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A partial adjustment model with rational expectations applied to the goat sector in Greece

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Abstract

In this paper an attempt is made to examine the rational expectations hypothesis for the goat-meat sector in Greece within the framework of a single equation method that describes the factors affecting demand and supply. The structural equations of the model are estimated by applying the Cochrane–Orcutt technique. The calculated elasticities suggest that Greek goat producers should pay more attention to milk rather than meat production. Statistical indications also confirm the effects of the Chernobyl accident upon the goat sector. Moreover, the forecasting ability of the model has been tested using simulation procedures, which indicate a small deviation between theoretical and observed values. Finally, some further implications concerning the goat sector are drawn from this analysis.

1. Introduction

The purpose of this paper is to analyse and quantify the basic factors that affect the demand for and supply of goat-sector products in Greece. This empirical research aims on the one hand to provide the necessary information for the formation of an effective policy in this area and on the other to form models for the prediction of the volume of output and animal capital.

The goat sector constitutes the most important area of stock breeding in Greece, being oriented towards the production of meat and milk and representing an important share of the total gross value of livestock production (for 1989, within the total gross value of meat and milk production, goat meat accounted for 8% and goat milk for 7.6%—Ministry of Agriculture, 1991a). An important advantage of the goat sector is that it is highly dependent on animal feeding from grazing.

The annual consumption of goat meat in Greece is approximately 50 000 tons, of which 96% is produced domestically. However, the share of goat meat in total meat consumption fell from 15% in 1960 to 5% in 1989, due to health considerations. Between 1970 and 1987, the annual per capita consumption of mutton (goat) decreased from 1.41 kg to 0.8 kg, while kid meat consumption increased from 2.36 kg to 3.15 kg. Due to the fact that kid meat of average slaughter weight of

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Table 1
Percent consumption of different kinds of meat

Kind of meat	1979	1984	1988	1989
Beef	52.6	57.9	59.2	58.6
Lamb/kid	23.5	18.6	13.4	12.8
Pork	11.6	10.7	10.0	9.9
Poultry	6.7	7.8	11.1	12.0

Source: Ministry of Agriculture, 1991b.

7–9 kg dominates the market (70–80% of the overall goat market), this analysis focuses on the supply and demand for kid meat.

A consumer market research for the whole country carried out in 1989 (Ministry of Agriculture, 1991b), showed a reduction of nearly 50% in the consumption of lamb/kid meat over the last 10 years, and a shift towards chicken and beef (Table 1). Greek consumers generally prefer to consume other kinds of meat on a regular basis, while lamb or kid meat is used on special days like Easter (about 20% of total production is consumed on Easter Day) even if its price is very high. Moreover the sheep/goat sector shows high level (20%) of self-consumption. Kid and lamb are almost equally popular, but Greek consumers prefer kid meat slightly over lamb meat, as it has less fat. This slight preference is reflected by a price differential (Fotopoulos and Patsis, 1994).

On the other hand, the goat milk market has developed much more favourably. The dominant position of feta cheese in the dairy products market has helped to maintain the demand for goat milk at high levels. This is also proved by the higher increase in milk prices compared with meat prices (it quadrupled between 1970 and 1988, while the corresponding price of goat meat increased 3.3 times). However, the importance of the goat-milk market is also justified by the significant increase in the average productivity in goat milk production that has been observed from 1970 and onwards (Fotopoulos and Patsis, 1994).

Within the 1970–1987 period two alternative policies have been implemented in the goat sector. Before 1980, under the national policy, goat producers enjoyed input subsidies together with high market prices, achieved through the banning of fresh kid imports. After 1980, the following assistance was provided to the goat sector under the CAP: (1) an annual goat premium for the loss of income by goat producers; (2) a compensatory allowance for the conservation of adult goats in the hill and upland areas; (3) structural payments; (4) implementation of an intervention mechanism for the support of prices—however, this mechanism does not work properly in Greece as the level of prices in the domestic market is much higher than that of the other Community member states.

The CAP subsidies are greater than those provided by the national policy and are mostly given directly to the producers.

Nerlove's (1979) model, as provided by Askari and Cummings (1976), still remains a useful analytical tool for investigating farmers' supply behaviour, not only because its underlying assumptions allow a straightforward application of the model but also because such a model appears to function well in a number of empirical studies.

