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An investigation into the relationship between producer, wholesale and retail prices of Greek agricultural products

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CENTRE OF PLANNING AND ECONOMIC RESEARCH

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ABSTRACT

In this paper price relationships and patterns of price transmission among farm, wholesale and retail levels are analyzed for potato, tomato, orange and milk markets in Greece. Lag length, direction of causality, and asymmetric relationships are empirically verified. The analysis is performed using the co-integration approach introduced by von Cramon-Taubadel (1998), on monthly price data for the period 1995-2003. The results indicate that a long-run relationship exists between each pair of producer and retail prices for all products. The direction of Granger-causality runs from retail to producer prices for all products except oranges and milk where it runs from producers to retailers. Perfect price transmission between farmers and retailers is accepted in the case of potato and tomato. The results support the hypothesis of asymmetric price transmission between farm and retail levels for all products. In contrast, symmetric price transmission between farm and wholesale levels exists for all products. Especially, for potato, asymmetric price transmission was found between the two marketing levels. The empirical results indicate that the inclusion of the wholesale level in the marketing chain plays an important role in the analysis of price transmission.

1. Introduction

A recent article by Meyer and von Cramon-Taubabel (2004) provides a comprehensive discussion of the possible cause of asymmetric price adjustments together with a review of the relevant empirical literature. Their article stresses the importance of identifying asymmetric price transmission between the different marketing channels, because its presence provides insights into market efficiency and degree of competition which are useful for choosing the appropriate policy instrument. Past literature on price transmission in agricultural markets has examined different products, geographic areas and time periods. The majority of these studies are focused on the meat and dairy sector of the US economy and less on European markets. European applications cover mainly the UK and German markets providing different econometric techniques for extending the research results to other European markets. Recently, London Economics was commissioned by the Department for Environment, Food and Rural Affairs (DEFRA, 2004) to undertake an econometric analysis of the factors that have affected the spreads between farm gate prices and retail prices. The EU Member States covered by the study include in addition to the United Kingdom, the following EU countries: Austria, France, Denmark, Germany, Ireland, Italy, Netherlands and Spain.

In line with the above, the Greek food market is lacking applications in the context of price transmission among farm and retail markets for a variety of products. Especially, Greek fresh vegetable and fruit markets have not been investigated previously for asymmetric price adjustment, despite their inefficient marketing system. Furthermore, as agricultural raw products are processed along with packing and other services into final food products, knowledge about the relationships among producers and retail food prices is important for many contemporary policy and commodity market analyses. Additionally, price transmission is a crucial variable in determining the economic benefits of CAP reforms to consumers.

Attention has to be paid to the evolution of the producer price index for agricultural products and the consumer price index for food and non alcoholic beverages. According to the Greek Statistical Service the farm gate price index increased by 4.3% over the period 1996-2003 and the consumer price index for food and non alcoholic beverages increased by 4.4% (see Figure 1). This shows that increases in farm prices are fully passed on through the marketing, distribution and processing industries to consumers. However, the rate of change of the price indices was different during the two sub-periods 1996-1999 and 2000-2003. Over the period 1996-1999 farm price index increased by 2.2% while the food price index increased by 4.5% implying that increases in farm prices have more than fully transmitted to consumer prices. To the contrary, during the last four years (2000-2003) producer price index increased well above the food price index (around 6.3%), while the consumer price index for food increased by 4.3%.

Producer prices in 2003 increased sharply by more than 8% where 11% for the crop sector and 1.3% for the livestock sector. Fruits and vegetables exhibited the highest increase in producer prices ranging from 30% to almost 70% (melons, watermelons and peaches), followed by cotton (22%) and potatoes (17%). In livestock production price variations are much smoother, where lamb and goat meat producer prices increased by more than 4% and pork prices continued to fall (6%). In 2003, consumer prices of food products continued to increase at an extent significantly higher that the overall Consumer Price Index (CPI); CPI increased by 3.5%, whereas the food index increased by more than 5% and the non-alcoholics index increased by 4%. The highest increase in process was for potatoes (19.2%), poultry meat (7.3%), olive oil (4.3%), juices (3.8%) and fruits and dairy products (3%).

The purpose of this paper is two-fold: first, to evaluate price linkages among farm, wholesale and retail markets for three unprocessed products (potatoes, tomatoes, and oranges) and one processed product (milk); and second to identify whether the price transmission process is asymmetric. It aims at investigating the way and extent to which prices are transmitted between these vertical stages in the marketing chain. This paper is an attempt to provide answers to the following questions: how price changes in one stage of the marketing chain are transmitted along the supply chain? To what extent price transmission reacts differently to a positive or negative initial price change?

In this empirical work, the methodology developed by von Cramon-Taubadel (1998) has been used estimating a Vector Error Correction Model (VECM). The analysis follows a four-step procedure which begins with unit root testing to determine the time-series properties of the data, continues with lag length specification and weak exogeneity test for flow durations and direction of causality flows, and finishes with asymmetry tests. The article is structured as follows. Section 2 presents briefly the structure of the Greek market mainly for fruits and vegetables. Section 3, discusses previous findings from relevant studies and section 4 describes the methodological framework. Section 5 introduces the data used and their time series properties. Section 6 reports the empirical results, and the final section concludes with a discussion of the main results.

2. The marketing process of Greek agricultural products

In terms of its share of the domestic economy, Greece has one of the largest agricultural sectors in the EU. The agricultural sector's contribution to GDP fell to 5.8% in 2003 (in constant prices) as opposed to almost 7.7% in 1998. The Gross Value Added of agriculture exceeded 8.5 million €, increased by 3.5% since 2002. The country is a leading producer in peaches and tomatoes and the third-largest producer of olive oil. Vegetables, milk, fruit and meat products are important components of the Greek diet. Per capita consumption of fruit and vegetables in Greece is among the highest in the European Union. On the other hand, consumption of meat is well below the EU average, with the possible exception of poultry meat. The self-sufficient rate for sheep and goat is 90% while the rates for beef and pork are very low, 27% and 48% respectively.

