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Farm Production Costs, Producer Prices and Retail Food Prices: A Cointegration Analysis

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Abstract

The relationship between farm production costs, producer prices and retail food prices is frequently the subject of research. This study examines the existence of cointegrating relationships between the above variables and their direction of causality. Data used refer to price indices of farm inputs and outputs, for crop and livestock production and retail price indices for food and non alcoholic beverages. They are quarterly covering the period 2000-2012 and their source is the Greek Statistical Authority. The stationarity of time series is examined using alternative econometric tests, followed by cointegration analysis while the issue of the correct specification for the cointegrating relationship is also considered. Short and long run causality relationships between the variables are also analyzed. Econometric results lead to the conclusion that there is a long run equilibrium relationship between the variables which are estimated and that production costs and producer prices influence retail food prices in the short and long run.

Keywords: *Input Prices, Output Prices, Food Prices, Time Series, Stationarity, Cointegration, Error Correction Model, Causality*

Introduction

The relationship between farm input prices and output prices is well established in theory. Supply and demand conditions in one market and its price changes can affect the prices of the other. Farm output prices and retail food prices are also connected through supply and demand conditions in their respective markets and marketing margin costs.

These refer to transport, packaging, processing, etc., when not received by the first and final stage of the production and trading process. They are actually inflows and outflows of the intermediate stages (Wohlgenant, 2001). Changes in conditions of supply and demand of the initial or final stage, have the effect of changing the prices of the intermediate stages, that is changing the marketing margin as well. Moreover, changes in the supply and demand conditions of various elements of the marketing margins will cause a decrease or increase of their respective prices and this will affect the prices at other stages. Initial changes in market conditions of any stage are caused by changes in productivity, international trade conditions and / or exchange rates, preferences, etc. In a macroeconomic level we can find the causes of changes in income, taxes and subsidies in one or more stages, as well as changes in parameters in monetary policy (Sephton, 1989). The overall effects of price changes at any level of the marketing chain depend on the elasticities of supply and demand in the various stages (Marsh, 1991).

Engle (1978) studied the relationship between wholesale and retail prices of food products and Guthrie (1981) analyzed the relationship between general wholesale and retail price indicators. Both surveys suggest causality from lower to higher levels (retail prices). Larue (1991) found bidirectional causality, searched for cointegrating relations and concluded that (contrary to the prevailing notion that output prices are more flexible than input prices) output prices are "weakly exogenous" in the model in the sense that although they are cointegrated, they don't respond systematically to the imbalance of input prices and retail prices.

Lolos, Chondrogiannis and Papapetrou (1998) investigated the causal relationship between farm input prices, producer prices and consumer food prices for Greece using data for the 1986 to 1997 period. They found long run equilibrium between these three variables and they concluded that a bidirectional causal relationship exists between consumer food prices and farm producer prices, a bidirectional causal relationship between farm input prices and producer prices and a unidirectional causal relationship from food prices to input prices.

Moss (1992) used cointegration analysis to investigate whether the prices received by producers and the price they pay move together in the long run. He found no cointegrating relationship, implying that the effect of margin's compression between input costs and reduced selling price (Cost-Price Squeeze) cannot be rejected in the long run. If the prices that farmers receive and the prices they pay are cointegrated, the Cost-Price Squeeze effect is not sustained in the long run. This means that under the presence of inflation input prices are rising more than output prices, since farmers are price receivers and they are not able to pass higher input costs to consumers and thus they have to adjust the use of inputs and outputs, as the ratio of output / input decreases.

On the contrary, according to Campiche et al. (2006), the null hypothesis of cointegration between input prices and output prices cannot be dismissed. They suggested that prices received and prices paid by producers move on an one to one ratio and any cost increases pass to the next level in less than eight months, on the average. Katsouli et al. (2002) calculated the relative influence of producer prices on various consumer price indices. They found that the food price index absorbs the largest part of the impact of a rise in the producer price index within the first month. Tweeten (1980) argued that the terms of trade deteriorate for farming as inflation increases, while Starleaf et al. (1987) found that under conditions of inflation agricultural output prices adjust faster than farm input prices.