Criticism of Nerlove's (1979) model has focused mainly on its inadequate theoretical basis and on the statistical estimation problems arising when the ordinary least squares method is used (e.g. Johnson, G., 1960; Griliches, 1967; Johnston, J., 1972; Doran and Griffiths, 1978; Maud, 1979; Baltas, 1987). The criticism also refers to the underpinning adjustment and expectations mechanism which are expressed in terms of a geometric lag of past observations on output or prices. However the use of a declining geometric lag model introduces measurement errors resulting in a high correlation between the expectational variable and the disturbance term. Given this criticism, an attempt is made here to eliminate the theoretical weakness using a rational expectations model. Nevertheless, studies in this area are limited in the agricultural economics literature. (e.g. Eckstein, 1984; Zanias, 1987; Baltas and Apostolou, 1988).

This paper has five sections. In the next section, a rational expectations model for the goat sector is described. In Section 3, the sources of the data as well as some general characteristics of the estimation method are given. The estimates of the model and empirical results are then presented in Section 4. In the last section, the results are summarised and some policy implications are also drawn.

2. Rational expectations model

In order to study the decision of goat farmers in allocating their limited resources to produce various products and their risk-taking entrepreneurship in an uncertain environment of future prices, we can employ a simplified model of rational expectations, which consists of two behavioural equations and an identity. We assume that farmers are rational in the sense that they respond to the various signals given by the economic environment and formulate their own expectations about the price of their products taking into account the role of their adjustment costs, technical progress, and so forth.The demand equation is given by:

$$q_t^d = \alpha_0 + \alpha_1 p_t + \alpha_2 y_t + u_t \quad (1)$$

with $\alpha_1 < 0$ and $\alpha_2 > 0$, while the supply equation is given by:

$$q_t^s = \beta_0 + \beta_1 p_t^* + \beta_2 W_t + \beta_3 T_t + v_t \quad (2)$$

with $\beta_1 > 0$, $\beta_2 > 0$ and $\beta_3 > 0$, where p_t is product price, y_t is income, $p_t^* = E(p_t/I_{t-1}$ is the farmers' current expectation about the product price (E is the mathematical coefficient of expectation, and I denotes the information set upon which expectation depends), W_t is weather conditions, T_t is technical progress, and u_t, v_t are random disturbances with zero mean and diagonal variance–covariance matrix

$$\begin{bmatrix} \mathbf{u_t} \\ \mathbf{v_t} \end{bmatrix} \sim \mathbf{N}\left[\begin{bmatrix} \mathbf{0} \\ \mathbf{0} \end{bmatrix}, \begin{bmatrix} \sigma^2\mathbf{u} & \mathbf{0} \\ \mathbf{0} & \sigma^2\mathbf{v} \end{bmatrix}\right] \quad (3)$$

The model is completed by introducing the assumption that in each period the quantity demanded, q^{d}, is equal to the quantity supplied, q^{s}:

$$q_t^{\mathrm{d}} = q_t^{\mathrm{s}} = q_t \quad (4)$$

After some algebraic manipulation we can take the reduced-form equations which show that output and prices depend on unanticipated income, unanticipated weather conditions and unanticipated technical progress (all exogenous variables).

There are several methods by which the unobservable exogenous variables can be determined. According to the rational expectations model, the initial structural form of the function remains apparently the same, but the expected value is defined by a suitable ARIMA model (e.g. with ARIMA of (0, 2, 1) + (0, 0, 1) for meat and milk prices, respectively).

The specification of the meat supply model was carried out by using all possible combinations of meat and milk prices, but without giving statistically significant results. In contrast, weighting prices by time (T_t) gives satisfactory results. This can be expected by the fact that the time trend (T_t) is traditionally used in supply models as a separate cumulative factor, either for explaining technological progress or for expressing the influence of time. In the meat model used above, time (T_t) is not introduced as an additive term but as a multiplicative one with meat and milk prices.

The weather variable (W_t) has been tested, as temperature and rainfall in critical months influence the availability of free grazing; however, no influence on supply was revealed. Furthermore, before the final specification with prices being the basic explanatory variables, additional variables were tested unsuccessfully (production cost, dummy variable of Easter Day, consumer preferences change, and so forth). Also the explanatory variables tested—but with no apparent effect on the supply of kid meat—included the prices of possible competitive sectors such as the sheep and beef sectors. Results showed that the variable that expresses the prices of the supposedly competitive sectors, is statistically unimportant. This is due to the fact that sheep and goats, which are found more often in the mountainous and semi-mountainous areas, can be nurtured under the same ecological conditions, but no competition is experienced since goats feed mainly on bushes, while sheep feed on short grass, and beef sector is concentrated in the plains.