The food and beverages industry in Greece constitutes a significant part of the domestic manufacturing sector and the economy as a whole. The food and beverage sector is the most dynamic sector of the manufacturing sector, accounts for 2.6% of the national GDP. In 2001, the total sales of the food and beverage industries in Greece accounted for 25.6% of the total industrial sales. However, in 2003 the sector performed very poorly. Especially regarding the food processing industry, net profits reached 157,467 thousand €, down by 26.7% compared to 2002. The overall poor performance of the food industry can be explained by two main factors: Firstly, the considerable reduction in agricultural production during the last two years due to adverse weather conditions and secondly, the fact that a number of industries that were profitable in the previous years, exhibited high losses in 2003. Overall, the volume of production of food and drinks was down by 3.2% in 2003. The results of the 346 largest food companies in 2003 showed that net profits dropped by 15%, while total sales increased slightly by 3% (CIHEAM, 2005).

The Greek dairy sector processing industry, the most important sub-sector with 18% of the total industrial value added, is characterized by a large number of firms typically small in size and operating on local markets. Only, a very small number of firms (5) hold almost 90% of the market share and there is intensive competition among these firms (CIHEAM, 2001).

Regarding the demand side, Greek consumers are used to buy fresh fruits and vegetables in the popular open markets and/or in traditional grocery stores. On the other hand, large chain market-stores are offering a huge variety of fresh agricultural products at lower prices than open markets. The Ministry of Development is exploring measures to certify transactions between traders (agents and wholesalers) and farmers, in order to control extremely high consumer prices which are noticed frequently in the open markets for fresh fruits and vegetables.

Agriculture as a production sector is closely related to marketing activities, which transform, transport and transfer food to the consumer. Additionally, agriculture is served by a large number of industries which are supplying farm inputs. Therefore, great changes in concentration and specialization occurring in agriculture are becoming more and more linked to other great transformations such as those occurring in the retail sector and in food consumption. Actually, farmers' economic decision on what to produce and how to produce are more and more influenced by the signals coming from the processing industry and the retail sector.

In general, the marketing of Greek agricultural products exhibits deficiencies regarding packaging, standardization and conformity with quality standards. The share of cooperatives is low and is concentrated on certain products and certain geographical areas such as Crete and Northern Greece. For certain products such as milk and dairy products, sugar, processed tomatoes and some wine-making, there is a well organized marketing system based on contract farming and vertical integration. However, the processing of other vegetables is low, and only small quantities are exported (CIHEAM, 2001).

The marketing process of the Greek agricultural products, after leaving the farm gate and before reaching the retailer from whom the ultimate consumer buys, involves one or two intermediaries (local agent middlemen and/or merchant wholesalers). In general, local agents are situated nearby the production stage where they assemble the products (usually their income is based on fees and commissions). The agents send the product for sale in large quantities to the central fruit and vegetable markets in Greece (mainly in Athens and Thessalonici) or to other merchant wholesalers outside the central markets, who sell to retailers. The central market of Athens assembles products into large units. There are roughly 550 wholesale industries for the fruits-vegetables (550,000 ton.) and meat (60,000 ton.) market. The wholesalers of the two central markets sell the product to the traditional groceries, to the open market merchants and to market-stores.

During the last five years, the marketing system has been decentralized. Processors and wholesalers contact farmers to take title to the products in the production area. Then, these wholesalers sell the products in open markets as their own product. Even though the number of farmers-sellers in the open markets has been increased, there is not significant price variation among the merchants.

The retail food sector is still growing and concentrating, especially in metropolitan Athens. There are 3,200 market-stores in Greece, 687 of which are located in the Athens metropolitan area. The top 10 supermarkets account for 84% of total market-stores sales, reaching approximately 7.4 billion euros. The retail sector is very dynamic, facing competition as a result of the emergence of new international grocery store chains and mergers of existing companies and food processors (GAIN report, 2004).

3. Previous empirical studies

A large number of studies have examined asymmetric price transmission in agricultural markets between different stages of the marketing chain by means of co-integration techniques. The data are the starting point, while the tests indicate the extent to which prices are adjusting toward equilibrium. According to Barret and Li (2002) testing for the presence of price transmission can be interpreted as an exercise to check the degree of efficiency of the markets, in terms of their being closer to the competitive model, or as a test for market integration. Therefore, factors causing asymmetric transmission cannot be determined under this framework.

Given the lack of empirical studies on price transmission in the Greek agricultural market, a recent study by Rezitis (2003) investigates price transmission processes between producers and consumers in lamb, beef, pork and poultry markets in Greece, using a Generalized Autoregressive Conditional Heteroskedastic model. Although the results conclude that imperfect price transmission exits between farm and retail markets in each meat category, they do not determine whether responses to price increases may differ from responses to price decreases.

Studies on price transmission for the sector of fruits and fresh vegetables are not many compared with those in meat and dairy sectors. Hassan and Simioni (2001) investigate the existence of price transmission between shipping-point and retail prices for two major French fresh vegetable, tomatoes and chicory, by using threshold co-integration methods. In the tomato case, half of the short-run models are shown to be symmetric. However, in other asymmetric cases, the estimates suggest that reductions in shipping-point prices are rapidly passed by middlemen on to consumers while there is a slower transmission of shipping-point price increases.

Another study by Zachariasse and Bunte (2003) examine price transmission for Dutch potato and find asymmetric price transmission. They observe that retailers respond to negative price changes at the farm gate, but not to positive price changes, which means that farmers benefit from the asymmetric price transmission.

A large literature exists on price transmission with respect to the meat and dairy products. Regarding the UK meat sector a recent study by Tiffin and Dawson (2000) show that a long-run relationship exists between producers and retailers and causality flows from retailers to producers. However, other study by Palaskas (1995) indicates lack of co-integration for the U.K. lamb, beef and pork prices. The results of Goodwin and Holt (1999) find unidirectional price transmission from farm to wholesaler for the U.S. beef market.

Studies focused on the nature of price transmission have reached mixed conclusions. Some empirical work supports the existence of positive asymmetric transmission between producer and wholesale prices. This work covers mainly the meat sector, such as, the pork market in Germany (von Cramon-Taubadel, 1998), the pork sector of the U.S. (Goodwin and Harper, 2000) and Switzerland (Abdulai, 2002), and the Dutch poultry market (Zachariasse and Bunte, 2003).