From a theoretical point of view it can be argued that farmers will gain (lose) after a rise in inflation if output prices are more (less) flexible than input prices. Chambers (1983) found that the estimated impacts caused by monetary factors (when the prices of certain products are more flexible than others) are affected by autocorrelation. In other words, the quantity of money is not neutral in the short run. It is worth noting that there are opinions that support the existence of "neutral" effects of inflation in terms of trade for farmers. Prentice & Schertz (1981) and Gardner (1979) did not find a statistically significant relationship between changes in the general price level and the relative price level of inputs and outputs in agriculture. A major weakness of these studies is the failure to distinguish non expected from expected inflation (Falk, 1986).

Methodology and results

This study uses cointegration analysis and error correction models in order to investigate the mechanism of adjustment between farm input prices, producer prices and retail food prices. It uses quarterly data for Greece and for the period 2000-2012. Data on the three respective price indices are available from the the Greek Statistical Authority. The stationarity properties of the three time series and their degree of integration are initially examined. The maximum likelihood method of Johansen is then applied in order to determine whether there are long run equilibrium relationships between the three variables. The number and nature of these relationships are estimated. In stationarity and cointegration tests, the usual methods are applied in order to select the appropriate number of lags and establish the presence or absence of deterministic terms in the estimated model. For the determination of lags in particular we use the AIC, SIC, HQ, FPE and LR criteria. Deviations from the equilibrium, which represent the remains of the cointegrating vector are included in the Error Correction Model (ECM) and represent the short-term dynamics. Finally, the existence and direction of short-run and long-run Granger causality between the three variables is examined.

Stationarity is examined using unit root tests. The Augmented Dickey-Fuller test – ADF (1981) is used, together with the Phillips and Perron – PP (1988) and the Kwiatkowski et al. – KPSS (1992) tests. The commonest and most convenient approach is the ADF test which tests the null hypothesis that the series contains one unit root against the alternative hypothesis that the series does not contain a unit root (i.e. stationary). In practice, it is essential, to determine the appropriate lag number of the variable. Using a small number of lags it may result in the over rejection of H_0, when it is true (i.e. increases the size of the test), however the use of a larger number of lags than the appropriate can result in non-rejection of Ho, while it is not true (i.e. reducting the power of the test).

Ng and Perron (1995) propose a maximum limit of lags ρ_{max} and the running of the ADF regression with lags $\rho = \rho max$. If the absolute t-value of the last lag is greater than 1.6, then we set $\rho = \rho max$ and we perform a unit root test. Otherwise we reduce the lags by one and repeat the process. Alternatively, Schwert (1989) suggested the selection of lags of the variable Δy_t to be based on the formula $\rho_{max} =$ $\text{int}\left[12\left(\frac{T}{100}\right)^{\frac{1}{4}}\right]$, where "int" denotes the nearest integer, which allows the number of lags ρ to be an increasing function of the number of the T sample's observations.

The approach followed is the introduction of a relatively large number of lags in the test regression and the progressive elimination of terms with the longer lags if their coefficients are "statistically insignificant" and the regression shows evidence of 1st or 2nd order residual autocorrelation based on tests used in dynamic models (e.g. Lagrange Multiplier Test). The process is reapplied until statistical significance or lack of autocorrelation is achieved.

The process starts with the more general model (including determistic trend and constant term) and then if there are indications that the deterministic variables are redundant (with the combined use of statistical ADF, Φ1 and Φ3), the corresponding model is estimated without trend. Finally if there are indications that the constant term is redundant, the model is estimated without trend and without constant term (Perman and Holden, 1995). Unit root test results are presented in Tables 1-6, Appendix 1 for the ADF, PP, and KPSS tests, where * denotes to stationarity at the 5% level and ** indicate stationarity at 10%. The results provide strong evidence that the variables are non-stationary in levels and stationary in their first differences.

The theory of cointegration refers to the long-run equilibrium of an economic relationship, which means that although the time series, may contain stochastic elements (i.e. they are not stationary), they will line in the long run and the difference between them will be determined by a certain relationship if these time series are cointegrated. In other words, the economic variables may have an independent course between them in the short-run (non-stationary), but on the other hand, if there are long paths (i.e. if they are cointegrated), these must be taken into account through the specification of the error correction, in the examination of causal relationships between these economic variables.

