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Wheat Supply Response In Greece And The European Union Policy

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Abstract

This paper attempts to estimate the supply response for wheat production in Greek agriculture. In our analysis we use the rigorous cointegration and the error correction method, as it is superior to the generally used Nerlovian partial-adjustment model. Since wheat is one of the most important commodities in the Greek agriculture, comprising 26 percent of the total cultivated land, the estimation of its price responsiveness is vitally important in supporting agricultural policy decisions. The results of our analysis reveal that there is a long-term stable relationship between the supplied quantity of wheat and real gross revenue of wheat producers, suggesting that in order to raise wheat yield and farmer incomes, considering the European Union agricultural policy, productivity increases play a vital role. The government's policy should therefore be channelled through measures that will encourage productivity increases.
Keywords: Greek agriculture, supply wheat response, co-integration, error correction model
JEL Classification: Q11, C22

I. Introduction

A supply response model for an agricultural commodity, in general, relates the supply of a commodity to its price at a specific time period. The theoretical and empirical work on this topic is rich. Although Nerlove's model [Nerlove (1958), (1979)] has been widely criticised[1], it has been a dominant feature of agricultural supply for more than thirty years. The Nerlovian supply model, using a partial adjustment framework, either on its own or in combination with the adaptive expectations model, worked well in a number of empirical studies[2]. In

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1 See for example Johnson (1960), Doran and Griffiths (1978) and Waud (1979). The duality approach to production theory [McFadeen (1978)] is another way to deal with the shortcomings of the Nerlovian model. A significant number of short-term models using the duality approach have been estimated in agricultural empirical analysis. See for example Higgins (1986), Thijssen (1992), Mergos (1994).

2 See for example Askari and Cummings (1976) who present a survey of econometric evidence in various countries.

such models, under different assumptions of expectations, it is claimed that there is a long-run relation among relevant variables to test supply response in order to give a general short-run equation.

This class of models is generally concerned with the levels of the variables and since most of the economic time series data are non-stationary, their statistical significance derived from conventional student t-tests is generally meaningless. This problem is overcome by using a general methodology of cointegration and error correction mechanisms [Hallam and Zanoli (1993), Ghatak and Albayrak (1994)].

Although supply response models have been estimated using Greek data [Drakatos (1965), Pavlopoulos (1967), Papaioannou and Jones (1972), Tsingos (1976), Baltas (1986), Baltas (1987), Apostolou and Varelas (1987), Baltas and Alogoskoufis (1990), Lianos and Katranidis (1992)], they all constitute an application of the Nerlovian theoretical model with its corresponding shortcomings, such as inadequate theoretical basis, statistical estimation problems, etc. This paper attempts to estimate the supply response for wheat in Greek agriculture and the proposed analysis is based on the cointegration and the error correction model framework. This approach is more general than the partial adjustment mechanism, because it allows for a wider pattern of dynamic adjustment. Since wheat is one of the most important commodities in Greek agriculture, consisting 26 percent of the total cultivated land of the Country, an accurate estimation of its price responsiveness is vitally important in supporting agricultural policy decisions.

The rest of the paper is organised as follows: Section II describes the wheat market in Greece. Section III specifies the model and the empirical results are presented, while the last section draws conclusions.

II. The wheat market in Greece

Wheat is one of the most important commodities in Greek agriculture. It comprises 26 percent of the total cultivated land of the country, while its value added ranges from 3.3% to 8.7% of the total agricultural output. In Greece, both the soft and durum varieties of wheat are cultivated. Before the eighties, soft wheat acreage was almost three times higher than that of durum. From the end of the eighties, this trend has gradually been inverted in favour of durum wheat. Wheat production mainly goes as an input in the Greek flour-industry, while a small part of it is exported as plain wheat.