The dairy sector has received less attention although its products have different degrees of transformation and perishability. The results of Serra and Goodwin (2003) suggest that there aren't asymmetries in the transmission of shocks in highly perishable daily product prices (pasteurized milk and cream caramel) but asymmetries are present in the sterilized milk. Finally, a study by Chavas and Metha (2004) examine the price dynamics in the U.S. butter market. They find strong positive asymmetric retail price responses, meaning that retail prices respond strongly to wholesale price increases but less to wholesale price decreases.

Most of the studies suggest a variety of possible causes of asymmetric price transmission but without any empirical justification. Among the causes found in the literature, market power and adjustment costs have been supported as the most important (Meyer and von Cramon-Taubadel, 2004).

4. The econometric model

The econometric analysis consists of five steps. First, the price series are tested for their order of integration as a precondition to the examination of the relationships that exist between them. Second, if the series are found to be integrated of order one, testing for co-integration is performed by specifying a Vector Autoregressive Model (VAR) and using the Johansen technique (Johansen and Juselius, 1990). A k-dimensional VAR is given by:

$$P_t = \mu + \sum_{j=1}^{k} \Pi_i P_{t-1} + \phi D_t + e_t \qquad (1)$$

where for this study P_t is a (2×1) vector of prices, D_t are seasonal dummies, et are Gaussian residuals. The VAR in (1) can be reparameterized into a Vector Error Correction (VECM) form:

$$\Delta P_t = c + \Pi P_{t-1} + \sum_{j=1}^{k-1} \mathrm{B}_j \Delta P_{t-j} + \phi D_t + \varepsilon_t \qquad (2)$$

where Π is a (2×2) matrix of long-run and adjustment parameters, B_j is a (2×2) matrix of the short-run parameters, ε_t is the vector of i.d.(0, Σ) and j is the number of lags. Following the Johansen procedure, the co-integration relationship between prices was examined under equation (1), where each price is a function of its own lagged values and the lagged values of the other price series. The trace and maximum eigenvalue statistics are used to determine the rank of Π. Having established the number of co-integrating vectors the estimated VECM can be rewritten analytically in the following form:

$$\begin{bmatrix} \Delta p_{1t} \\ \Delta p_{2t} \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} + \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} [\beta_1 \beta_2] \begin{bmatrix} p_1 \\ p_2 \end{bmatrix} + \sum_{i=1}^{k-1} \begin{bmatrix} B_{i,11} B_{i,12} \\ B_{i,21} B_{i,22} \end{bmatrix} \begin{bmatrix} \Delta p_{1,t-i} \\ \Delta p_{2,t-i} \end{bmatrix} + $$

$$+ \begin{bmatrix} \Phi_{r1} \ldots\ldots \Phi_{r11} \\ \Phi_{s1} \ldots\ldots \Phi_{s11} \end{bmatrix} \begin{bmatrix} D_{1t} \\ .. \\ .. \\ D_{2t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \qquad (3)$$

where, the size of the adjustment coefficients [α_1 α_2] describes the speed of adjustment towards the long-run equilibrium.

Third, the Johansen test for weak exogeneity (Johansen, 1992) is applied by testing the statistical significance of the error correction coefficients, α_1 and α_2. The significance of one coefficient indicates which of the prices in each pair responds to maintain the long-run relationship. For example, α_1=0 means that p_1 does not cause p_2 and the long-run solution to p_1 is not affected by departures from the equilibrium specified by the co-integrating vector.

Fourth, the homogeneity restriction (β_1=-β_2) is tested in order to verify whether price behavior corresponds to the perfectly competitive environment.

Fifth, under the results of weak exogeneity, co-integration analysis for testing asymmetric price transmission is based on the estimation of the single partial equation:

$$\Delta P_t = \rho_1 e^-_{t-i} + \rho_2 e^+_{t-i} + \sum_{j=1}^{k-1} \mathrm{B}_j \Delta P_{t-j} + \phi_j D_t + \varepsilon_t \tag{4}$$

where, e^-_{t-1} and e^+_{t-1} is the negative and positive divergences from the long-run equilibrium respectively. Using a χ^2-test the null hypothesis of symmetry (ρ_1=ρ_2) is tested. The traditional belief is that the advantage of the co-integration approach over other methods is that it permits the joint modeling of short-run dynamics, long-run equilibrium and the speed of adjustment.

5. The data and their time series properties

Data for the selected products (potatoes, oranges, tomatoes and milk) used in this study, include monthly price for producers, wholesalers and retailers from January 1995 through December 2003, which makes a total of 108 observations. Producer prices for all products were obtained from the Agricultural Price Indices (PPI) provided by the National Statistical Service of Greece. Wholesale prices in euro per kilogram for potatoes, tomatoes and oranges were provided by the Central Market of Athens, where prices of fruits and vegetables used to be published daily. Retail prices for all products were obtained from the publication of the Consumer Price Index (CPI) provided by the National Statistical Service of Greece.

The NSSG publishes only CPI and PPI and not producer and retail price levels measured in euro per kilogram. For having an indication of the evolution of the price spread between producer and retailer it was able to get from the NSSG data on the monthly producer and consumer price levels from 2000:01 to 2003:12 for potatoes and oranges. By combining these level prices with the CP and PP indices, producer and retail price series can be generated from

1995:01 up to 2003:12. For obtaining monthly producer prices for tomato we combine the yearly producer prices in levels from FAO and the PPI from the NSSG. Finally, by combining the CPI for tomato with the retail price level from the ILO databank we obtain a monthly retail price for tomato. Price series data for oranges, potatoes and tomatoes in the three stages of the marketing chain is presented in Figures 2, 3, 4 and 5. Table 1 presents the basic statistics for the period 1995:01 to 2003:12 for all products.

Common characteristic for the three products is that wholesale prices are more volatile than farm and retail prices. In addition, tomatoes exhibit the highest variability and milk the lowest. The average margin as a percentage of the consumer price for tomatoes is 35% while for oranges and potatoes is 53% and 58% respectively. In the case of milk the average margin reaches the 67% of the consumer price.