The existence of a long run equilibrium-cointegrating- relationship is examined using the Johansen test. This requires the convertion of a vector autoregression model (VAR) to a first differences VAR model with error corrections (VECM). It is essential to determine the VAR's order, as the results may vary if the VAR has been misspecified. One common approach is to start with the number of lags used during the ADF tests and apply the criteria AIC, SIC (and / or HQ, FPE, LR) for selecting the "best specified model." Two of the criteria suggest a VAR with three lags while the other results differ between thmeselves as shown in Appendix 2. In particular, the Schwartz Information Criterion (SIC) and the Hannan-Quinn Information Criterion (HQ) suggest three lags. The Sequential modified LR test statistic (each test on 5% significance level) suggests two lags and the Final Prediction Error (FPE) five lags. Only the Akaike Information Criterion (AIC) gave a largely different number of quarterly ten lags. Based on the above, we adopted three lags.

The choice of deterministic terms in the used VECM model is important, since in many cases the estimation of the "standard" model (which includes constant term but no trend) is not sufficient and it is necessary to say more about the model and how variables and cointegrating relationships may evolve over time. Johansen proposes to estimate all five models:

1: Constant term = 0 both in the first difference equations and in the cointegrating vectors.

2: Constant term = 0 in the equations, but ≠ 0 the vectors.

3: Constant term ≠ 0 the vectors and linear trend in the VAR.

4: Constant term ≠ 0 and trend in the vectors.

5: Constant term ≠ 0 and quadratic trend in the vectors.

It is argued that only models 2, 3 & 4 are interesting (Cottrell, 2011). According to others (Franses, 1999) only models 3 & 4 are worth testing. The first is too restrictive, while the fifth is rather unrealistic. From a purely quantitative point of view, models 1 and 5 are interesting too, but they are not considered to be satisfactory for economic analysis.

In order to select the best model Johansen proposes to estimate models 2, 3 & 4 and then examine the null hypothesis of no cointegrating vector in all cases starting from model 2. If the null hypothesis is rejected for model 2, the null hypothesis is tested for model 3. If rejected again, model 4 is tested. If the three models reject the hypothesis that there is no cointegrating vector, the next step is to test the null hypothesis that there is one cointegrating vector starting from model 2 and following the same process with regards to the models and the number of cointegrating vectors. The process is repeated to the point where the null hypothesis for the number of cointegrating vectors cannot be rejected. Then there is no reason to proceed further and the appropriate model is selected (Sjo, 2008). This process is detailed in Appendix 3.

This process was applied and model 2 was selected. Both, the Trace-test and and the Maximum-Eigenvalue test for this model reject the null hypothesis that there is no cointegrating vector and accept that there is at most one cointegrating vector (at 5% significance level). The critical values of Mckinnon-Haug-Michelis (1999) and Osterwald-Lenum (1992) where used for all conducted tests. Moreover, the estimated cointegrating vector suggests after normalization (with respect to retail food prices) the following long-term equilibrium relationship:

FOOD = 0,54 OUTPUT + 0,16 INPUT + 31,55

(-6,76) (-3,3) (-8,81)

The coefficients of the cointegrating vector are all statistically significant (t-values in parentheses). The model shows that retail food prices (FOOD) in the long run move in the same direction with farm input (INPUT) and farm output (producer) prices in agriculture. It follows that in equilibrium an increase of farm output prices by one unit increases the food price index food 0.54 units, while an increase of input prices by one unit increases the food price index by 0.16 units.

Estimation of the cointegrating relationship allows the implementation of the Vector Error Correction Model VECM) in order to detect the deviation paths from this equilibrium. Using the cointegrating vector we define the Error Correction Model (ECM) as ECM_{t-1}=$FOOD_{t-1}$-0,54OUT_{t-1}-0,16IN_{t-1}-31,5. Then the VECM has the following form:

$$\Delta FOOD = -0{,}55ECM_{t-1} + \sum_{i=1}^{k}[a_{1i}\Delta FOOD_{t-i} + \beta_{1i}\Delta OUT_{t-i} + \gamma_{1i}\Delta IN_{t-i}] + \varepsilon_{1t}$$

$$\Delta OUT = 1{,}08ECM_{t-1} + \sum_{i=1}^{k}[a_{2i}\Delta FOOD_{t-i} + \beta_{2i}\Delta OUT_{t-i} + \gamma_{2i}\Delta IN_{t-i}] + \varepsilon_{2t}$$