During the period 1960-95, the average annual rate of increase of wheat production was 0.8%. Although the corresponding acreage under wheat decreased by 1.6%, this was the result of increasing yields. The annual rate of change of yield was 1.7%, for the period 1960-95, 3.6% for the pre-EU accession period 1960-80, -0.7% for the after EU accession period 1981-95 and 6.4% between 1990-95. It is worth mentioning that, while the supply of wheat was, in the 1990s, more than 40 percent higher than in the early 1960s, the area under cultivation, for the same period, declined by more than 20 percent (Figure 1).

The significant increase of yields is mainly attributed to technological improvements[3], such as higher fertiliser consumption, the introduction of imported seed, more efficient cultivation methods, etc.

Before the Greek entry to the E.U. in 1981, wheat producers could sell their production to a State Intervention Agency (KYDEP), at a fixed price determined by the Government. This price was normally higher than the international wheat price. After 1981, under the Common Agricultural Policy of the E.U. (CAP), wheat farmers could supply their commodity to some local Intervention Agencies, at an administered price which is determined by the Ministers' Committee of the E.U. After the 1992 CAP reform, administered prices for wheat have gradually decreased[4].

III. Model Specification and Estimation

A supply response model for an agricultural commodity generally relates the supply of a commodity to its price (expected price) at a specific time (t). That is:

$$Q_t = f(P_t^e , Z_t) \qquad (1)$$

where, Q is the supplied quantity, Pe is the expected price level of the commodity and Z is a set of exogenous variables that influence the production level (e.g. technological change, weather conditions, etc.).

Turning to the empirical work, there are models that use the acreage instead of the quantity supplied[5] as the dependent variable of relationship (1). As far as the notion of prices is concerned, variables as the producer prices, the wholesale commodity prices, or the ratio of the above prices to the relevant prices of other competitive commodities have been alternatively used[6]. Others use the expected gross returns[7], instead of the expected price level. As far as the assumption of expectations is concerned, it could be assumed to be a perfect foresight, a static expectation or an adaptive expectation[8]. An interesting feature of our study is

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3 See for example Baltas (1986), p. 24.

4 A presentation of the wheat price support system, before and after the entrance of Greece to the EU, is included in Rosolimos (1994), pp. 11-20.

5 See Nerlove (1958)and (1979), Falcon (1964), Behrman (1967), Miranda-Novak-Lerohl (1994) and Ghatak and Albayrak (1994). For example, Nerlove (1958) found the existence of a positive relationship between acreage and price for the case of U.S. Cotton and Ghatak and Albayrak (1994) found that such a relationship is also valid using data for crop of Turkey. On the contrary, Falcon (1964) and Behrman (1967) showed that for the case of Tayland and Pakistan, the acreage is independent from the commodity price.

6 See for example Baltas (1986) and (1987), Apostolou and Varelas (1987).

7 See for example Ghatak and Albayrak (1994).

8 Under perfect foresight, the expected variables of the model are $P_t^e = P_t$, while according to static expectations, the current expected value equals the previous actual value, therefore $P_t^e = P_{t-1.}$ On the other hand, the adaptive expectations hypothesis implies that the current expectation is a geometric weighted moving everage of past observations, ie $P_t^e = (1-\lambda)\Sigma(\lambda^i)(P_{t-1-i})$, where λ is the coefficient of expectation.

that unlike the traditional analysis, here we test the direct relationship between output supply and gross revenue.

In this paper the error correction model estimated can be stated as follows[9]:

$$q_t = \alpha_0 + \alpha_1 gr_t + \alpha_2 TIME + u_t \quad (2)$$

and

$$\Delta q_t = \beta_0 + \beta_1 \Delta gr_t + \beta_2 W + \lambda u_{t-1} + e_t \quad (3)$$

where $gr_t = \{y_t + (p_t - cpi_t)\}$.
q is the supplied quantity of wheat, gr is the real gross returns of the wheat producers - defined as the average yield times the deflated producer prices, which in log terms is (y+(p-cpi)) - , TIME is a linear trend term as a measure of technical change, W is a dummy for the weather conditions, λ is the error-correction coefficient and u and e are random disturbance terms. The variables q, gr, y and p are expressed in logarithms and «Δ» is the first difference operator. The model assumes perfect foresight[10], that is $P_t^e = P_t$.

