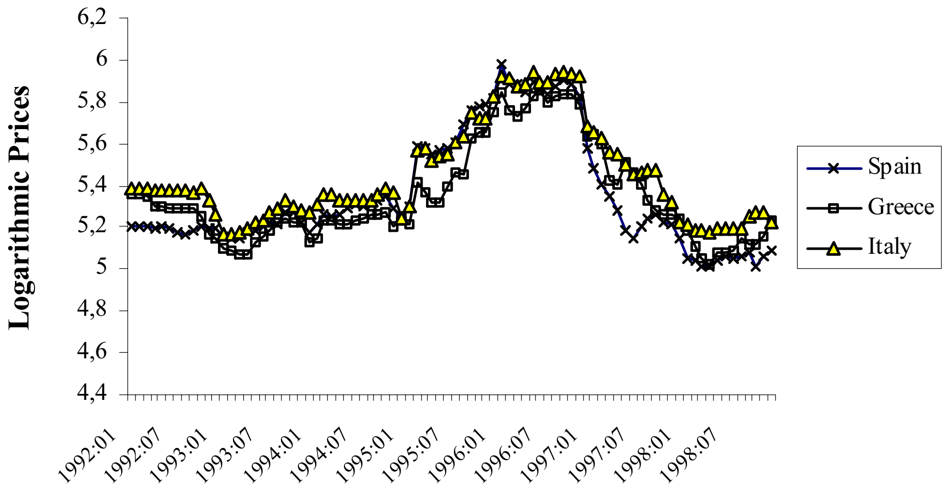

Figure 2. Prices of Virgin Olive Oil (in Logs)

Prior to the cointegration analysis one must confirm that all prices are non stationary and integrated of the same order. This is done with the ADF test. The results are presented in Tables 1a to 2b. The null hypothesis of non stationarity cannot be rejected for the natural logarithms of price levels. It is, however, rejected for the respective first differences suggesting that all series are integrated of order one (I(1)).

Table 1a. ADF Tests on the Logarithms of Prices for Extra Virgin*

Country	Lags Used	Empirical Value
Spain	6	-1.78
Italy	1	-1.54
Greece	3	-2.3

Table 1b. ADF Tests on the First Differences of the Logarithms of Prices for Extra Virgin

Country	Lags Used	Empirical Value
Spain	0	-7.27
Italy	1	-6.53
Greece	2	-4.47

Table 2a. ADF Tests on the Logarithms of Prices for Virgin

Country	Lags Used	Empirical Value
Spain	4	-1.45
Italy	2	-1.11
Greece	4	-2.12

Table 2b. ADF Tests on the First Differences of the Logarithms of Prices for Virgin

Country	Lags Used	Empirical Value
Spain	1	-6.23
Italy	1	-6.25
Greece	2	-5.06

* The critical value at the 5 percent level is –2.90. The lag lengths have been selected using the univariate Akaike criterio (Judge et al, 1985).

The Empirical Results

The Market for Extra Virgin Olive Oil

The VECM for extra virgin olive oil has been estimated with 3 lags. As shown in the Appendix, this number of lags ensures that all equations in the system are free from autocorrelation and autoregressive conditional heteroscedasticity (ARCH). Table 3a presents the cointegration results on the logarithmic prices of extra virgin olive oil. Both the Trace and the corrected (for degrees of freedom) Trace statistics indicate the existence of two cointegrating vectors at the 5 percent level of significance or less. Given that with three non stationary series the maximum possible rank of the corresponding β matrix is two, one may conclude that the Mediterranean market for extra virgin olive oil exhibit a very high degree of integration.