$$\Delta IN = 0{,}05ECM_{t-1} + \sum_{i=1}^{k}[a_{3i}\Delta FOOD_{t-i} + \beta_{3i}\Delta OUT_{t-i} + \gamma_{3i}\Delta IN_{t-i}] + \varepsilon_{3t}$$

and its estimation yields:

$$\begin{bmatrix}\Delta FOOD\\ \Delta OUT\\ \Delta IN\end{bmatrix} = \begin{bmatrix}-0{,}55\\ 1{,}08\\ 0{,}04\end{bmatrix}(FOOD_{t-1} \quad -0{,}54OUT_{t-1} \quad -0{,}16IN_{t-1} \quad -31{,}5)+$$

$$\begin{bmatrix}0{,}12 & 0{,}21 & -0{,}15\\ 0{,}6 & 0{,}32 & 0{,}55\\ 0{,}11 & 0{,}1 & 0{,}06\end{bmatrix}\begin{bmatrix}\Delta FOOD_{t-1}\\ \Delta OUT_{t-1}\\ \Delta IN_{t-1}\end{bmatrix}+$$

$$\begin{bmatrix}0{,}43 & 0{,}11 & 0{,}04\\ 0{,}14 & -0{,}43 & 0{,}49\\ 0{,}01 & 0{,}05 & -0{,}14\end{bmatrix}\begin{bmatrix}\Delta FOOD_{t-2}\\ \Delta OUT_{t-2}\\ \Delta IN_{t-2}\end{bmatrix} + \begin{bmatrix}0{,}1 & 0{,}08 & 0{,}11\\ 1{,}12 & -0{,}57 & 0{,}48\\ 0{,}02 & 0{,}05 & 0{,}07\end{bmatrix}\begin{bmatrix}\Delta FOOD_{t-3}\\ \Delta OUT_{t-3}\\ \Delta IN_{t-3}\end{bmatrix} + \begin{bmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\\ \varepsilon_{3t}\end{bmatrix}$$

We can determine the long run and short run direction of causality since two sources of causality can be found here; one through the error correction term, which measures the long-term equilibrium relationship and one through the coefficients of the lagged differences which indicate the short-term dynamics. The suggestion that x_{κ} variable does not Granger cause the x_j variable in the long run, is equivalent to a zero error correction term. That is, the x_j variable does not react to the equilibrium errors and in other words is weakly exogenous. In addition, the suggestion that the variable x_{κ} does not Granger cause the x_j variable in the short run, implies that the coefficients of the lagged differences are equal to zero.

As the results in Appendix 4 show, hypothesis testing concludes that only the adjustment coefficient of FOOD is statistically significant. Thus, it is suggested that a short-term change of the farm output price index and farm input price index affects the food price index. Also, the deviation of the food price index from the long-run equilibrium is corrected by 0.55 each quarter and for this reason it is expected to be negative (which is indeed the case). In other words, the disequilibrium error indicates that 55% of any disequilibrium between the retail food price index and the other variables included in a quarter, is corrected within the next quarter, which suggests a rather quick adjustment. The adjustment coefficients of the input and output price indices are not statistically significant. This suggests that a change in the food price index, in the long run will not lead to adjustment of the input and output price indices. In other words it will not activate the error correction mechanism to neutralize the deviation from equilibrium conditions and the input and ouput price indices can be considered as weakly exogenous.

In the long-run, only changes in the variables involved in the right part of the cointegration equation lead - through the error correction mechanism - to adjustments of the food price index. There is a certain direction of long run causality therefore. In the short run the food price index is Granger caused by the farm output price index. The null hypothesis of block exogeneity of the food price index with respect to the input price index and the output price index is rejected when the lags of these variables are considered together, which means that both variables jointly Granger cause the food price index.

Conclusions

Initially, the stationary properties of the available time series were tested to confirm their suitability for econometric modeling. It was found that the time series are non-stationary in levels and stationary in the first differences. The maximum likelihood method of Johansen showed a long-term equilibrium relationship; that is a positive constant relationship between the three variables in the period 2000-2012. Moreover, the error correction model shows the degree of disequilibrium in the short run and correlates: a) changes in the food price index with changes in the output and input price indices and b) the equilibrating error of the previous period with the long-run equilibrium. The results showed a small lag in the adjustment of the food price index to changes in producer and farm input prices. Estimation of the error correction model shows that only retail food prices are moving towards restoration of equilibrium (endogenous variable), while the farm output prices and farm input prices are characterized by weak exogeneity.