The above error correction model is more general than a partial adjustment model, since it allows for a wider pattern of dynamic adjustment. This can be stated as follows:

In a partial adjustment mechanism, a long-run function is defined in terms of aggregate desired production (q_t^d):

$$q_t^d = c_0 + c_1 gr_t + v_t \quad (4)$$

A partial adjustment model of actual production towards its desired level will be:

$$q_t - q_{t-1} = \delta (q_t^d - qt\text{-}1) \quad (5)$$

This yields the following estimating equation:

$$q_t = c_0\delta + c_1 \delta gr_t + (1-\delta)q_{t-1} + v_t \quad (6)$$

An error correction model combines long and short run interaction amongst a group of variables. To be related to one another in the long-run (cointegration) variables must be, individually, non stationary, but a linear combination of those variables will be stationary.

Suppose q_t and gr_t are cointegrated, the long-run relationship between these two variables is given by the Equation (2), or in its simplest form by Equation (7):

$$q_t = \alpha_0 + \alpha_1 gr_t + u_t \quad (7)$$

or

$$u_t = q_t - \alpha_0 - \alpha_1 gr_t \quad (8)$$

Since q_t and gr_t are cointegrated, ut is stationary and there is an error correction representation of these variables of the form:

$$\Delta q_t = \beta_0 + \beta_1 \Delta gr_t - \lambda u_{t-1} \quad (9)$$

or

$$\Delta q_t = \beta_0 + \beta_1 \Delta gr_t - \lambda (q_{t-1} - \alpha_0 - \alpha_1 gr_{t-1}) \quad (10)$$

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9 For the explanation why the variables TIME and W are included in Equation (2) and (3), see below.

10 The use of the one period lag gr instead of the current gr has not been verified by the data.

and

$$q_t = (\beta_0 + \alpha_0\lambda) + (\beta_1 gr_t) + \{(1-\lambda)q_{t-1}\} - \{(\beta_1 - \alpha_1 \lambda)gr_{t-1}\} \qquad (11)$$

The models (6) and (11) will coincide only if the lagged gross revenue term (gr_{t-1}) is omitted from the error correction specification. So, the partial adjustment model is nested within the more general error correction model. Moreover, in the error correction model all variables are stationary and methods based on classical OLS assumptions are appropriate for the estimation of the short-run model.

Returning to our error correction model, equation (2) shows the long-run relationship between the quantity supplied and the real gross returns of the farmers and it is expected a priori that α_1 and $\alpha_2 > 0$. Equation (3) is the dynamic error correction model of the short-term behaviour of the supplied quantity of wheat. The coefficient «λ» is interpreted as the long-run disequilibrium, which is partly corrected next year. It is expected that β_1 and $\beta_2 > 0$ and $\lambda < 0$ and significant.

The empirical analysis uses annual series for the period 1960 - 1995. The relevant data on wheat are obtained from the National Statistical Service of Greece and the Ministry of Agriculture (Table 1).

Following the standard practice, the first step is to test for the presence of unit roots. The series were examined for their order of integration by means of the Augmented Dickey-Fuller (ADF) tests. Table 2 reports the results of the unit root tests for the levels and the first differences of the series.

As far as the levels of the variables are concerned, the ADF test suggests the presence of at least one unit root. This test applied on the first differences of the series provides evidence that the differences of the series are stationary. Consequently, all series are difference stationary, denoted I(1).