Table 3a. Johansen Cointegration Tests on the Prices of Extra Virgin Olive Oil

Ho: Rank of $\Pi = r$	**Eigenvalue**	**Trace Statistic**	**Corrected Trace Statistic**	**Critical Value 5%**
r=0	0.193	31.49	27.99	24.3
r<=1	0.160	14.11	12.6	12.5
r<=2	0.0002	0.016	0.014	3.8

Number of Lags used: 3

The two (standardized) cointegrating vectors are

$$(\ln P_S,\quad \ln P_G,\quad \ln P_I) = (1,\quad -0.38,\quad -0.2) \text{ and}$$

$$(\ln P_S,\quad \ln P_G,\quad \ln P_I) = (-0.26,\quad 1,\quad -1.22)\,,$$

where S, G, and I stand for Spain, Italy, and Greece, respectively.

The three price series, however, cannot pass the test for the LOP. Indeed, the empirical value of the ML statistic for the LOP is 12.25 with probability of observing a higher value being equal to 0.002. The rejection of the LOP hypothesis may be attributed to the existence of non stationary transportation costs (Barret, 1996; Fackler, 1996).

The corresponding (standardized) a matrix is

$$\begin{bmatrix} a_{S1} & a_{S2} \\ a_{G1} & a_{G2} \\ a_{I1} & a_{I2} \end{bmatrix} = \begin{bmatrix} 0.07 & -0.024 \\ 0.12 & -0.326 \\ 0.19 & 0.021 \end{bmatrix}.$$

The empirical value of the ML statistic for the null hypothesis $a_{S1} = a_{S2} = 0$ (the price in the Spanish market is weakly exogenous) is 1.91 with probability of observing a higher value 0.39. The empirical values of the ML for the null hypotheses $a_{G1} = a_{G2} = 0$ and $a_{I1} = a_{I2} = 0$ are 11.99 (0.0025) and 14.15 (0.0008), respectively, with the probalilities of observing higher values in parentheses. The test results suggest that Spain is the leader in the formation of prices for extra virgin olive oil, while Italy and Greece are followers. As mentioned above, Spain and Greece are the surplus regions, while Italy is the deficit region. Also, between the two net exporters Spain is (according to FAO statistics) by far the biggest producer and exporter during the period considered in the present study. One may conclude, therefore, that it is the largest net exporter the one which exercise the greatest influence on prices. The findings here are in agreement with Sanjuan and Gil (2001) who report that in the EU pork and lamb markets the exporting countries are leaders and the importers are followers. They contrast, however, with the view expressed by several researchers in Greece (e.g. Tzouramani, Mattas, and Fotopoulos, 1999; Chaniotakis and Tzimitra, 1996) that it is the net importer (Italy) which exercises the greater influence on olive oil prices.[5]

The Choleski decomposition for the FEV analysis depends upon the way the variables in the system are ordered. Here, guided by the weak exogeneity tests we employ the *ordering* Spain, Greece, Italy. This particular ordering implies that innovations in Greece and Italy have no contemporaneous effect on prices in Spain and innovations in Italy have no contemporaneous effect on prices in Greece.[6]

Table 4a presents the FEV decomposition for horizons 1, 4, 8, and 12 months. It appears that own-price innovations explain 99 percent of the FEV in Spain even in longer time horizons (twelve months). This is perfectly consistent with the weak exogeneity property of the price series for Spain. For Italy, the price in which is the most endogenous in the system, and after one month, own-price innovations account for 45 percent of its FEV. The influence of own-shocks, however, is reduced to about 17 percent after twelve months. The contribution of the shocks from Spain increase from less than 50 percent in the first month to almost 80 percent after twelve months, while the contribution of Greece is reduced from 8 to 4 percent. For Greece, an own-price shock has a strong influence (almost 55 percent) in the very short-run by it drops to only 11 percent in the longer-run. The influence of Spain increases with time while that of Italy decreases. Overall, the FEV decomposition analysis suggest that, although own-price innovations have substantial influence in the movements of prices in Italy and Greece, in the longer-run the shocks from Spain dominate the system.