In the co-integration literature it is often to test economic data for stationarity. There are numerous unit root tests available in the literature. Due to the unclear power of the unit root tests, here we employ the following: the Augmented Dickey Fuller (ADF) test of the Dickey and Fuller (1979) and the KPSS (Kwiatkowski *et al*., 1992). The results from the unit root tests are reported in Table 2. The ADF test could not reject the hypothesis that prices for potato, orange and tomato are stationary in levels and first differences. The stationary test (KPSS) provide evidence for unit root in the levels, but stationarity in the first differences suggesting that all prices are I(1) variables. When a linear trend is included all variables are trend stationary except for the retail and wholesale price of milk which is non-stationary. Bearing in mind the mixed results from the unit root tests, we proceed to testing for co-integration and estimating a Vector Error Correction Model (VECM) in order to avoid producing results from spurious regressions. When first differences were used, the hypothesis of unit root non-stationarity was rejected, suggesting that all prices are I(1) variables. Therefore, testing for co-integration is the next step in the model specification in order to avoid producing results from spurious regressions.

5. Co-integration analysis results

Having established that prices in the three different levels of the supply chain (producer-wholesaler-retailer) are integrated of order one, we proceed to obtain a long-run relationship using a vector autoregression (VAR) model. The Likelihood Ratio test statistic was used to specify the number of lags in the VAR system. Given the monthly nature of the data, lag length was initially set at 24. Next, the Johansen procedure (Johansen and Juselius, 1990) was applied to examine the existence of a co-integrating relationship between the pairs of prices. The selection of the optimal lag-length was based on the issue of whether the residuals are Gaussian.

The results of the co-integration analysis and the weak exogeneity tests for the products selected are presented in Table 3. In all cases, we found that the series are co-integrated and as a result, we can analyze the relationships between prices along the different levels of the marketing chain. The direction of price flows in the long-run was tested performing weak exogeneity tests. In this application, the test of weak exogeneity indicates the role of price leadership in the markets. The null hypothesis of weak exogeneity for producer prices is rejected in the case of potatoes and tomatoes but it is accepted for oranges and milk. This means that in the orange market price changes flowed from farm to wholesale to retail while in the potato and tomato markets only the farm gate price responds to deviations from the long-run equilibrium. Another important test which we can perform is testing for perfect price transmission which is equivalent to test the restriction $\beta_{11}= - \beta_{12}$ in the co-integrating vector (see Table 3). Between farmers and retailers the hypothesis of perfect price transmission was not rejected in the long-run for all products apart from milk, meaning that farm and retail prices are linked through a constant absolute margin. However, imperfect price transmission between farmers and wholesalers exists for potatoes and tomatoes.

Based on the normalized co-integration vectors, the equations in Table 4 describe the long-run relationship between prices, after allowing all adjustments to take place. In the case of oranges, according to Tiffin and Dawson (2000) theoretical consideration[1], we found perfect price transmission between farmers and wholesalers (e_{WP}=1) and imperfect price transmission between farmers and retailers (e_{WP}=0.84). Whereas, as prices are determined at the retail level in potatoes and tomatoes, imperfect price transmission between farmers and retailers exists only in the tomato market because the elasticity of price transmission is greater to one (e_{PR}=1.18). For potatoes, the elasticity of price transmission is 0.92 supporting perfect price transmission between farmers and retailers. Having confirmed the existence of long-run relations among the

[1] If prices are determined at the producer level, price transmission elasticity (e_{RP}) equal to one implies perfect price transmission and $0<e_{RP}<1$ implies imperfect price transmission. If prices are determined at the retail level perfect price transmission is where e_{RP}=1 and imperfect price transmission when e_{RP}>1.

different marketing levels, the error correction representation defined by equation (4) will be used to investigate asymmetric price transmission among the different marketing levels.

As we can notice from equation (4) for testing asymmetric price transmission the deviation from equilibrium should be segmented to its positive and negative deviations and then estimate a segmented ECM (von Cramon-Taubadel, 1998). The estimated ECMs' for each product and the results of the symmetry restrictions are presented in Tables 5-8.

The x^2-test of long-run symmetry null hypothesis between farmer and retailer is rejected for all products. For tomatoes, this is not in line with Ward's (1982) work where he argues that no asymmetries are apparent in the transmission process of highly perishable products. However, symmetries were found in the other levels of the marketing channel, between farmer-wholesaler and wholesaler-retailer. Focusing on the identification of price transmission between farmers and retailers for potatoes and oranges, it is important to take into account the intermediate marketing level (wholesalers) by examining how it reacts to farm and retail price changes. For the potato market the transmission channel is from retail price to farm price (an uncommon result) while for the orange market is from farm price to retail price. It is interesting to notice that for oranges the wholesale and retail levels are not integrated implying no relation between wholesalers and retailers (Table 7). However, in the producer and wholesale price model for oranges symmetry is accepted meaning that wholesalers react the same to increases and decreases in farm prices. In the case of potato price transmission between retail and wholesale levels is asymmetric, in the sense that increases in wholesale pieces are passed on more quickly to retail prices than decreases in wholesale prices. (Table 5). In the producer price model for potatoes we accept the symmetry hypothesis between farmers and wholesalers implying that farmers respond the same to increases and decreases in wholesale prices.

7. Conclusion

The absence of past empirical analysis regarding the nature of price transmission in the Greek agricultural marketing process and the complexity of the marketing system in Greece were the main drivers for the work reported in this paper. In addition, the aim of this paper is to provide evidence on vertical price transmission in four main agricultural markets: potato, orange, tomato and milk using Johansen's maximum likelihood approach. The degree of price transmission can provide a broad assessment of the extent to which markets are functioning efficiently.

