DISTRIBUTED LAGS IN GREEK BEEF PRODUCTION

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abstract

Greece enters the EEC as its tenth member. Greece' s future prospects for beef production seem to be good.
Greek consumers will still continue to increase their consumption of beef since the domestic (Greek) consumption level of beef (and veal) was 16.9 kg per year, as by 1972, while that of the EEC-9 was 24.3 kg per year in the same year. But EEC is still in deficit as far as beef production is concerned. Hence, Greek policy following EEC's CAP should have to look at the supply response of her own national herd and have to know the resulting consequences of price changes in beef, milk and/or feed grain. Thus, from this point of view the paper gives some valuable insides to the decision-maker both in Athens and/or in Brussels.

1. Introduction

The length of time required for growth and reproduction of a cattle herd results in an inevitable lag in the response to changes in incentives or, generally speaking, in the factors which influence cattle production. By using appropriate polynomial lags a better understanding of both the biological production path and the economic environment of the feed-grain-catlle economy can be obtained. This kind of analysis is of great value to the decision-makers since any policy measure taken should know the resulting consequences in the supply response both in short-run and in long-run time span. In the short-run time horizon, beef supply cannot easily be increased due to well known biological, psychological and institutional constraints. In a longer time span the supply response is greater and the demand for beef influences both the productive capacity of the beef industry and the relative prices of the competitive livestock products. In such a tme frame, supply responds to economic, biological and institutional changes since all these factors are considered to be variable.
The high income elasticity of demand at the retail level was found to be 5.90 over the

sample period (1951-1972) (Kalaitzis, V., 1978. p. 99) and supports the view that the prospects for beef production are good and it is expected that investment in beef production in Greece should be profitable if other things remain unchanged.

2. The Problem

The situation in the production of beef industry in Greece over the sample period examined here (1951-1972) could be described as one wherein: a) low product prices have held in the market, b) uncertainty has existed as to the future, c) there has been inadequate production planning to chronic mismatching of supply and demand for beef (the per capita consumption of red meat was 79.4 kg per year in the EEC-9 member countries and 54.0 kg in Greece) while the self-sufficient rate for beef and veal was 67.1 percent in 1972, d) there have been huge payments for imports of red meat.

Import policy changes regarding beef may affect domestic production, distribution and consumption of beef through expectations and related uncertainty. There are strong interdependencies prevailing between the beef and the other livestock products and the feed industries as well. Feed supplies, for example, are affected by unpredictable elements such as weather, which influence production decisions to adjustlivestock inventories.

By the same token, changes in an already excess demand generate shortages of beef which are met by imports of beef which, in turn, give rise to Greece's balance of payments deficit.

In what follows the paper addresses itself to the following aims: a) to estimate the supply response in beef production by utilizing the Almon's distributed lug models, b) to estimate short-run and long-run elasticities of supply c) to examine producers' behavior (response) to changes in beef feed grain price ratio and milk feed grain price ratio, and, d) to draw some policy conclusions for the decision makers.

3. Polynomial Distributed Lag Models

Several recent research efforts (Almon 1965, Griliches 1967, Dhrymes 1971, Meilke et al. 1974, Kulshreshtha 1975, Kalaitzis 1978) have used polynomial lag models to estimate distributed lag structures to evaluate supply response. Older research efforts have suggested three reasons for the existence of a distributed lag: technological reasons, psychological reasons and institutional reasons.

The distributed lag models can incorporate into them the first and the second kind of reasons while the third one is hidden within the second kind.

Estimation of a polynomial lag model requires forming a number of «weighted price variables» consisting of weighted sums of a number of lagged prices. The number of weighted price variables required and the weighting scheme are a function of the a priori specified polynomial degree and the number of periods included in the lag.

Thus, the general form of an econometric distributed lag model is written as follows.

$$Q_t = \beta_0 P_t = \beta , P_{t \cdot 1} +$$

$$\beta_2 \Pi_{t-2} + \ldots \quad + \qquad \beta_\varkappa P_{t-\varkappa} + u_t \qquad \text{(i)}$$

where Q_t: quantity supplied in the period t.