Based on the above, the final specification of the supply model is as follows:

$$q_t^{\mathrm{s}} = \beta_0 + \beta_1 T_t p_t^* + \beta_2 T_t p_{mt}^* + \beta_3 q_{t-1} + e_t \quad (5)$$

Table 2a
Supply functions of kid-meat (Cochrane–Orcutt estimates)

Variable	Coefficient	t-value	Variable	Coefficient	t-value
Supply q_t^s			Animal capital [a] N_t		
Constant	8379	3.71	Constant	1868762	1.97
$T_t p_t^*$	−5.05	4.62	p_t^*	3985.6	1.20
$T_t p_{mt}^*$	7.32	5.56	N_{t-1}	0.52	2.22
q_{t-1}	0.68	7.17	DC	389986.42	2.55
R^2	0.89		R^2	0.89	
DW	2.08		DW	1.95	
ρ_1	−0.48		ρ_1	−0.14	

where the expected prices of kid meat (p_t^*) and goat milk (p_{mt}^*) are weighted by time T_t ($t = 1,\ldots,18$).

Next, a calculation of the theoretical values of the equations is initially carried out for each of the years for which available information and observations exist. Next, a comparison between the evaluated and real values takes place using the mean simulation error. The root mean-square simulation error (RMSE) is calculated by:

$$\text{RMSE} = \sqrt[2]{\frac{1}{T}\sum_{t=1}^{t}\left(q_t^s - q_t^a\right)^2} \qquad (6)$$

where q^s is the real value of q_t, q^a is the forecasted value of q_t and T is the number of forecasted years (Batzios, 1986).

Table 2b
Demand function of kid-meat (Cochrane–Orcutt estimates)

Variable	Coefficient	t-value
Demand q_t^d		
Constant	277175.3	3.63
p_t^c	−116.66	5.20
Y_t	+13776.53	0.62
A_t	−3229.96	3.45
T_t	+6679.52	3.80
R^2	0.98	
DW	2.32	
ρ_1	−0.38	

Dependent variables: N_t, animal capital (number of goat heads); q_t^s, kid meat supply; q_t^d, consumption per capita of kid meat.
Independent variables: $T_t p_t^*$, farmers' expected kid meat price ARIMA (0, 2, 1) weighted by time; $T_t p_{mt}^*$, farmers' expected goat milk price ARIMA (0, 0, 1) weighted by time; p_t^*, farmers' expected price of kid meat ARIMA (0, 2, 1); p_t^c, consumer price of kid meat; q_{t-1}, kid-meat supply of previous year; N_{t-1}, number of existing goats in previous year; DC, Chernobyl nuclear accident dummy-variable (zero value before 1985; unity after 1986); Y_t, per capita available income; A_t, change in urban population (degree of change index of urbanisation); T, time trend (effect).
[a] Function of animal capital is completely to supply function. It is included in our calculation because it exhibits the effects of the Chernobyl accident.

3. Data and estimation procedures

The behavioural equations of the model have been estimated using annual data for the period 1970–1987 obtained from the Greek National Statistical Service and the Ministry of Agriculture. The price index (farmer and consumer prices) was deflated by the consumer price index (1982 = 100).

The complexity of the structure of the error term makes it almost impossible to ensure that there is no serial correlation, though most likely the opposite is true. Moreover, the presence of lagged-dependent variables make the Durbin–Watson statistic inappropriate. Also, the estimates of the parameters are biased and generally inconsistent, since lagged-dependent variables are included in the model. Taking all the above into consideration, we assume there is serial correlation of the error term of first and second order. Then we try to remove autocorrelation using the Cochrane–Orcutt iterative technique, through SPSS. The estimated demand and supply function

Table 3
Elasticities and other parameters

	Adjustment coefficient (λ)	Adjusted years (90% full)	Elasticities			
			Price of meat (short/long-run)		Price of milk (short/long-run)	
(1) Supply	0.32	6	−0.20	−0.60	0.24	0.76
(2) Animal capital	0.48	4	0.07	0.15	–	
(3) Demand	–	–	−0.34 [a]			

[a] Mean elasticity of demand.

parameters for kid meat are presented in Tables 2 and 3 which were derived after repeated economic and statistical confidence tests for theoretical consistency.

