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MEAT SUPPLY RESPONSE: A COINTEGRATION ANALYSIS FOR THE GREEK LIVESTOCK SECTOR

By

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Abstract

This paper examines the impact of input and output prices in the process of enterprising decision-making for meat production in Greece by means of econometric modelling. For estimating supply elasticites, econometric methods are used, namely a 'naive' expectations model form. Cointegration analysis is used for investigating the actuality of a long-run relationship between the variables of interest. The statistical results show that the estimated supply models possess desirable statistical properties and the estimated supply elasticities are credible. The estimated elasticities are consistent with a priori expectations and are superior to other estimates because proper procedures have been used (cointegration tests have established the existence of long-run relationships). (JEL Q11).

1. Introduction

The estimation of supply functions of agricultural products is of great interest both practically and theoretically. Policy makers wish to know the features of agricultural supply, the elements that predominantly determine the level of production and especially the way in and the extents to which prices and supply are related to each other. Especially in recent years when the European Union experienced large surpluses of its main agricultural products and spent a great amount of money supporting prices and farm incomes, policy makers became more interested in using effective instruments to control supply.

The factors influencing dynamic supply response have been the subject of considerable research (Askari and Cummings, 1976). Supply dynamics have been associated with the dynamic nature of the production process. In the case

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of production from biological populations, biological time lags typically influence the nature of population dynamics, which in turn effects the dynamics of supply response (Marsh, 1983; Rucker et al., 1984; Whipple and Menkhaus, 1989; Holt and Johnson, 1989). There are only a few studies of supply response concerning agricultural production, and especially meat production, in Greece using either the well-known Nerlovian or rational expectations framework and a single equation estimation model or a log-linear single estimation framework (Pavlopoulos, 1967; Apostolou and Baltas 1987; Katranidis and Lianos, 1993).

This paper constitutes an econometric supply analysis covering all the meat producing sectors with the use of a linear dynamic model. The products to which the model refers are: a) pig meat, b) poultry meat, c) goat meat, d) sheep meat and e) beef. The analysis of supply response for the Greek livestock sector is crucial in order to determine the effects of government intervention and of EU policies. It is especially important due to the fact that present policies seem to favour the crop rather than the livestock sector. Thus, the estimates of the elasticity of supply relative to its own price is a fundamental prerequisite for estimating the effects of internal and external policies on Greek producers.

A number of different modelling methodologies are available for the analysis of supply response in agricultural commodity markets, and have proved useful in one time or another. They differ in data requirements, in computational needs and of course, in the complexity. These different modelling methodologies are: a) Box Jenkins time series analysis, b) mathematical programming and c) econometric modelling. In practice, one may combine these different approaches. The focus of this paper — in order to get estimates of the supply elasticities for meat production in Greece— is on econometric approach.

The paper also explores the application of the theory of cointegration to agricultural supply analysis. Cointegration theory has a relatively recent history going back only twelve years (Granger, 1986). It can be regarded as the empirical manifestation of a long-run relationship between variables and provides a statistical framework which identifies and hence avoids the spurious regressions so easily specified and accepted with series which exhibit strong trend, resulting in misleading conclusions (Hallam and Zanoli, 1993). The importance of this paper lies on the facts that it is the first paper which uses so analytical data set (for Greece) and refers to all meat producing animals and also uses cointegration analysis for the investigation of the existence of a long-run relationship between the variables of interest.

The remainder of this paper is organized as follows. In section 2, the methodological considerations underlying this study are presented. In section 3, policy implications for the meat market that resulted from the reform of the CAP are examined. In section 4 specification, data and issues related to the models are discussed. Estimated parameters, elasticities and tests carried out are presented in section 5. Finally, summary and conclusions are presented in section 6.

2. Methodological Considerations

Accurate estimation of the price responsiveness of agricultural commodities is vitally important in supporting policy decisions. Government policy measures and trade negotiations rely on supply estimates for predicting the effects of changing government programs and for anticipating the consequent social benefits and costs of such programs (Mergos, 1991).

Early research efforts devoted to agricultural supply response in various countries of the world have been reviewed by Askari and Cummings (1976). In order to include important innovations which are related to methodological issues, several economists extend their research efforts. Serious limitations which are related with the ability to provide accurate and useful information to policy makers in taking decisions cannot be overcome despite the fact that substantial resources were devoted to supply analysis over the last ten years. During this period extreme variability of livestock products and input prices have shown that performance in anticipating commodity supply response in this environment was inadequate. The need for a dynamic specification of the supply function arises from the fact that in most cases farmers will not be able or willing to adjust their production activities instantaneously in response to market change (Hallam, D. 1991).