Table 4a. FEV Decomposition for the Extra Virgin Olive Oil Market

Forecast Horizon (Months)	**FEV in:**	**Standard Error**	**Percentage of Forecast Error Explained by Innovations in**		
			Spain	**Italy**	**Greece**
1	**Spain**	0.055	100	0	0
4		0.12	98.52	0.51	0.97
8		0.181	99.26	0.24	0.49
12		0.238	98.89	0.32	0.79
1	**Italy**	0.052	46.23	44.64	9.13
4		0.105	49.99	41.76	8.24
8		0.15	66.31	27.28	6.41
12		0.194	78.46	17.27	4.26
1	**Greece**	0.052	45.22	0	54.77
4		0.111	62.92	3.26	33.83
8		0.16	78.59	2.96	18.44
12		0.207	87.02	1.84	11.13

The Market for Virgin Olive Oil

The VECM for virgin olive oil has been estimated with 3 lags which ensured that all equations in the system are free from autocorrelation and autoregressive conditional heteroscedasticity (ARCH). Table 3b presents the cointegration results. The Trace statistics indicates that there are two cointegrating vectors, implying that the Mediterranean markets for virgin olive oil exhibit a very high degree of integration.
The two (standardized) cointegrating vectors are

$$(\ln P_S, \quad \ln P_G, \quad \ln P_I) = (1, \quad 17.92, \quad -1.39) \text{ and}$$

$$(\ln P_S, \quad \ln P_G, \quad \ln P_I) = (8.88, \quad 1, \quad 0.02) .$$

Table 3b. Johansen Cointegration Tests on the Prices of Virgin Olive Oil

Ho: Rank of $\Pi = r$	Eigenvalue	Trace Statistic	Corrected Trace Statistic	Critical Value 5%
r=0	0.384	55.76	49.56	24.3
r<=1	0.184	16.48	14.65	12.5
r<=2	0.00014	0.011	0.01	3.8

Number of Lags used: 3

As it is the case with the extra virgin olive oil, the three price series cannot pass the test for the LOP since the empirical value of the LM statistic is 35.06 which exceeds by far the theoretical value (5.89).
The corresponding (standardized) a matrix is

$$\begin{bmatrix} a_{S1} & a_{S2} \\ a_{G1} & a_{G2} \\ a_{I1} & a_{I2} \end{bmatrix} = \begin{bmatrix} 0.003 & -0.23 \\ 0.12 & -0.70 \\ 0.20 & 0.17 \end{bmatrix} .$$

The empirical value of the ML statistic for the null hypothesis $a_{S1} = a_{S2} = 0$ is 1.61 failing, thus, to reject the null that the price of virgin olive oil in Spain is weakly exogenous. The empirical values of the ML for the null hypotheses $a_{G1} = a_{G2} = 0$ and $a_{I1} = a_{I2} = 0$ are 6.97 and 21.79, respectively, rejecting the weak exogeneity at the five percent level or less. Again, Spain appears as the leader while Italy and Greece as the followers.

Table 4b presents the FEV decomposition and it is based on the ordering Spain, Greece, and Italy. The price movements in Spain are dominated exclusively by own-innovations both in the short- and in longer-runs. In Italy, the own-shocks explain 27 percent of FEV after one month and 11 percent after twelve months.

In Greece, the own-shocks contribute more than 60 percent in the first month but less than 20 percent after twelve months. Overall, the FEV decomposition for virgin olive oil indicates that, in the long-run, shocks from Spain tend to dominate the price movements in the Mediterranean market.

Table 4b. FEV Decomposition for the Virgin Olive Oil Market

Forecast Horizon (Months)	**FEV in:**	**Standard Error**	**Percentage of Forecast Error Explained by Innovations in**		
			Spain	**Italy**	**Greece**
1	**Spain**	0.055	100	0	0
4		0.142	99.61	0.31	0.09
8		0.22	98.41	1.11	0.48
12		0.278	98.36	1.16	0.48
1	**Italy**	0.053	62.56	27.29	10.14
4		0.123	74.05	11.38	14.57
8		0.178	76.67	12.33	10.99
12		0.22	77.83	11.82	10.34
1	**Greece**	0.052	36.31	0	63.69
4		0.113	56.9	8.18	34.9
8		0.158	64.9	11.73	23.37
12		0.212	68.81	12.58	18.6

Conclusions

The objective of this paper has been to assess the degree of integration of the Mediterranean market for olive oil. This has been pursued using wholesale level prices for two grades of olive oil (extra virgin and virgin) and time series techniques. The cointegration analysis indicates that there exist very strong price interdependencies in the geographically separated markets of Spain, Italy, and Greece. This, in turn, implies a high degree of market integration and market performance.