In the empirical analysis, various pair-wise price relations in different marketing levels have been tested for long-run relations, exogeneity and symmetric price transmission. Using the Johansen approach, long-run price relations for potatoes, tomatoes, oranges and milk were determined. There was no evidence found for long-run relation between farmers and wholesalers in the milk market and for wholesalers and retailers in the orange market. Evidence was found for imperfect price transmission between retailers and farmers in the tomato and orange markets. The exogeneity tests found that the retail prices are weakly exogenous and established a unidirectional price transmission from retail to farm prices in the potato and tomato markets. In this case, prices are set on the retail market and retailers make 'offers' to producers further down the marketing chain. To the contrary, in the orange and milk market the price transmission process flows from producer to retailer.

Symmetric price responses are found between farmers and wholesalers in all markets. However, we found strong evidence of asymmetric price transmission between farmers and retailers in all markets. Especially, for potato market, asymmetries imply that wholesalers tend to respond more to retail price decreases than to retail price increases. Finally, it is noticed that short-run responses are quicker than to deviations from equilibrium for all products. An important result of this study is that the evidence of asymmetric price transmission in the potato, tomato, orange and milk markets gives the stimulus for further research on the structural and institutional features of the relevant markets.

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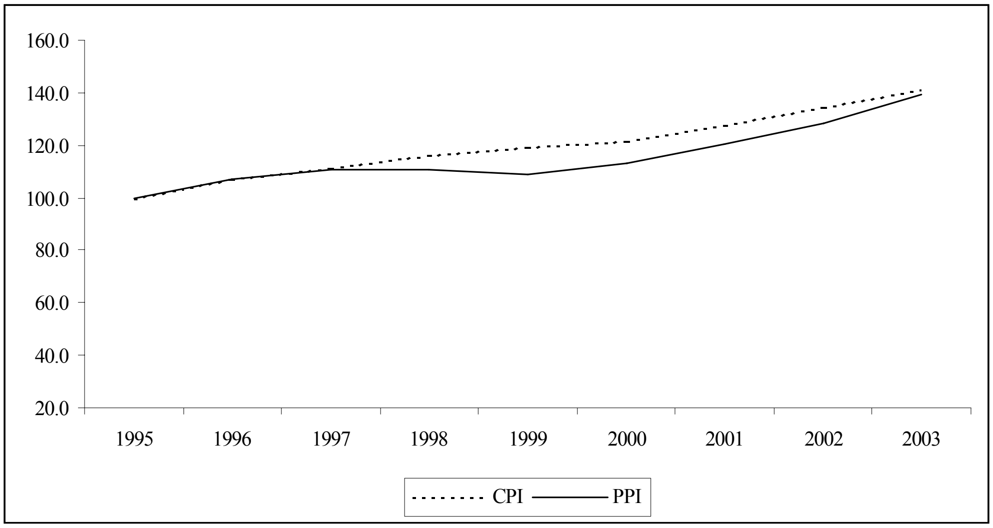
FIGURE 1. Consumer price index for food and beverages and producer price index for agricultural products (1995=100)