The adaptive expectations model was proposed by Cagan (1956). In this model, the unobservable expected price P_t^* determines the quantity supplied, Yt, that is:

$$Y_t = a_0 + a_1 P_t^* + E_t \qquad (1)$$

The expectations P_t^* are revised in proportion to the error associated with the previous level of expectations:

$$P_t^* - P_{t-1}^* = \lambda (P_{t-1} - P_{t-1}^*) \qquad (2)$$

where $0<\lambda<1$ is the coefficient of expectations, P_{t-1} is the actual observable price, E_t is the stochastic term and a_0 and a_1 are parameters. If one solves the above difference equation for P_t^*, then:

$$P_t^* = \sum_{i=0}^{\infty} \lambda (1 - \lambda)^i P_{t-1-i} \tag{3}$$

which suggests a distributed lag form for expected prices which is declining geometrically as a function of all past prices. The substitution of (3) into (1) results in the following geometric lag function:

$$Y_t = a_0 + a_1 \sum_{i=0}^{\infty} \lambda (1 - \lambda)^i P_{t-1-i} + E_t \tag{4}$$

In 1954, Koyck showed that an equation of the above form can be reduced by lagging it once, multiplying through by $(1 - \lambda)$ and subtracting it from the original equation, to yield a simple form:

$$Y_t = a_0 \lambda + a_1 \lambda P_{t-1} + (1 - \lambda) Y_{t-1} + E_t^* \tag{5}$$

where $E_t^* = E_t - (1 - \lambda) E_{t-1}$· using lag operator notation gives:

$$Y_t = a^0 + \frac{a_1 \lambda L}{1 - (1 - \lambda) L} P_t + E_t \tag{6}$$

Assuming that E_t is Gaussian white noise, this model is completely specified.

The partial adjustment model was proposed by Nerlove (1956). The basic idea is that the current value of the independent variable determines the 'desired' value of the dependent variable:

$$Y_t^* = a_0 + a_1 P_t + E_t \tag{7}$$

but only some fixed fraction (δ) of the desired adjustment is accomplished in one period:

$$Y_t - Y_{t-1} = \delta (Y_t^* - Y_{t-1}) \tag{8}$$

where $0<\delta<1$ is the coefficient of adjustment. Combining (7) and (8) gives:

$$Y_t + a_0 + \frac{a_1 \delta}{1 - (1 - \delta) L} P_t + \frac{\delta}{1 - (1 - \delta) L} E_t \tag{9}$$

The above model is also completely specified provided the standard assumptions for U_t are made. The agricultural supply response models considered so far, however sound they may be on theoretical grounds they may not be able to provide reliable parameter estimates if adequate attention is not paid to the statistical properties of the series used in the empirical analysis. Conventional model estimation and evaluation are based on the existence of stationary data series. Such an assumption is frequently violated when dealing with economic series leading to false and unreliable results.

Following the work of Granger and Newbold (1974) considerable attention has been paid to the time series properties of variables entering econometric models. Of particular concern is the use of integrated variables which are commonly found in economics. Cointegration analysis has been introduced as a means of combining long-run information into equations that contain stationary components. Moreover, cointegration provides a link between the integrated series typically used in estimation and the motion of long-run equilibrium relationships. Cointegration has become increasingly popular with econometric modelling as a means of avoiding spurious regressions and as a means of purging standard practice.

Consider a series X_t measured at equal intervals over time. A series X_t is said to be integrated of order d if the series becomes stationary after differencing d times, denoted $X_t \sim I(d)$. Thus, if X_t is stationary after differencing once then it may be denoted $X_t = I(1)$ and $\Delta X_t \sim I(0)$. While few series that are encountered in economics are stationary they may be transformed into series that are. The importance of the order of integration is brought more sharply into focus with the analysis of the concept of cointegration. Let X_t and Y_t denote two I(1) series, each of which is generated by a random walk process. Generally, any linear combination of these series will also be I(1) yet there may exist some parameter A such that:

$$U_t = Y_t - AX_t \tag{10}$$

is I(0). Where this is so, X_t and Y_t are said to be cointegrated and A is known as the cointegrating parameter. The existence of a cointegrating parameter implies that there exists a very special relationship between the two series, in that the behaviour of one series is 'mirrored' by the other. Considering $Y_t = AX_t$ as an equilibrium relationship posited by economic theory, then U_t denotes a quantity which measures the extent to which the relationship is out of equilibrium; U_t may thus be interpreted as a 'disequilibrium error'. Consequently, the existence of a linear combination of two I(1) series that is I(0) suggests that the series generally move together over time, such that the relationship holds in the long-run.