The short-term dynamic model shows that there is unidirectional causal relationship from output prices to food prices. When considered jointly, farm input and farm output prices again Granger cause the retail food prices. In the long run there is unidirectional causality from output and input prices towards retail food prices. The results of statistical tests for both types of causality, short-term (through chi squared statistics) and long- term (through t-statistics), showed no further causal relationships between the variables. The results suggest that increases of producer prices (output) have a direct impact on food prices. Furthermore, increases of production costs in conjunction with increases of wholesale producer prices, both in the short run and in the long run, lead to increases of retail food prices. On the contrary, there is no evidence that producers are able to pass any production cost increases to output (wholesale producer prices), as input prices don't cause output prices. In addition, inflationary expectations (if any) increasing food demand and consequently retail food prices, don't feedback any price increases on the previous marketing levels (farm inputs and farm outputs).

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APPENDIX 1
STATIONARITY TESTS

TABLE 1: Dickey-Fuller test on levels

Variables	Lags	ADF	LM (1)	LM (2)	Φ_1	Φ_3
FOOD (intercept, trend)	8	-3,16	1,69	1,76	-	5
FOOD (intercept)	9	-1,01	0,09	2,8	2,66	-
FOOD	4	4,36	0,40	0,82	-	-
OUTPUT (intercept, trend)	4	-2,66	0,22	1,23	-	4,17
OUTPUT (intercept)	3	-1,47	1,29	2,13	3,12	-
OUTPUT	3	1,79	1,34	2	-	-
INPUT (intercept, trend)	6	-3,36**	0,02	0,55	-	5,92
INPUT (intercept)	8	0,9	0,09	0,17	6,07	-
INPUT	8	3,54	0,09	0,17	-	-

TABLE 2: Dickey-Fuller test on 1st differences

Variables	Lags	ADF	LM (1)	LM (2)	Φ_1	Φ_3
FOOD (intercept, trend)	8	-2,63	0,07	2,73	-	3,46
FOOD (intercept)	3	-2,82**	0,69	1,44	3,98	-
FOOD	-	-	-	-	-	-
OUTPUT (intercept, trend)	2	-10,33*	1,07	2,06	-	53,7
OUTPUT (intercept)	-	-	-	-	-	-
OUTPUT	-	-	-	-	-	-
INPUT (intercept, trend)	7	-4,42*	0,1	0,17	-	9,86
INPUT (intercept)	-	-	-	-	-	-
INPUT	-	-	-	-	-	-

TABLE 3: KPSS test

Variables	Bandwidth	LM test (levels)	Bandwidth	LM test (1st difference)
FOOD (intercept, trend)	4	0,08*	15	0,18*
FOOD (intercept)	5	0,95	15	0,24*
OUTPUT (intercept, trend)	8	0,12*	13	0,12*
OUTPUT (intercept)	5	0,92	13	0,13*
INPUT (intercept, trend)	5	0,1*	2	0,04*
INPUT (intercept)	5	0,9	2	0,09*

TABLE 4: Phillips – Perron test

Variables	Bandwidth	PP test (levels)	Bandwidth	PP test (1st difference)
FOOD (intercept, trend)	7	-3,6*	15	-11,21*
FOOD (intercept)	16	-1,06	15	-10,31*
FOOD	16	4,44	20	-6,81*
OUTPUT (intercept, trend)	10	-6,67*	14	-21,14*
OUTPUT (intercept)	12	-2,91	14	-21,49*
OUTPUT	13	1,68	15	-14,7*
INPUT (intercept, trend)	2	-2,49	2	-4,04*
INPUT (intercept)	2	0,10	2	-4,03*
INPUT	2	2,68	0	-3,49*

APPENDIX 2
LAG LENGTH CRITERIA

Endogenous variables: FOOD OUTPUT INPUT
Exogenous variables: C
Observations: 42

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	-437.9258	NA	263777.5	20.99647	21.12058	21.04196
1	-335.8816	184.6513	3146.034	16.56579	17.06227	16.74777
2	-320.3164	25.94199	2319.134	16.25316	17.12200	16.57163
3	-301.5099	28.65756*	1481.051	15.78619	17.02738*	16.24113*
4	-290.6530	14.99282	1404.030	15.69776	17.31131	16.28919
5	-278.8134	14.65866	1300.149*	15.56254	17.54845	16.29045
6	-270.1156	9.526088	1443.977	15.57693	17.93520	16.44133
7	-263.6147	6.191326	1861.064	15.69594	18.42656	16.69682
8	-258.7663	3.924950	2760.065	15.89363	18.99661	17.03100
9	-237.8322	13.95605	2079.795	15.32534	18.80068	16.59919
10	-221.2869	8.666578	2211.735	14.96604*	18.81374	16.37638