Following the Engle and Granger (1987) two-step methodology, we check the relationship between the quantity supplied and the real gross returns of the wheat producers. To this end, the residual-based ADF method is used. To reject the null hypothesis of no cointegration, we check whether the OLS residuals from equation (2) are stationary I(0) that will imply cointegration. In order to test the existence of a deterministic or a stochastic cointegration[11], equation (2) was also estimated excluding the trend term. In this non-detrended specification, if cointegration were to be established, this would correspond to a deterministic cointegration. This would imply that the estimated cointegrating vector eliminates both stochastic and deterministic trends. On the other hand, if cointegration was to be detected through the estimation of the detrended equation (2), this would correspond to a stochastic cointegration.

The estimation results are shown in Table 3.

The ADF test statistic on residuals rejects the null hypothesis of cointegration in the case of the non detrended expression of the equation (2), while it does not reject the hypothesis in the case of the detrended expression of the equation (2). Consequently, the test provides evidence of a stochastic cointegration between the quantity of wheat supplied and the real gross revenues of the

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[11] See Ogaki (1993).

wheat producers. This means that the linear stationary combinations of the I(1) variables at issue have non-zero linear trends [12].

We also estimated equation 2 using the fully modified (FM) OLS estimator of Phillips and Hansen (1990)13. The residuals obtained from the FM estimated regression were subjected to cointegration testing. The P/P unit root test for the Phillips and Hansen residuals was -5.042, validating the results of the Engle and Granger cointegration test and confirming the existence of cointegration. It is noted that the most commonly used method of Johansen and Juselius (1990)14 was not applied, since its application in small samples, as in this study, is inadvisable [Phillips (1994)]. Furthermore, since in our case we have only two variables that can only form one cointegrating vector, the use of a single equation estimation method is more appropriate.

The fact that wheat production and gross farmers returns move closely together in the long run is also identified by an inspection of Figure 2. It presents the movement of deflated gross returns and production of wheat. These two series are closely related together for the whole period.

The second step is to estimate the error correction model (ECM). The results are presented in Table 4.

Since the production of wheat is very sensitive to weather conditions, the dummy variable W is included in the short-run equation. This variable for the weather conditions in Greece has been constructed and applied by Baltas (1986, 1987) and Apostolou and Varelas (1987). It is based on the relative fluctuations of the yield of the production that are not explained by the development of new methods of crops, or by the changes of the size of areas under crops. So the «extremely high» changes are ranked as «4», the «high» changes are ranked as «3», the «small» changes are ranked as «2» and the «extremely small» changes are denoted as «1». Moreover, qualitative data on whether conditions have been obtained from agronomists' services to counter-check this weather dummy variable.

All the coefficient estimates have the expected signs, while the model has a satisfactory explanatory power and passes residual misspecification tests. The coefficient of the differenced real gross returns term (+0.510) represents the short-run gross revenue elasticity, while the coefficient of the error correction term (-0.6) measures the adjustment towards the long run relationship between supplied quantity and real gross returns. This terminology suggests that if an error q grows too quickly, the last term of equation (3) becomes bigger and since λ is negative, Δq_t is reduced, correcting this error.

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12 The detrending procedure in the variables q and gr gives residuals that are still non-stationary. The corresponding ADF statistic is -2.73 and -0.59 respectively.

13 The Phillips and Hansen (1990) estimator removes some bias in OLS estimation of the cointegrating vector.These corrections are asymptotically efficient, since they take account of serial correlation in the residuals of the cointegration regression and possible endogeneity of the explanatory variables.

14 This procedure gives consistent estimates of the cointegrating matrix, as well as statistical tests for the size of of the producing cointegrating vectors.

IV. Concluding Remarks

In this paper the supply response for wheat is examined, using data from the Greek agriculture over the period 1960-1995. Our analysis has been based on the error-correction model.