Three residual-based tests have emerged as the most popular choices in formal testing for cointegration: the 'cointegrating regression Durbin-Watson' (CRDW) test of Sargan and Bhargava, the Dickey-Fuller (DF) test and the Augmented Dickey-Fuller (ADF) test. All of these are tests for unit roots and hence of whether a series is I(1) against the alternative that the root is less than one and the series is I(0). Typically, but perhaps unnecessarily, all three of these tests are carried out and the results reported. Unfortunately, critical values for these tests have not been determined for all sample sizes and numbers of variables, although useful tables are provided by Engle and Granger (1987). These earlier residual-based tests have been superseded by the maximum likelihood methods proposed by Johansen. The latter provide likelihood ratio tests for the existence of different numbers of cointegrated vectors.

3. Common Agricultural Policy in the Meat Sector - Its Application and Implication

In order to proceed and specify a statistical model for the Greek meat producing sector, it is important to consider some policy implications that result from the 1992 reform of the CAP. This analysis is of vital importance, since there is a direct relation between the estimated elasticities and the effectiveness of various policy measures. As it was mentioned in the introduction, the analysis of supply response for the Greek livestock sector is crucial in order to determine the effects of government intervention. Thus, the estimates of the elasticity of supply relative to its own price is a fundamental prerequisite for estimating the effects of CAP on Greek producers.

The May 1992 agreement by the EU Council of Ministers to reform the CAP contains several items that depart from previous EU practice. The main points of the reform is to reduce market support for cereal's oilseed and protein crops (COP), which are the most important EU agricultural products, by 40% over a 3 year period, and replace it by a system of direct compensatory payments. This will increase domestic demand, especially demand for feed in the animal sector, and will reduce the growth of COP yields. The reforms also involve some drastic non-compensated reduction in support for sheep meat, while mild reforms in supprt in the milk and beef sectors are largely resultant from the reforms in the COP sector. The products covered by the new regulations (Commission of the EU, 1993) are: beef and veal, sheep and goat meat and pig meat.

a) **Beef and Veal:** The reform covers the prices for beef and veal, premiums and intervention. It also takes account of environmental concerns. The prices fixed for this market are: a) The guide price for adult bovine animals which takes account of the situation on the markets for both beef and dairy products; b) the intervention price which is the price where market support measures are based. Intervention is opened if, for two consecutive weeks, the average market price in the EU for the grade or class of grades of meat in question is less than 84% of the intervention price, and the average market price in the Member State concerned by tendering procedure. Invitations to tender for one or more grades or class of grades are suspended once the intervention conditions are no longer met. To protect the community market from imports from third countries, an import levy is charged. It can be fixed in advance in contracts. The basic levy represents the difference between the guide price and the free-at-frontier price plus import duty. The levy actually charged can be more than or less than this basic levy depending on price on representative markets in the Community. There are two exceptions to this general rule: i) in the case of frozen meat intended for processing, special import arrangements require an annual balance to be drawn up showing supplies to and requirements of the Community processing industry. The quantities thus determined may be partly or fully exempt from the levy, subject to the issue of a certificate; ii) in the case of young male bovine animals intended for fattening in the EU. Export refunds may be granted, fixed in advance and set at different levels depending on the destination.

b) **Sheep and Goat Meat:** Each year the Council fixes a basic price - the same throughout the EU —which is used for calculating the amount of the ewe premium. To take account of seasonal variations on the market, this price is seasonally adjusted. In order to ensure a fair standard of living for farmers and to stabilize markets, a premium was granted to compensate farmers for their loss of income. Before the 1989 reform, the Community was divided into seven regions. At the end of the marketing year, the income loss was estimated for each region on the basis of the market prices recorded during the year. This income loss was calculated as the difference between the basic price and the arithmetic mean of the market prices recorded during the year. The income loss allowed the amount of the premium payable per ewe to be calculated for each region.

A Community quotation for standard quality, corresponding to the most widespread production for specialized flocks, is established. A distinction is made between light-lamb and heavy-lamb producers, all producers of sheep milk being taken to be light-lamb producers, save proof to the contrary. The loss of income to producers is any difference between the basic price and the arithmetic mean of the market prices recorded during the marketing year. The amount of the premium is divided by applying a technical coefficient for "heavy lambs" or, at 80% of that rate, "light lambs" to the loss of income. The premium is paid at the full rate up to the limit of: i) 1.000 animals per producer in less-favoured areas, ii) 500 animals per producer in other areas, iii) above these limits, the premium is reduced by 50%. Since the 1991 marketing year, an additional premium of ECU 4 per ewe has been paid as part of the rural development measures for mountain and hill farms and farms in other less favoured areas. This aid was increased to ECU 5.5 for the 1992 marketing year. Import arrangements differ depending on the products imported. Thus, the CCT rates of duty apply to offal. A levy is apllied to live animals other than pure-bred animals for breeding and to chilled or frozen meats. This levy is equal to the difference between the seasonally adjusted basic price and the free-at-Community-frontier offer price established on the basis of the purchasing possibilities most representative as regards quality and quantity recorded during the period prior to the fixing of the levy. For products bound under the GATT, however, the levies are restricted to 20% of the *ad valorem* duty. As part of the voluntary restraint agreement concluded with the main non-Community supplying countries these levies are restricted to 10% *ad valorem.* However, by the end of 1993 this levy was temporarily reduced to zero as part of the temporary adjustments to the voluntary restraint agreements.