Statistical tests have been employed to identify price leaders and followers. These indicate that, for both grades, the price of the major surplus region (Spain) leads those in Italy and Greece. Finally, Forecast Error Variance (FEV) decomposition has been used to shed some light on the short-run dynamics of the time paths of prices towards a market equilibrium. It appears that, although own-innovations play some role in the evolution of olive oil prices in Italy and Greece in the short-run, it is the innovations in Spain which determine the behavior of the price system in the long-run.

Notes

1. For a detailed discussion about the strengths and the weaknesses of alternative methods see Sanjuan and Gil (2001).
2. In practice, responses to orthogonalised impulses are used. These are obtained through the Choleski decomposition of the variance-covariance matrix of the initial innovations. An othrogonalized unit impulse has size equal to one standard deviation (for further details see Lutkepohl and Reimers, 1992).

3. The simultaneous analysis of the interactions among the two grades in the three countries would probably have provided richer insides into the price dynamics. It has not been possible, however, because of the length of the time series available.
4. The corrected Trace statistic, calculated as $-(T-nk)\sum_{i}\ln(1-\mu_i)$, accounts for the number of the estimated equations and the number of lags used (Reimers, 1992)
5. The Italian manufacturers import olive oil in bulk from Spain and Greece and export it bottled in the world markets. Therefore, although Italy is a deficit region within the Mediterranean market (Spain, Greece, Italy) for olive oil in bulk, it is the major exporter for bottled olive oil in the world. The empirical analysis here relies on prices for olive oil in bulk and this probably explains the dominance of Spain in the price movements. Extension of the analysis to the market for bottled olive oil is certainly warranted.
6. Notice that the null hypothesis that Greece is weakly exogenous has been rejected at a higher level of significance compared to that of Italy. This indicates that Greece should precede Italy in the ordering. However, the alternative ordering Spain, Italy, Greece has been tried with quite consistent results.

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Technical Appendix

A. .Diagnostic Testing for the Equations of the VECM for ExtraVirgin Olive Oil[+]

	LM-Test for Autocorrelation			**LM-Tests for ARCH**		
Equation for:	Lags 4	Lags 8	Lags 12	Lags 4	Lags 8	Lags 12
Spain	1.30 (0.86)	12.7 (0.13)	18.17 (0.1)	0.47 (0.98)	4.35 (0.82)	5.18 (0.95)
Italy	5.71 (0.22)	6.42 (0.61)	12.5 (0.47)	1.88 (0.76)	2.16 (0.98)	17.89 (0.12)
Greece	5.21 (0.27)	8.15 (0.42)	8.66 (0.73)	0.84 (0.93)	5.97 (0.65)	3.51 (0.99)

B. Diagnostic Testing for the Equations of the VECM for Virgin Olive Oil[+]

	LM-Test for Autocorrelation			**LM-Tests for ARCH**		
Equation for:	Lags 4	Lags 8	Lags 12	Lags 4	Lags 8	Lags 12
Spain	3.28 (0.51)	4.37 (0.82)	9.51 (0.66)	1.56 (0.82)	2.74 (0.95)	8.82 (0.72)
Italy	1.004 (0.9)	1.97 (0.98)	8.33 (0.76)	1.41 (0.84)	2.59 (0.96)	4.87 (0.96)
Greece	1.09 (0.89)	7.30 (0.5)	7.89 (0.79)	3.34 (0.51)	7.73 (0.46)	11.5 (0.51)

[+] The test statistics follow the χ^2 distribution with degrees of freedom the number of lags. Probabilities for higher values in parentheses.