* Indicates the order of lag length per criterion

LR: Sequential modified LR test statistic (each test on 5% significance level)

FPE: Final prediction error

AIC: Akaike information criterion

SIC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

APPENDIX 3

TEST PROCEDURE FOR SELECTING THE APPROPRIATE MODEL AND THE NUMBER OF COINTEGRATING VECTORS

A) Hypothesis testing *according to the critical values of MacKinnon-Haug-Michelis (McK/H/M)) & OsterwaldLenum (O/L) on 5% statistical significance level*

Hypothesized No. of CE(s)	Trace Statistic	0.05 CriticalValue	Max-Eigen statistic	0.05 CriticalValue
None	55.23	35.19 (McK/H/M)	35.64	22.29(McK/H/M)
		34.91 (O/L)		22.29(O/L)

- Step 1: Model No 2: No deterministic trend (restricted constant)

Rejection of hypothesis that there are none cointegrating vectors in model No 2.

- Step 2: Model No 3: Linear deterministic trend

Hypothesized No. of CE(s)	Trace Statistic	0.05 CriticalValue	Max-Eigen statistic	0.05 CriticalValue
None	38.54	29.79 (McK/H/M)	28.63	21.13 (McK/H/M)
		29.68 (O/L)		20.97(O/L)

Rejection of hypothesis that there are none cointegrating vectors in model No 3.

- Step 3: Model No 4: Linear deterministic trend (restricted)

Hypothesized No. of CE(s)	Trace Statistic	0.05 CriticalValue	Max-Eigen statistic	0.05 CriticalValue
None	54.25	42.91 (McK/H/M)	36.11	25.82 (McK/H/M)
		42.44 (O/L)		25.54(O/L)

Rejection of hypothesis that there are none cointegrating vectors in model No 4.

- Step 4: Model No 2: No deterministic trend (restricted constant)

Hypothesized No. of CE(s)	Trace Statistic	0.05 CriticalValue	Max-Eigen statistic	0.05 CriticalValue
At most 1	19.59	20.26 (McK/H/M)	10.24	15.89 (McK/H/M)
		19.96 (O/L)		15.67(O/L)

The hypothesis that there is at most one cointegrating vectors in model No 2 is accepted and the test procedure stops at this point.

APPENDIX 4
SHORT-RUN & LONG RUN CAUSALITY TABLE

VEC Granger Causality/Block Exogeneity Wald Tests (Short run causality)					Weak exogeneity test (Long run causality)
	Excluded variables				
	D(FOOD_CPI)	D(OUTPUT)	D(INPUT)	*All*	ECM_{t-1}
Dependent variables	χ^2-stat				t-stat
D(FOOD_CPI)		18,85*	3,63	21,02*	-4,3*
D(OUTPUT)	2,57		2,84	5,7	1,53
D(INPUT)	0,31	1,91		3,34	0,24

- The null hypothesis that the lagged coefficients of the variable OUTPUT in the regression equation of FOOD are equal to zero, is rejected due to the high value of χ^2 statistics. This means that the output price index affects the food price index in the short run.
- The null hypothesis that the lagged coefficients of the variables INPUT and OUTPUT in the regression equation of FOOD are jointly equal to zero (i.e. that the variable FOOD is block exogenous), is rejected due to the high value of χ^2 statistics. This means that output and input price indices jointly Granger cause, in the short run, the food price index.
- The high value of t statistics of FOOD’s adjustment coefficient, leads to the rejection of the null hypothesis that is equals to zero. This means that the variable FOOD is influenced by OUTPUT and INPUT in the long run.
- No other causal relationship seems to exist, as the null hypothesis of no causality (short run or long run) is accepted in all other cases, since the values of χ^2 and t statistics are very low. This means that both variables OUTPUT and INPUT are not affected either separately or jointly by another variable (they are block exogenous to the others)