The empirical results reveal that wheat production is dominated by real gross returns rather than wheat prices. That is, Greek farmers trade off increases of agricultural productivity with the possible reduction of real wheat prices. This is not an astonishing conclusion, since during the period under consideration (that is 1960-95), wheat productivity measured as average yield per hectare has increased by more than 80% (81.3%). Such productivity increases are associated with wheat production and after 1995, that is over a longer period. Long and short-run relationships between wheat supply and the real gross returns of the wheat farmers were estimated. The long-run revenue elasticity of the wheat supply was found to be 0.41, while the short-run is 0.5115

In the medium-term, the reforms of the Common Agricultural Policy, which are compatible with the Uruguay Round agreement, will lead to a decrease in the EU support to farmers. Additionally, the restrictive fiscal policy that the government is determined to follow, to enable Greece to achieve the Maastricht criteria, will reduce the national assistance to farmers16. Consequently, a substantial decrease in the gross revenue of Greek farmers is expected, including that of wheat producers. According to our results, this is expected to exert a significant negative influence to wheat production, given the high elasticity. The only way for Greek farmers to avoid the reduction in their gross revenues (and therefore the reduction of wheat production), is the implementation of such measures that will raise their yields and returns. Such measures that increase agricultural productivity could be the introduction of improved seed, more efficient cultivation methods and increase in farm size. If the national objective is to sustain or increase the current level of wheat production, the government's policy should be channelled through measures which will encourage the above mentioned interventions aimed at increases in productivity. Particular importance should be paid to improving the organisation of production and the production processes and techniques, by strengthening the role and increasing the responsibility of agricultural co-operatives and by training Greek farmers and co-operative managers.

References

Apostolou N. and A. Varelas, 1987, «Supply Functions of Specific Agricultural Crop Products», Agricultural Bank of Greece, Athens (in Greek).

Askari, H. and J.T. Cummings, 1976, «Agricultural Supply Response : A Survey of Econometric Evidence», Praeger Publishers, N.Y.

Baltas, N., 1986, «An Analysis of the Supply of Agricultural Products: Cereals», Agricultural Bank of Greece, Athens (in Greek).

Baltas, N., 1987, «Supply Response for Greek Cereals», *European Review of Agricultural Economics*, vol. 14, No. 2, pp. 195-200.

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[15] Using different sample periods and methods, Baltas (1987) found a wheat long-run price elasticity of 0.37 and a short-run of 0.34. Pavlopoulos (1967) estimations are respectively 0.73 and 0.43.

[16] An example of a national assistance to the farmers is that, under a law passed in 1996, a 30% reduction of the excise tax has been granted on gasoline used for agricultural functions.

Baltas, N. and G. Alogoskoufis, 1990, «A Rational Expectations Model of the Poultry Sector», National Foundation of Agricultural Research, Athens.

Behrman, J.R., 1968, «Supply Response in Underdeveloped Agriculture: A Case Study of Four Major Annual Crops in Thailand 1937-1963», North-Holland Publ.Co., Amsterdam .

Dickey, D.A. and W.A. Fuller, 1981, «Likelihood Ratio Statistics for Autoregressive Time-Series with Unit Root», *Econometrica*, vol. 49, pp. 1057-1072.

Doran, H.R. and W.E. Griffiths, 1978, «Inconsistency of the OLS Estimator of the Partial Adjustment-Adaptive Expectations Model», *Journal of Econometrics*, vol. 7, pp. 133-146.

Drakatos, C., 1965, «Quantitative Analysis of Supply and Demand for Greek Cotton», Athens.

Engle, R., 1982, «Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of U.K. Inflations», *Econometrica*, vol. 50, pp. 987-1008.

Engle, R. and C.W.J. Granger, 1987, «Cointegration and Error Correction: Representation, Estimation and Testing», *Econometrica*, vol. 55, pp. 251-76.

Falcon, W.P., 1964, «Farmer Response to Price in a Subsistence Economy: The case of West Pakistan», *American Economic Review*, Papers and Proceedings, vol. 54.

Ghatak, S. and N. Albayrak, 1994, «Supply Response in Turkish Agriculture. An Error Correction and Cointegration analysis», Paper Presented at the International Symposium on Economic Modelling, The World Bank, Washington D.C., USA.