c) Pig Meat: Each year the Council fixes a basic price for Grade U pig carcasses for that marketing year. The price represents the average production cost, including slaughter costs. The level must be such as to contribute to stabilizing market prices without leading to the formation of structural surpluses in the Community. The buying-in price, derived directly from the basic price is the price at which the intervention agencies buy in to public intervention. The price is fixed in accordance with the Management Committee prodecure. Each quarter, the Commission calculates a sluice-gate price corresponding to the production cost in third countries, the world market price for feedingstuffs and other production and marketing costs being taken into account. An import levy is fixed every quarter for imports from third countries. The levy is made up of one component equal to the difference between prices on the world market and within the Community for the quantity of feed grain required for the production of one kilogram of pig meat, and one component equal to 7% of the sluice-gate price. Where the free-at-frontier price for a product falls below the sluice-gate price, an additional levy equal to the difference between the two prices is applied. Exports qualify for a refund which is fixed for each product and uniform throughout the Community. This refund may be set at different levels depending on the destination and is based on the difference between the world market price and the price within the Community.

4. Specification and Data Requirements

In order to proceed and specify a particular model for the estimation of supply elasticities for the Greek livestock sector, it is important to take into consideration the special biological and technical characteristics of this sector. These characteristics are the guides for determining: a. the length of the time lags and b. the variables to be included in the model (i.e. the particular inputs). It is necessary to point out that these technical and biological characteristics can be used more effectively in the case of cross-section data rather than in the case of time-series due to the fact that there is a close relationship between efficiency in production and the technical and biological characteristics.

The variables that have been used in the supply analysis for the Greek livestock sector are the following: a. The number of slaughtered animals and the yield as dependent variables, b. The prices of meat (output) and c. The prices of the main inputs.

The selection of the number of slaughtered animals and of the yield as dependent variables is easily understood. If the basic assumption is that total meat production (= Q) is given by the total number of animals (= H) and their yield (= Y), then the following stands:

$$Q = H * Y \tag{11}$$

Let us also assume that changes in prices affect considerably the total number of animals as well as their yield and by taking the first derivative of eq. 11 with respect to price:

$$\partial Q / \partial P = (Y \cdot \partial H / \partial P) + (H \cdot \partial Y / \partial P) \tag{12}$$

Considering that there are constant returns to scale and dividing the above equation with Q/P, the final result is:

$$E_{q,\,p} = E_{h,\,p} + E_{y,\,p} \tag{13}$$

where, $E_{q,\,p}$: elasticity of output with respect to price, $E_{h,\,p}$: elasticity of herd with respect to price, $E_{y,\,p}$: Elasticity of yield with respect to price.

It is important to emphasize that the price of meat was used as an independent variable in all econometric models because it is considered as exogenously determined. Another point that needs to be stressed is that the production process is affected by market conditions of the previous time periods. For that reason, the output price is used in the econometric models with a time lag of one or two periods depending as was mentioned above on the biological and technical characteristics of the livestock population. Supply is also affected by the price of the inputs which are connected with the production of a specific product. The most important inputs in meat production are: a. feedingstuffs, b. fixed capital and c. labour.

Feedingstuffs: Animal feed is the most important input in supply analysis of any livestock product (it contributes 60% - 75% to the total production cost). For the production of beef, goat, sheep, poultry meat the use of the price of corn was considered necessary in order to analyze its effects on the dependent variables. In the case of the supply model for pig meat and taking into consideration, as before, the technical and biological characteristics of production, the use of the price of barley was considered essential.

Fixed Capital: In order to estimate the fixed capital input, it is important to get estimates for the fixed capital stock. Fixed capital stock is estimated using the perpetual inventory method. The stock of fixed capital is equal to a weighted sum of all past investments where the weights are the assets efficiency as of a given age (Ball et al. 1993). Following convention, the efficiency of a new asset is normalised to unity and assumed to decline monotonically with age. The function relating efficiency to age of the asset is approximated by a rectangular hyperbola. The family of hyperbolic efficiency functions is given by:

$$S_t = \frac{L - t}{L - \beta_\delta}, 0 \leq t \leq L$$
$$S_t = 0, t \leq L \quad (14)$$

where St is the relative efficiency of an asset t years of age, L is the service life and β is a curvature parameter describing the form of depreciation. The calculated value of the above function yields the quantity of assets available for production t years after the purchase date expressed as a proportion of the initial investment. Subtracting this from unity yields the proportion of accumulated physical depreciation t years after the purchase date. In order to get estimates for the cost of capital (defined as the user's cost of capital) one must use, as an explanatory variable, the real rate of return (real interest rate):

$$R = \frac{1 + r}{1 + \Pi} - 1 \qquad (15)$$

where, R: real interest rate, r: rate of return, Π: Consumers Price Index (C.P.I.).