Source: Statistical Service of Greece**.**

FIGURE 2. Orange prices in Greece, 1995:01-2003:12

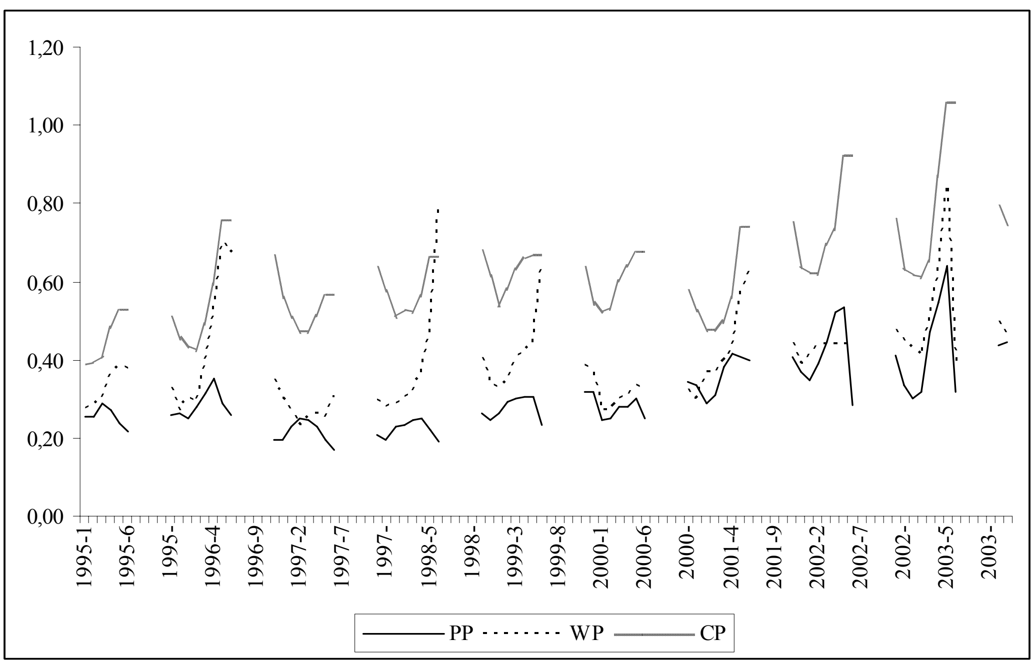


FIGURE 3. Potato prices in Greece, 1995:01-2003:12

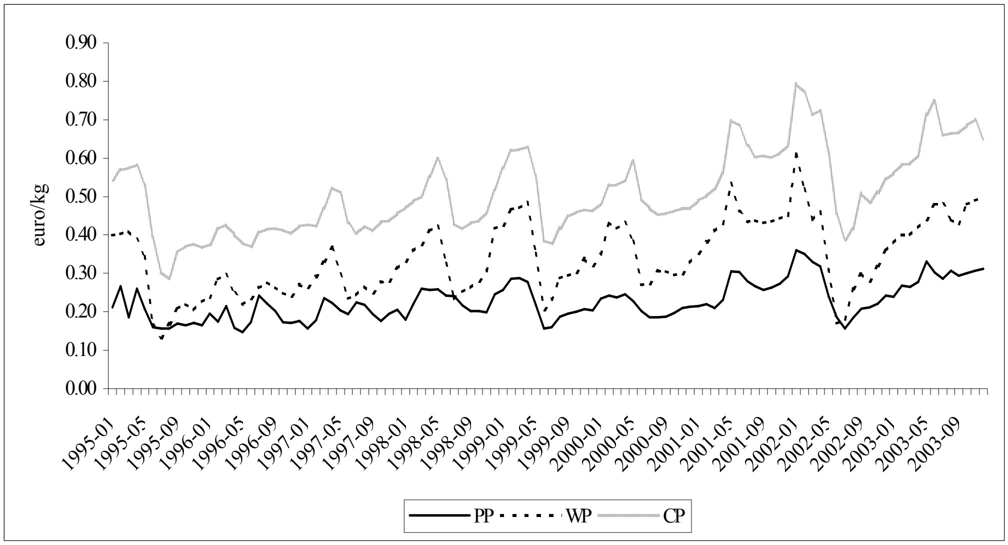


FIGURE 4. Tomato prices in Greece, 1995:01-2003:12

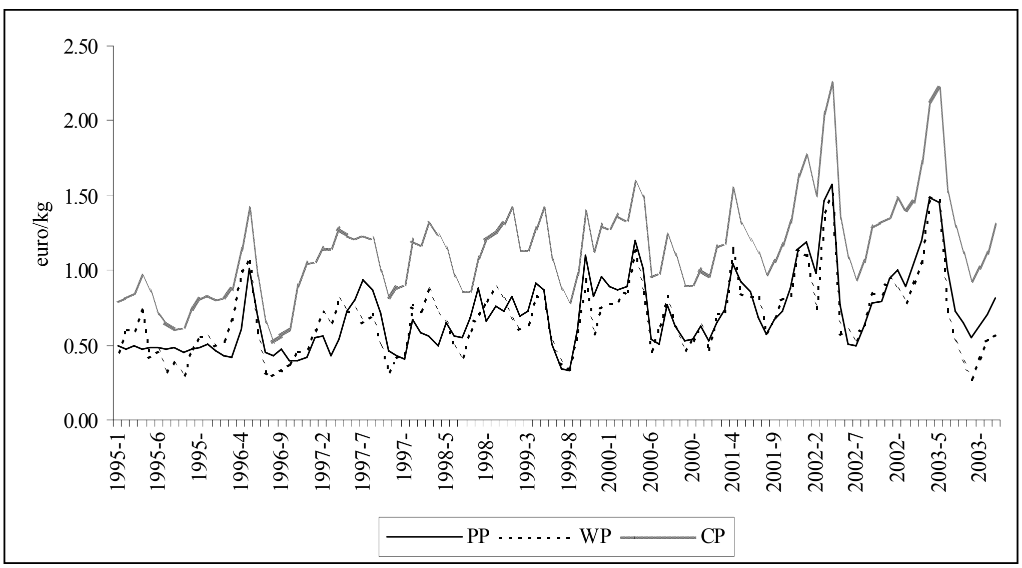


FIGURE 5. Milk prices in Greece, 1989:01-2003:12

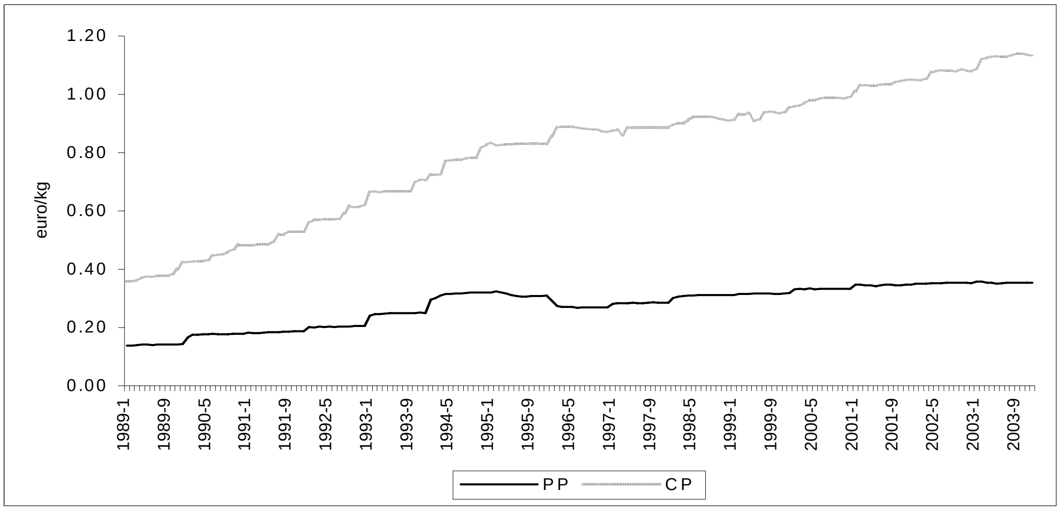


TABLE 1. Basic statistics: 1995:01-2003:12

Product	Type	Mean	Std. Deviation	Minimum	Maximum	Coefficient of variation
	Farm	0.29	0.09	0.17	0.64	31
Oranges	Wholesale	0.40	0.13	0.23	0.85	32
	Retail	0.64	0.19	0.30	1.35	30
	Farm	0.22	0.05	0.14	0.35	23
Potatoes	Wholesale	0.34	0.09	0.13	0.61	26
	Retail	0.53	0.11	0.30	0.83	21
	Farm	0.71	0.26	0.33	1.58	37
Tomatoes	Wholesale	0.68	0.25	0.27	1.51	37
	Retail	1.08	0.31	0.49	2.14	29
Milk	Farm	0.32	0.03	0.27	0.36	9
	Retail	0.96	0.09	0.82	1.14	9