Godfrey, L., 1978, «Testing Against Autoregressive and Moving Average Error Models when the Regressors Include Lagged Dependent Variables», *Econometrica*, vol. 46, pp. 1293-1302.

Hallam, D. and R. Zanoli, 1993, «Error Correction Models and Agricultural Supply Response», *European Review of Agricultural Economics*, vol. 20-2, pp. 151-166.

Higgins, T., 1986, «Input Demand and Output Supply on Irish Farms - A microeconomic Aproach», *European Review of Agricultural Economics*, vol. 13, pp. 477-493.

Johansen, S. and K. Juselious, 1990, «Some Structural Hypothesis in a Multivariate Cointegration Analysis of the Purchasing Power Parity and the Uncovered Interest Parity for the U.K.», Institute of Mathematical Statistics, University of Copenhagen, Unpublished reprint.

Johnson, G.L., 1960, «Review of Nerlove», *Agricultural Economic Research*, vol. 12, pp. 25-28.

Lianos, T. and S. Katranidis, 1992, «Modelling the Beef Market of the Greek Economy», *European Review of Agricultural Economics*, vol. 20, No. 1, pp. 49-64.

MacKinnon, J.G., 1991, «Critical Values for Cointegration Tests», in R.F. Engle and C.W.J. Granger (eds.), *Long-Run Economic Relationships: Readings in Cointegration*, N.Y. : Oxford University Press, pp. 267-276 .

McFadden, D., 1978, «Cost Revenue and Profit Functions», in *Production Economics*: *A Dual Approach to Theory and Applications*, by Fuss, M. and McFadden (ed.), North Holland Publishing Co., Amsterdam .

Mergos, G., 1994, «Modelling for Policy Analysis in Agriculture: Estimation of Short-run Output Supply and Input Demand Elasticities», in Alogoskoufis, G. Kollintzas, T. and Provopoulos, G. (eds), *Essays in Honor of C. Drakatos,* Athens, Papazissis Publ .

Miranda, M., F. Novak and M. Lerohl, 1994, «Average Response under Canada's Western Grains Stabilisation Program», *American Journal of Agricultural Economics*, vol. 76, pp. 270-276.

Nerlove, M., 1958, *The Dynamics of Supply: Estimation of Farmers Response to Price*, The Johns Hopkins University Press, Baltimore.

Nerlove, M., 1979, «The Dynamics of Supply: Retrospect and Prospect», *American Journal of Agricultural Economics*, vol. 61, pp. 874-888.

Ogaki, M., 1993, «Unit Roots in Macroeconometrics: A Survey», Rochester Centre for Economic Research, Discussion Paper No. 364.

Papaioannou, M.C. and G.T. Jones, 1972, «Supply Response of Cattle, Sheep and Goats in Greece», *Oxford Agrarian Studies* I (2).

Pavlopoulos, P., 1967, *Supply Functions of Agricultural Products: A Quantitative Investigation*, Centre of Planning and Economic Research, Athens (in Greek).

Phillips, P.C.B. and B.E. Hansen, 1990, «Statistical Inference in Instrumental Variables Regression with I(1) Processes», *Review of Economic Studies*, vol. 57, pp. 99-125.

Rosolimos, P., 1986, *Trade of Flour and Cereals*, Institute of Economic and Industrial Research, Research Group: Food-Beverages, 118.

Thijssen, G., 1992, «Supply Response and Input Demand of Dutch Dairy Farms», *European Review of Agricultural Economics*, vol. 19, No. 2.

Tsingos, G., 1976, *Supply Response in Agriculture : The Case of Greek Farmers*, M.A. Dissertation, Univ. of Bristol .

Waud, R.J., 1979, «Mis-specification in the 'Partial Adjustment' and 'Adaptive Expectations' Models», *International Economic Review*, vol. 9, pp. 204-217.