Having estimated capital stocks at current and 1970 price levels and capital consumption which in fact represents the efficiency loss over time, and with the use of real rate of return, we can estimate user's cost of capital (Christensen and Jorgenson, 1969):

$$C_{ik} = C\,S\,T_i \cdot R + CCON_i \qquad (16)$$

where, Ci*: user's cost of capital, CST_i: capital stock for asset, I, R: real rate of return, CCONji capital consumption for asset I. By using expression (16) and by adding all capital stocks for each capital good and then by dividing the current prices by the 1970 price levels, the price of capital is obtained.

Labour: Under the Greek production patterns most of the labour required in the livestock sector is provided by the family. A major exception is the beef meat sector where due to the intensification of the production process, extra labour units are required. The high cost of annual labour during the last decade has created a pressure for it to be replaced by form of capital (mainly in the calf reating sector). Thus, the price of labour has not been included as an explanatory variable for the estimation of supply response for animal products.

Another important factor which influences the quantity of a product coming into the market and producers decisions, is the existence of competitive products. Economic theory prescribes competitive products, among other things, as products competing for common factors of production. In the case of Greek meat production the competing products are mainly pig meat, poultry meat, goat meat, sheep meat and beef. However, these products cannot be considered as substitutes in production because they are produced by different production systems. All the price variables mentioned above are expressed in real terms, with the consumer price index playing the role of the deflator (CPI). A crucial factor in the supply analysis is the total number of animals slaughtered in the previous periods. The hypothesis is that producers reach their economic decisions taking into consideration the number of animals they slaughtered the previous periods and it is based on the idea of 'naive' expectations. It is important to point out here that the linear time trend was added to some regression equations (in which yield was the dependent variable) in order to capture the effects of technical progress.

In order to analyse policies systematically, there is a need for a way to state the terms of a policy so that it can be interpreted in a supply model. The statement typically reduces a policy to a single variable, a "policy instrument". The policy instrument is a variable that can be incorporated in a supply model, and policy alternatives consist of different values being set for this variable (Gardner 1987). More fundamental alternatives consist of the introduction of a new instrument or combination of instruments. Although choice of types of policy are the predominant topic of long-run debate, the crux of political debate on farm policy often turns on the level of a policy instrument. Incorporation of the operational procedures of a policy instrument into a supply model can be tricky. It is often harder to assess the likely consequences of such a procedural change than of a change in the price support level. Other complications arise when policy instruments are interrelated. The formal basis for supply analysis begins with a model that in its simplest version states that the quantity produced of a commodity increases as its price increases, and that this relationship can be specified as a supply function,

$$Q_s = S(P_s),\ S' > 0 \tag{17}$$

where S' is the derivative of the supply function S, Q_s is quantity produced, and P_s is supply price, that is, the price received by producers for each unit of output. The function S, as well as the behavioral functions to follow, is assumed continuously differentiable over positive values of P and Q. It measures the marginal social cost of producing Q. In economic terms, it is the opportunity cost of the quantity Q; it reveals what price must be paid to attract the necessary resources to produce Q instead of the best alternative uses available for the resources at the margin. The supply model is a partial equilibrium model, partial because all prices other than the commodity's own price, and all nonprice variables other than the quantity are omitted. Many agricultural policies (CAP) regulate subsidy payments, tariffs, acreage, and other related variables. For purposes of policy analysis, these policy instruments need to be included in the supply model. Consider a policy of paying producers a subsidy of V per unit produced. The producer now receives not the market price only, but the market price plus V. The equilibrium price received by producers, including the subsidy, is now different from the equilibrium price paid by consumers, while the equilibrium is characterized by $Q_s = Qd$. This is one reason why policy analysis is more straightforward when expressed in terms of price-dependent supply and demand.

$$P = S^{-1}(Q) - V \tag{18}$$

where S^{-1} is the inverse of the function S, obtained by solving Eq. (17) P. It is assumed that S generally is function for which inverse exists, and that the function is such that equilibrium exists at positive P and Q for positive values of V. For simplicity of notation the -1 notation will be dropped, and inverse supply function will be written as S(Q), the Q being written as a reminder of what is on the right-hand sides. It is important to see that the left-hand side of Eq. (18) is not P_s but P_s - V. It is important also to investigate what happens to P and Q as V changes, beginning at market equilibrium, where P = Pd = P_s and Q = Q_s = Qd and writing out the differentials of Eq. (18):