The model predictive ability can be checked by forecasting 3 years (1988–1990) beyond the examined period 1970–1987. The observations for the period 1988–1990 were published after the model had already been estimated. Table 4 presents the relative deviations for these 3 years. The low value of the RMSE constitutes a criterion for evaluation of the model's forecasting ability.

4. Empirical results

Firstly the estimated supply function has a high explanatory power (Table 2; $R^2 = 0.89$). Although this does not necessarily imply that all suitable variables have been included in the model, it is nevertheless a useful feature especially for forecasting purposes.

The expected producer's kid meat price, $T_t p_t^*$, is an essential explanatory variable of the supply function from a statistical point of view ($t = -5.05$). The short-term elasticity of the produced quantity with respect to producer's price was found to be −0.20, while the long-term one was −0.60. The difference in the evaluated elasticities is a consequence of the long time period required for the adjustment of production to the desirable level. The limited short-term response capabilities of the producer, where the coefficients of the production process are relatively constant, make supply price inelastic, thus lowering in the short-term the importance of prices as a factor in the determination of meat supply. On the other hand, in the long-term conditions are differentiated and the producer's behaviour is greatly affected by the level of expected prices.

Table 4
Relative deviations

Year	Kid meat supply (q_t^s) [a]	Animal capital Number of goats (N_t) [b]	Consumption of kid meat (q_t^d) [c]
1988	0.0171	0.0028	0.063
1989	0.0247	0.0028	0.124
1990	0.0462	0.0011	0.125

[a] RMSE = 1259.
[b] RMSE = 12389.
[c] RMSE = 4289.

The negative sign of the producers' expected kid meat price indicates that its importance is gradually decreasing (note that prices are weighted by time). This trend is estimated to be the result of subsidy policies per animal capita in the years following Greece's entry into the EU. The producers supplement their income with the amount received from these subsidies and thus place less importance on the expected price of kid meat, since they supplement their income outside the price mechanism. Moreover, its negative sign is explained together with the relation between meat and milk prices which can either affect the use of more or less milk to kids' feeding, or the production of new animal breeding for the increase or decrease of the flock.

The producer's expected goat milk price, $T_t p_{mt}^*$ is a significant explanatory variable of kid-meat supply from an economic (positive sign) and a statistical point of view. The high significance of this variable ($t = 5.56$) denotes that the importance of milk price is essential and gradually increasing. The opposite signs of meat and milk prices clearly indicate a short-term competition between meat and milk prices, while in the long-term (the long-run elasticity is 0.76) the price of milk is expected to reduce the slaughter level by keeping more animals for milk production. Due to the completion of income from milk and meat and to the mixed character of the goat sector, producers respond to the high price of milk and increase the volume of their flock, leading to an increase in total milk and meat production.

The high statistical significance ($t = 7.17$) of kid meat supply of the previous year q_{t-1} must be stressed too, because of its effect on the producer's long-term decision-making with regard to the volume of meat production. The significance of this variable also denotes that the adjustment is not instantaneous. The speed of this adjustment is determined by the adjustment coefficient of Table 3, where $\lambda = 0.32$ clearly shows that supply is adjusted to the desired level in 6 years. This is confirmed by the function of animal capital, where the corresponding variable of the number of existing goats in the previous year, N_{t-1}, is statistically significant ($t = 2.22$) with an adjustment period of 4 years ($\lambda = 0.48$). The required time period of production adjustment (4–6 years) under the effect of the given change of price does not differ from the one Pavlopoulos (1967) found when examining the period 1951–1963. This proves that the technical conditions of production —as well as the acquired habit of applying a production system—have an important effect upon production, while price behaviour does not.