Note: Coefficient of variation = (Std. Dev./Mean)*100

TABLE 2. Results of Unit Root tests

Variable	Test	Level		1st Difference	
		Without trend	With trend	Without trend	With trend
Potato					
PP	ADF	-3.61 (0)**	-5.10 (1)**	-10.23 (0)**	-10.18 (0)**
WP	ADF	-2.85 (2)	-5.60 (1)**	-7.97 (1)**	-7.95 (1)**
RP	ADF	-3.12 (2)*	-5.28 (3)**	-8.83 (1)**	-8.81 (1)**
PP	KPSS	0.87**	0.04	0.08	0.07
WP	KPSS	0.07	0.04	0.07	0.06
RP	KPSS	0.88**	0.04	0.09	0.06
Orange					
PP	ADF	-2.73 (0)	-3.99 (0)*	-2.86 (11)	-2.93(10)
WP	ADF	-3.80 (0)**	-4.07 (0)**	-11.38 (0)**	-11.33 (0)**
RP	ADF	-3.35 (0)*	-4.58 (0)**	-10.39 (0)**	-10.34(0)**
PP	KPSS	0.88**	0.18	0.18	0.11
WP	KPSS	0.44	0.07	0.05	0.04
RP	KPSS	1.03	0.13	0.16	0.11
Tomato					
PP	ADF	-5.02 (1)**	-6.72 (1)**	-9.18 (1)**	-9.14 (1)**
WP	ADF	-4.99 (1)**	-5.58 (1)**	-8.15 (1)**	-8.11 (1)**
RP	ADF	-4.44 (1)**	-6.14 (1)**	-7.83 (1)**	-7.79 (1)**
PP	KPSS	1.00**	0.04	0.13	0.09
WP	KPSS	0.57*	0.12	0.12	0.08
RP	KPSS	0.98**	0.09	0.13	0.12
Milk					
PP	ADF	-0.73 (1)	-2.89 (1)	-7.47 (0)**	-7.54 (0)**
RP	ADF	-0.02 (0)	-3.20 (1)	-9.01 (0)**	-8.99 (0)**
PP	KPSS	0.94**	0.13	0.26**	0.16
RP	KPSS	1.16**	0.25**	0.11	0.05

Note: Lag length in parentheses, PP producer prices, WP wholesale prices, RP retail prices.
The critical value for ADF with constant (and trend) at the 5% significance is -2.88 (-3.45) and at the 1% significance is -3.49 (-4.04). The critical value for KPSS with constant (and trend) at the 5% significance is 0.463 (0.15) and at the 1% significance is 0.739 (0.22). * Indicates significant at 5% and ** significant at 1%.

TABLE 3. Johansen tests for pairwise cointregration and restrictions on the VECM

Price 1 Price 2	Lags	Rank	Max. Eigenval.	Trace		Weak exogeneity	
Potato prices					H_0:β_{11}=-β_{12}	Price 1 H_0: α_{11}=0	Price 2 H_0: α_{21}=0
PP ← WP	(2)	r=0	30.82*	39.84*	4.73* [0.029]	12.11* [0.000]	0.34 [0.557]
		r≤1	9.02	9.02			
WP → RP	(1)	r=0	20.34*	31.12*	2.38 [0.123]	4.62* [0.032]	0.05 [0.826]
		r≤1	10.78	10.78			
PP ← RP	(2)	r=0	35.90*	44.32*	1.13 [0.288]	13.34** [0.000]	0.08 [0.777]
		r≤1	8.42	8.42			
Tomato prices							
PP → WP	(3)	r=0	36.06*	47.83*	4.69* [0.030]	5.74* [0.016]	0.35 [0.552]
		r≤1	11.77	11.77			
WP ← RP	(2)	r=0	26.29*	30.42*	5.53* [0.018]	22.04** [0.000]	14.09** [0.000]
		r≤1	4.13	4.13			
PP ← RP	(2)	r=0	29.30*	39.22*	1.38 [0.241]	7.60** [0.006]	0.15 [0.639]
		r≤1	9.92	9.92			
Orange prices							
PP → WP	(1)	r=0	22.96*	25.87*	0.07 [0.956]	14.73** [0.000]	1.77 [0.182]
		r≤1	2.90	2.90			
PP → RP	(13)	r=0	15.96*	16.16*	1.57 [0.210]	13.51** [0.000]	1.44 [0.230]
		r≤1	0.20	0.20			
Milk prices							
PP → RP	(21)	r=0	20.92*	20.90*	15.46** [0.000]	17.83** [0.000]	1.43 [0.232]
		r≤1	0.03	0.03			

* Significant at the 1% level. Critical values: 18.63 and 6.65 at the 1% level for the Maximum eigenvalue test; 20.04 and 6.65 at the 1% for the Trace test. ** significant at the 1% level for the $x^2(1)$ test statistic with critical values, 6.64 with [p-values] and * significant level at the 5% with critical value 3.84.