$$dP = S\,(Q)\,dQ - dV \tag{19}$$

using the definitions of elasticity of supply ε, it can be written,

$$S'\,(Q) = \frac{1}{e}\,\frac{P}{Q} \tag{20}$$

substituting these expression in Eq. (19),

$$\frac{1}{e}\,\frac{P}{Q}\,dQ - dV = \frac{1}{h}\,\frac{P}{Q}\,dQ \tag{21}$$

dividing by dV and solving for dQ/dV,

$$\left[\frac{1}{e} - \frac{1}{h}\right]\frac{P}{Q}\,\frac{dQ}{dV} = 1$$

$$\frac{dQ/Q}{dV/P} = \frac{1}{1/e - 1/h} \tag{22}$$

where dQ/Q is the percentage change in Q and dV/P is the change in the subsidy as a percentage of price.

Equation (22) is typical comparative-statics results in policy analysis. It tell us how equilibrium price and quantity change when the policy control variable V changes. In particular, Eq. (22) shows how the result of a subsidy paid to producers depends on the relative size of supply and demand elasticities. Equation (22) constitutes a subsidy simulation model proposed by Gardner (1987). Suppose that there was a proposed policy of paying sheep and goat meat producers 20 ECUs per kg of meat they sold. It is possible to build an econometric model of industry incorporating past subsidies and then use the regression coefficients to derive a price effect of a 20-ECU subsidy. The government (through

CAP) acquires commodities at market prices, perhaps but not necessarily through price support programs, and resells them at lower prices. In some cases the commodities are given away. A cash subsidy paid to consumers of the same size, V, that has already been analyzed when paid to producers, is modelled by adding V to Eq. (18). A subsidy of given size has exactly the same effects on output, producer price, and consumer price whether the subsidy is paid to producers or consumers. This is an elementary point, but it seems elusive in policy discussions, where it is sometimes presumed that a consumer subsidy is not beneficial to producers in the way that a producer subsidy is (Gardner, 1987).

It is important to point out at this stage that a number of policy instrument adopted by CAP present a number of problems if we attempt to treat them as a price effect. An important policy instrument, that works in this direction (used extensively in CAP mechanisms) is production control (Burrell, 1992). The concept of supply management is not new; it is over 30 years since the Cohrane proposal on supply control and nearly 60 years since supply control policies were adopted in the USA. Two types od supply control are identified by Cohrane: first, restriction of one important factor of production, typically land, and second, control of output by marketing quotas (Dawson, 1991). There are many ways of dealing with production control in the modelling procedure (Herrmann, 1989). One way is to assume that Q = Q , so that the output level will be given by the quota level (Gardner, 1987, Mainland and Dryburgh, 1994). The problem associated with this approach is that it cannot incorporate changes in the output level when the price of the output declimes dramatically. Another way of dealing with production control schemes is to solve the maximization problem (maximize output) with the restriction that Q can not exceed the quota level (Jensen, 1993). This approach can be easily incorporated in cases of ad hoc specification of the supply function, where the dependent variable (Q) can change when the exogenous variables changes but can not surpass the predetermined quota level.

Combinming all the information presented above it is possible to present the general forms of the models that were used in order to get estimates for the supply elasticities for the meat producing sector:

$$H_t = f(\ln P_{t-n}, \ln Pin_{t-n}, \ln H_{t-n}, D_1, D_2, \ldots, D_n) \quad (23)$$

where H_i represents the number of animals (herd), P_i stands for the price of output, P_{in} for the price of inputs and $D_1 \ldots D_n$ are the dummy variable and,

$$Y_t = f(\ln P_{t-n}, \ln Pin_{t-n}, \ln Y_{t-n}, t, D_1, D_2, \ldots, D_n) \quad (24)$$

where Yi is the yield and T is the time trend.

The length of the data set for the estimation of the supply functions for the Greek meat producing sector is 24 observations (1970-1993) and was provided by the Ministry of Agriculture, by the N.S.S.G. (National Statistical Service of Greece), by the Agricultural Bank of Greece, by the Centre of Planning and Economic Research (mainly for the estimation of capital stock) and by the Bank of Greece.

5. Estimation and Evaluation of the Model

With the theoretical foundations of the model developed and specified in the previous sections, unbiased estimation of the parameters of the model will be sought through econometric methods. Table 1 show analytically the short-run and long-run own price elasticities that resulted from the 'partial adjustment' and the 'adaptive expectations'.