Secondly, the explanatory power of the linear (quasi-rational expectations) model of Animal Capital is relatively high ($R^2 = 0.89$) while all of the explanatory variables, except the expected price, are statistically significant. The advantages of this model are its forecasting ability which is very satisfactory (Table 4, RMSE = 12, 389 heads) and the fact that it captures the effect of the Chernobyl accident on the Greek goat sector, through the dummy variable *DC*. The radiation leak in 1986 from the Nuclear Electricity Plant in Chernobyl has afflicted both Greek and European agriculture. The goat sector was especially afflicted because goat feeding depends almost exclusively upon grazing. The product demand of this sector has thus dramatically decreased due to its possible contamination by radiation. The reduced demand forced producers to reserve kids further as breeding animals, resulting in an increase in animal capital (in 1986 there was an increase in animal capital of 364 000 heads). This fact had essential effects upon the usual production procedure which remained unchanged for some years. As stated earlier the period of adjustment of production to the desirable level requires 4–6 years (Table 3). This means that the consequences of the entry of Greece into the EU on the goat sector would be statistically proved by data after 1986. The lack of statistical data and the Chernobyl accident are the reasons why the introduction of a dummy variable reflecting the effects of Greece's entry into the Community, in this sector, was unsuccessful. However, the Chernobyl dummy variable *DC* both from an economic (a positive sign) and from a statistical point of view ($t = 2.55$) confirms the consequences of the Chernobyl accident upon the goat sector.

Finally the explanatory power of the estimated demand function is high ($R^2 = 0.98$) while all of the explanatory variables are statistically significant, except income. The retail price of kid meat has the correct negative sign and appears to be highly significant ($t = 5.20$). The low price elasticity for kid meat is justified both by the high percentage of self-consumption observed in agrarian households where the quantity consumed is therefore unaffected by the level of retail price and also by the consumption of a considerable quantity (approx. 20%) on Easter Day which again restricts the role of price.

The above are also confirmed by the statistical significance ($t = 3.45$) of the urbanisation change variable. The available income variable, Y_t, while it has a correct sign, is statistically insignificant ($t = 0.62$). The retail prices of competitive meat products did not prove to be that significant as explanatory variables, confirming the differentiation of kid meat with respect to other meat products. Thus, the more the consumer is informed about health matters, the more he/she avoids consuming kid meat, except for the already mentioned traditional occasions (Easter Day) together with some special occasions (e.g. taverns). The results of this demand research are in accordance with the results of the recent consumer survey on meat, carried out by the Ministry of Agriculture (1991b) which portrayed a poor image of kid-meat in comparison with other kinds of meat.

The estimated elasticities are in accordance with those found by other researchers such as Pavlopoulos (1967), Papaioannou and Jones (1971), while presenting small differences from Jones and Alexopoulos (1986) and Fotopoulos (1988, 1989, 1991). These differences are due to different approaches, time series and variables. Nevertheless, these differences cannot alter the general conclusions drawn for the goat sector.

With respect to simulation, the estimated supply model (Table 4) showed that the deviations between theoretical and observed values are small, while the mean-square errors fluctuate within acceptable levels. The adaptability of the animal capital model (N_t) in the simulation appears much better than the supply production model. The adaptability of the demand model is also satisfactory.

5. Conclusions and recommendations

The results of the statistical analysis of the supply and demand functions for kid meat are satisfactory, both concerning the explanatory capability and the statistical significance of prices, as well as some factors which determine the decision-making of producers and consumers. From the empirical analysis, we can claim the following: (a) the peculiarity of the Greek kid meat and goat milk market (small slaughter weight, the Easter custom, self-consumption, intense demand for goat milk which is transformed into cheese) and the resulting isolation of the domestic market from international trade, apparently created a stable evolutionary pattern of prices that producers trust and base their response upon; (b) the importance of the expected price for kid meat gradually decreases, since producers supplement their income with subsidies outside the price mechanism. The apparent time pattern of disconnection of the producer's behaviour from the kid meat price, can be regarded as a result of the EU structural policy, mainly reflecting the corresponding increase in the significance of milk price. The relatively greater increase in the price of milk as compared with meat, which is observed during this period, in conjunction with a long-term upward trend in milk productivity, is expected to turn the producer's interest to milk production; (c) as mentioned previously, the EU price intervention and support mechanism for kid meat was not applied in Greece, and consequently, any changes in the goat sector would result from the EU structural policy. The application of the above policy did not succeed in improving the production structure, as would have been expected, but contributed to the direct improvement of the producers' income and to the animal capital increase. It is obvious, however, that these achievements are expected more from a price policy than from a structural one. Greek goat producers used the subsidies to supplement their income, instead of investing in productivity improvements.

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