Table 1: *Unit Root Tests ** (ADF Statistic)*

Series	**l**	t_α	$t_{\alpha*}$
q	1	-2.73	-2.26
p	1	-1.79	-0.23
y	1	-2.37	-1.84
gr	1	-0.59	-0.50
Δq	0	-10.95 *	-11.05 *
Δp	0	-6.65 *	-6.83 *
Δy	0	-12.30 *	-12.36 *
Δgr	0	-11.72 *	-11.13 *

** t_α is the t-value of «α» in the regression $\Delta X_t = \mu + \alpha X_{t-1} + \beta t + \Sigma \delta_i \Delta X_{t-i} + u_t$. The critical values are given by Mackinnon (1990). The values for rejection of hypothesis of a unit root are : -3.5468 (5% significance level), -4.25056 (1% significance level). $t_{\alpha*}$ is the unit root test when the trend t is ommitted from the regression. The critical values are also given by Mackinnon (1990). The values for rejection of hypothesis of a unit root in this case are : -2.9499 (5% significance level), -3.6353 (1% significance level). l is the number of lagged dependent variables. The choice of the number of lags was based on the Lagrange Multiplier (LM) test for first order serial correlation in the residuals of the regression and on the significance of δ_i. « * » indicates significance at the 0.01 level.

Table 2: *The Engle-Granger Cointegration Test* **

Cointegration Regression : $q_t = \alpha_0 + \alpha_1 gr_t + \alpha_2 TIME + u_t$				
	α_0	α_1	α_2	ADF test statistic on Residuals
Non-detrended	4.47	0.31		-1.75
	(3.53)	(2.50)		
	Adj. R^2 : 0.13		S.E. : 0.189	
Detrended	3.16	0.41	0.014	-4.59 *
	(3.77)	(5.10)	(6.99)	
	Adj. R^2 : 0.64		S.E. : 0.122	

** The values in parentheses are the t-values. S.E. is the standard error of the OLS regression.The critical values of the ADF test on residuals are given by Mackinnon (1990). « * » indicates significance at the 0.01 level.

Table 3: *ECM model . Regression Results* **

Dependent variable : Δq_t		
	Coefficient	**t-statistic**
Constant	-0.0927	-1.70 *
Δgrt	0.5103	4.61 *
W	0.0428	2.12 *
ut-1	-0.600	-3.60 *

Statistics		
S.E.	:	0.106
Adj. R^2	:	0.7498
Q(2)	:	1.69
ARCH(1)	:	0.059

** Δq^t and Δgrt are differences of logs. S.E. is the standard error of the OLS regression. Q(2) is the Godfrey (1978) LM test for serial correlation in the residuals which is asymptotically distributed as $\chi 2(2)$. ARCH(1) is Engle's (1982) statistic for autoregressive conditional heteroscedasticity in the residuals which has an asymptotic $\chi 2(1)$ distribution. * indicate significance at the 0.05 level.

Figure 1
Wheat Production, Acreage and Yield

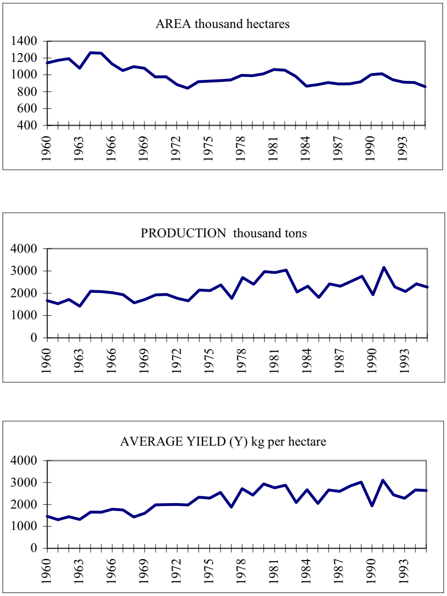

Figure 2
Wheat Production, Gross Returns and Producer Prices