The estimated results have closely followed the pattern predicted by theory (Table A, appendix) and by the technical and institutional prior knowledge concerning meat production in Greece. It is important, also, to point out the high t-statistics obtained and the correct signs of the parameters (according to a *priori* expectations). The Durbin-Watson statistic indicates no autocorrelation, the problem associated with it is that it is biased in cases where a lagged dependent variable appears as an explanatory variable. Durbin has indicated another statistic which is appropriate in these cases but it is applicable when the number of observations is greater than 30 (in this case we only had 24 observations). To ensure that the variables of interest are cointegrated it is important to establish first that they have the same basic statistical properties. In particular, they must be integrated of the same order (Table 2). To test the order of integration, we have used the Dickey-Fuller test and the Augmented Dickey-Fuller test. The results of the D.F. and A.D.F. tests (Table 2) for the meat products of Greece proved that all of the series used in the models are 1(1).

In order to answer the original question concerning whether there is a long-run relationship between the nonstationary variables, it is important to examine whether the deviations from the long-run path are stationary. If this is the case, the variables are said to be cointegrated. Following Johansen Maximum Likelihood procedure, the null hypothesis is rejected and the disequilibrium errors are stationary (Table 3). It follows from this that the variables are cointegrated and therefore, a long-run equilibrium relationship between the variables of interest exists.

Overall, the estimated elasticities (Tables 1) are consistent with *a priori* expectations and are superior to previous estimates by other researchers first because they are correctly estimated (cointegration tests have established the existence of long-run relationships), and second because they represent the only complete set of meat supply elasticities available for Greece.

6. Summary and Conclusions

This paper explores the application of cointegration analysis in agricultural supply response and the correct estimation of supply elasticities. Cointegration theory has a relatively recent history. It can be regarded as the empirical manifestation of a long-run relationship between variables and provides a statistical framework which identifies and hence avoids the spurious regressions so easily specified and accepted with series which exhibit strong trend, resulting in misleading conclusions. Cointegration analysis also, offers a set of easily implementable techniques for evaluating the specification of econometric models. The principal objective of this paper was the analysis of some aspects of meat production in Greece in order to reveal the special characteristics of the sector and its importance for the country as a whole, through: i) policy analysis, ii) econometric modelling, and iii) cointegration analysis.

In order to estimate the supply elasticities, the econometric method was used and more precisely the 'partial adjustment' and the 'adaptive expectations' models. Through the entire analysis the econometric models gave statistically precise and important results. As far as the price elasticity (output, imput) of supply is concerned the following can be said: a) The estimates of the short-run elasticity can be considered as quite reasonable from the economic and technical view, b) the long-run elasticity estimates were as expected (due to prior knowledge).

In addition, the analysis presented in this paper suggests that modelling livestock population dynamics (if the data set permits) provides considerable insights in the economic adjustments taking place on farms. The results showed that it is important to control continuously the subsidies of any kind concerning the planning of the agricultural policy in the livestock sector, given that subsidies do not affect positively the decisions of the producers as to whether they should increase or decrease their final output. The results also project the differentiation in the reaction of meat producers of all sub-sectors to input and output price variations. More precisely:

The goat meat producers react passively to price changes, this is based on the non-existence of any kind of management of their farms. A similar reaction on the part of poultry meat producers is based on the use of annual data in the present survey while the total annual rearing reach the number of 4-5. The rather intense reaction of the pig and beef meat producers to the price changes is due to their entrepreneurs attitude towards their farms. Moreover, the results of the cointegration analysis showed that there is a long-run relationship among the variables that have been used in the supply models, a fact that ensures the credibility of the estimated long-run elasticities thus reinforcing the above results given by the econometric models. As a concluding remark, it is important to point out that cointegration analysis should be a routine part in modelling integrated variables where long-run relationships should be present.

TABLE 1

Own Price Elasticities*

PRODUCTS		Short-Run	Long-Run
Beef:	Herd	0.18	0.51
	Yield	0.10	0.16
Pig Meat:	Herd	0.15	0.65
	Yield	0.10	0.17
Poultry:	Herd	0.15	0.30
	Yield	0.10	0.15
Sheep Meat:	Herd	0.04	0.08
	Yield	0.03	0.06
Goat Meat:	Herd	0.03	0.06
	Yield:	0.03	0.05

* Note: The functional forms used for the estimation of the elasticities are given in Table A in the Appendix.

TABLE 2

Unit Root Tests

VARIABLES	D. F.	A. D. F.
DNBF	-4.94	-3.50 (1)
DYBF	-3.90	-4.17 (1)
DNPM	-3.80	-4.52 (1)
DYPM	-3.73	-4.11 (1)
DNSMT	-4.13	-3.93 (1)
DYSMT	-5.44	-3.75 (1)
DNGMT	-3.68	-4.96 (1)
DYGMT	-3.78	-4.93 (1)
DNCH	-3.85	-4.53 (1)
DYCH	-3.84	-3.77 (1)
DPB	-5.30	-3.79 (1)
DPMZ	-5.49	-4.01 (1)
DPBF	-4.24	-4.22 (1)
DPSMT	-4.23	-3.65 (1)
DPGMT	-4.70	-3.60 (1)
DPCH	-4.85	-3.93 (1)
DPCP	-4.30	-4.90 (1)

* Notes: a. The variables are in first differences)letter D indicates the first differences), b. The numbers in brackets indicate the number of lags in ADF, c. Critical values for DF and ADF (with for the variables in differences: -3.6454, -3.6592.