TABLE 4. Long-run equations

Potatoes

$$\ln PP = -0.68 + \underset{(11.44)}{0.76} \ln WP$$

$$\ln RP = 0.26 + \underset{(14.37)}{0.81} \ln WP$$

$$\ln PP = -0.93 + \underset{(14.53)}{0.92} \ln RP$$

Tomatoes

$$\ln WP = -0.13 + \underset{(9.71)}{0.78} \ln PP$$

$$\ln WP = -0.51 + \underset{(5.46)}{0.68} \ln RP$$

$$\ln PP = -0.51 + \underset{(11.53)}{1.14} \ln RP$$

Oranges

$$\ln WP = 0.36 + \underset{(5.34)}{1.01} \ln PP$$

$$\ln RP = 0.59 + \underset{(7.37)}{0.84} \ln PP$$

Milk

$$\ln RP = 1.56 + \underset{(11.62)}{1.38} \ln PP$$

Note: Figures in parentheses denote t-statistics

TABLE 5. Estimates of the Error Correction Models for Potatoes

(PP ← WP)		
ΔPP	Estimates	Diagnostic results
ECM^{+}_{t-1}	**-0.47** **(-3.30)**	
ECM^{-}_{t-1}	**-0.56** **(-3.23)**	
ΔPP_{t-1}	-0.46 (-3.94)	
ΔWP_{t-1}	0.63 (6.31)	$R^2 = 0.36$ Q(2)=1.04 [0.595] Q(12)=7.09 [0.852] Jarque-Bera = 3.78 [0.151]
ΔWP_{t-2}	-0.21 (-2.87)	
S_5	-0.09 (-2.39)	
S_7	0.11 (2.37)	
D_1 (1996:4)	-0.32 (-2.82)	
		Symmetry test: $x^2(1)$=0.21 [0.644]
(WP → RP)		
ΔWP	Estimates	Diagnostic results
ECM^{+}_{t-1}	**-0.10** **(-0.98)**	
ECM^{-}_{t-1}	**-0.49** **(-4.17)**	
ΔWP_{t-1}	0.55 (6.28)	$R^2 = 0.67$ Q(2)=0.41 [0.814] Q(12)=13.24 [0.352] Jarque-Bera = 4.98 [0.083]
ΔWP_{t-10}	0.10 (2.83)	
ΔWP_{t-12}	-0.14 (-3.70)	
ΔRP_{t-1}	-0.60 (-3.58)	
D_1 (1995:6 & 1999:6)	-0.22 (-3.51)	
D_2 (2002:1)	-0.21 (3.86)	
S_6	-0.14 (-4.68)	
		Symmetry test: $x^2(1)$=7.74 [0.007]
(PP ←RP)		
ΔPP	Estimates	Diagnostic results
ECM^{+}_{t-1}	**-0.44** **(-2.72)**	
ECM^{-}_{t-1}	**-0.92** **(-5.89)**	$R^2 = 0.47$ Q(12)=6.24 [0.903] Jarque-Bera = 1.59 [0.452]
ΔRP_{t-1}	0.53 (3.52)	
ΔPP_{t-1}	-0.37 (-3.39)	
D_1 (1996:4, 1999:6 & 2002:6)	-0.34 (-8.21)	**Symmetry test: $x^2(1)$=5.91 [0.017]**

TABLE 6. Estimates of the Error Correction Models for Tomatoes

(PP → WP)		
ΔWP	Estimates	Diagnostic results
ECM^{+}_{t-1}	**-0.54** **(-3.21)**	
ECM^{-}_{t-1}	**-0.41** **(-2.71)**	$R^2 = 0.44$ Q(2)=1.34 [0.511] Q(12)=8.07 [0.755] Jarque-Bera = 2.24 [0.325]
ΔWP_{t-2}	0.43 (3.21)	
ΔPP_{t-2}	-0.57 (-3.90)	
D_1(2002:3)	0.71 (3.15)	
D_2(2002:5,2003:6 & 2003:9)	-0.63 (-5.50)	Symmetry test: $x^2(1)$= 0.36 [0.548]
(WP ←RP)		
ΔWP	Estimates	Diagnostic results
ECM^{+}_{t-1}	**-0.65** **(-3.51)**	
ECM^{-}_{t-1}	**-0.74** **(-4.90)**	$R^2 = 0.49$ Q(12)=1.41 [0.999] Jarque-Bera = 1.73 [0.420]
ΔWP_{t-1}	-0.19 (-2.38)	
ΔWP_{t-2}	0.23 (2.60)	
D_1(2002:3)	0.70 (3.19)	
D_2(2002:5,2003:6 & 2003:9)	-0.51 (-6.60)	Symmetry test: $x^2(1)$= 0.16 [0.684]
(PP ←RP)		
ΔPP	Estimates	Diagnostic results
ECM^{+}_{t-1}	**-0.44** **(-2.40)**	
ECM^{-}_{t-1}	**-0.95** **(-6.22)**	$R^2 = 0.47$ Q(2)= 0.71 [0.700] Q(12)= 9.15 [0.690] Jarque-Bera = 2.09 [0.350]
ΔRP_{t-4}	-0.66 (-3.04)	
ΔPP_{t-4}	0.38 (2.60)	
ΔPP_{t-9}	-0.25 (-3.60)	
S_6	-0.30 (-4.28)	
D_2 (1998:6, 1999:7 & 2002:5)	-0.49 (-4.32)	**Symmetry test: $x^2(1)$ = 4.86 [0.027]**

TABLE 7. Estimates of the Error Correction Models for Oranges

(WP ←PP)		
ΔWP	**Estimates**	Diagnostic results
ECM^{+}_{t-1}	**-0.25** **(-3.50)**	
ECM^{-}_{t-1}	**-0.22** **(-2.73)**	
ΔPP_{t-1}	0.20 (2.17)	$R^2 = 0.60$ Q(2)= 1.08 [0.412] Q(12)=9.16 [0.688] Jarque-Bera = 0.04 [0.980]
ΔPP_{t-6}	0.32 (3.27)	
D_1(1998:6 & 1999:6)	0.48 (5.43)	
D_2(1998:7 & 1999:7)	-0.65 (-7.14)	
S_8	0.14 (2.72)	Symmetry test: $x^2(1)$= 0.07 [0.789]
(PP →RP)		
ΔRP	Estimates	Diagnostic results
ECM^{+}_{t-1}	**-0.05** **(-0.21)**	
ECM^{-}_{t-1}	**-0.23** **(-3.82)**	$R^2 = 0.72$ Q(2)=0.25 [0.527] Q(12)=7.98 [0.786] Jarque-Bera = 1.28 [0.527]
ΔRP_{t-6}	0.13 (2.26)	
ΔRP_{t-12}	0.41 (5.90)	
D_1(1999:7, 2002:10 & 2003:4)	0.28 (4.88)	
D_2(1996:7, 1998:7, 2001:10, 2002:11& 2003:11)	-0.44 (-10.35)	**Symmetry test: $x^2(1)$=4.43 [0.035]**

TABLE 8. Estimates of the Error Correction Model for Milk

(PP →RP)		
ΔRP	Estimates	Diagnostic results
ECM^{+}_{t-1}	**-0.01** **(-0.97)**	
ECM^{-}_{t-1}	**-0.09** **(-4.25)**	
ΔPP_{t-12}	-0.15 (-2.10)	$R^2 = 0.62$ Q(2)=0.84 [0.656] Q(12)=6.27 [0.902] Jarque-Bera = 0.878 [0.645]
S_1	0.009 (3.42)	
S_2	0.01 (5.23)	
D_1(1997:4 & 1999:7)	0.03 (6.54)	**Symmetry test: $x^2(1)$= 7.62 [0.070]**
D_2(1997:3 & 1999:5)	-0.03 (-6.19)	

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