TABLE 3

Cointegration Results

PRODUCTS		LR Test Based on Trace of the Stochatic	LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
Beef:	Herd	44.8207	25.0705
	Yield	41.1413	22.6379
Pig Meat:	Herd	42.6861	24.5000
	Yield	46.3445	28.3550
Poultry:	Herd	49.3863	34.1413
	Yield	30.0816	21.0345
Sheep Meat:	Herd	30.9290	21.5540
	Yield	30.4500	22.3456
Goat Meat:	Herd	36.5561	23.5540
	Yield	36.2515	25.5545

* Note: a) The maximum lag in the VAR= 1, b) All the cointegration results proved r = 1, c) The critical values (95%) for the Trace of the Stochastic Matrix and for the Maximal Eigenvalue of the Stochastic Matrix respectively are: i) 34.9100 and 22.0020 for Pig Meat, Poultry (herd) and Goat Meat, ii) 31.5250 and 17.9530 for Beef (yield) III) 29.6800 and 20.9670 for Beef (herd), Poultry (yield) and Sheep meat.

Appendix

TABLE A.

Estimated Equation for Livestock Products

	Equation	R^2	F-Statistic	D.W.
Beef:	$\ln NBF = 3.17+0.18\ln PBF_{t-1}-0.14\ln PMZ+ 0.12D81+ 0.65\ln NBF_{t-1}$	0.99	375.04	2.10
	(4.98) (3.45) (-5.25) (2.45) (5.95)			
	$\ln YBF= 0.8+0.10\ln PBF_{t-1}-0.10\ln PMZ_{t-1}-0.11D81-0.15D90+0.38\ln YBF_{t-1}$	0.97	64.4	1.97
	(5.22) (4.25) (-5.00) (-3.25) (-2.90) (4.25)			
Pig Meat:	$\ln NPM=0.38+0.15\ln PPM-010\ln PB-0.03\ln PCP-0.05D81-0.08D90+0.77\ln NPM_{t-1}$	0.99	305.52	2.01
	(5.25) (3.25) (-2.95) (-3.05) (-2.05) (-1.95) (4.25)			
	$\ln YPM=0.14+\text{—}.10\ln PPM-0.08\ln PB-0.03\ln PCO_{t-1}-0.02D81-0.01D90+0.42\ln YPM_{t-1}$	0.99	262.75	2.06
	(3.25) (3.00) (-2.10) (-3.35) (-2.25) (-1.95) (4.25)			
Sheep Meat:	$\ln NSMT=0.1+0.04PSMT_{t-1}-0.03PMZ-0.1D81+0.5\ln NSMT_{t-1}$	0.99	209.90	2.10
	(5.25) (3.20) (-1.95) (-1.75) (-1.65) (4.25)			
	$\ln YSMT=0.05+0.03PSMT-0.03PMZ-0.05D81-0.03D90+0.5\ln YSMT_{t-1}$	0.99	468.23	2.00
	(5.25) (3.20) (-1.95) (-1.75) (-1.65) (4.25)			
Goat Meat:	$\ln NGMT=0.1+0.03PGMT_{t-1}-0.03PMZ_{t-1}-0.01D90+0.5\ln NGMT_{t-1}$	0.98	230.10	2.04
	(3.95) (2.90) (-3.05) (-2.00) (4.75)			
	$\ln YGMT=0.05+0.03PGMT_{t-1}-0.03PMZ_{t-1}-0.02D81-0.03D90$	0.98	345.45	2.03
	(5.25) (3.20) (-2.90) (-1.90) (-1.75)			
Poultry:	$\ln NCH=0.87+0.15\ln PCH-0.18\ln PMZ_{t-1}-0.13D90+0.5\ln NCH_{t-1}$	0.96	245.55	1.87
	(6.25) (3.50) (-2.90) (-1.95) (4.75)			
	$\ln YCH=0.75+0.1\ln PCH-0.1\ln PMZ_{t-1}-0.09D90+0.34\ln YCH_{t-1}$	0.94	238.20	1.92
	(6.25) (2.15) (-1.95) (-2.00) (3.75)			

Note: a) Letter N indicates number of animals, letter P the price and Y indicates yield and b) the numbers in the brackets present the t-tests.

The variable are defined as: BA:barley, MZ:maize, BF: beef, PM: pig meat, SMT: sheep meat, GMT: goat meat, CH: poultry, CP: capital, D81: dummy variable for 1981 (accession of Greece in the EEC), D90: dummy variable for 1990 (liberalisation of the cereal market).

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