P_t, P_t-k: price per unit of supply in period t and/or in period t-k.

K: time lag of a finite value.

$\beta_0, \ldots, \beta_\varkappa$: Parameters f the supply function to be estimated.

U_t: disturbance term of the equation.

In the beef production (supply) case it is often more realistic to assume that the effect of a variable is distributed over several time periods, since beef is defined as the meat coming from the slaughtering of cattle of more than two years of age. Feeding the beef cattle in a given time period, for instance, may result in meat formation which lasts in several subsequent years. The regression equation is thus called a distributed lag model because the influence of the explanatory variable P on E (Qt) is distributed over a number of lagged values of P which are taken over the periods K. This number of periods can be either finite or infinite. The assumptions concerning the behavior of the variable P and the disturbance term U_t hold. In order to avoid explosive values of E (Qt), it is assumed that the Bs have a finite sum, i.e.,

$$\sum_{i=o}^{k} b_i < \infty$$

The averange lag is defined as the weighted averange of all the lags involved, with weights being the relative size of the respective B coefficients.

$$\text{Average lag} = \frac{\sum_{i=o}^{k} i\beta_i}{\sum_{i=o}^{k}} \qquad \text{for } i=o \text{ to } i=K.$$

Theoretically, model (1) can be estimated by the least squares method or by some other method which leads to estimates with some desirable properties under the usual assumptions about the properties of the disturbance term U_t. Almon' s distributed lag model is based on a mathematical theorem stating that, under general conditions, a curve may be approximated by a polynomial (Almon S, 1965). The Almon lag method used here does not reduce the number of observations that are lost due to the presence of lagged variables;

however, it reduces the number of parameters to be estimated. Moreover the method appears to have two advantages over any other method previously used. First, it does not violate any of the assumptions of the regression model and second, it is far more flexible than any other method in terms of the forms of admissible lag structures (Kelejan and Oates 1974, p. 151).

In practive, several difficulties are likely to arise: (a) theory does not generally indicate the length of the run, and if K is large, we may not have enough observations to estimate all the parameters, (b) but, even if we have enough degrees of freedom, the lagged values of the Ps are likely to be highly correlated from period to period, thus leading to a high degree of multicollinearity which affects the standard errors of the estimated coefficients. These difficulties have, in practice, led to the imposition of a priori restrictions on both the number of the regression parameters and the form of the reaction coefficient patterns.

The restrictions reduce the number of parameters, thus saving degrees of freedom and eliminating the need for a number of highly correlated independent variables. In a generalized polynomial lag model of the nth degree containing K periods, the weights for each lagged period f (K) are given by.

$$f(K)\ f(K) = a_0 + a1K + a2K^2 + a_3K^3 + \dots + a_nK^n \quad (2)$$

Following the approach outlined by Johnston (1972) and Kelejan and Oates (1974) for estimating weights to be applied to lagged prices, f (K) is expanded to derive the following set of equations where n=3 and K=5.

$$\beta_0 = f(o) = o$$
$$\beta, = f(1) = a_0 + a, + a_2 + a_3$$
$$\beta_2 = f(2) = a_0 + 2a, + 4a_2 + 8a_3$$
$$\beta_3 = f(3) = a_0 + 3a, + 9a_2 + 27_{a3}$$
$$\beta_4 = f(4) = a_0 + 4_{a1} + 16_{a2} + 64_3 3$$
$$\beta_3 = f(5) = a_0 + 5a, + 25a_2 + 125_a 3$$

The parameters a_0,... ,a_3 are estimated by the use of OLS (Ordinary Least Squares) regression. Once these parameters are estimated they can be used in the above functions to find the weighting scheme for lagged prices which provides the least error in estimating the E (Qt).

Thus, the actual pattern of weights is determined by the estimation process and may take any pattern an nth degree polynomial is capable of obtaining. J. Johnston seems to prefer the simple polynomial procedure, while Dhrymes (1971) prefers Almon's technique since it is easier to incorporate zero restrictions on the lag coefficients. The function estimated to determine a_0, ..., a_3 for the above case is derived by expressing the expanded set of equations and forming n+1 weighted price variable. The function for the case where n=3 and K=5 is shown below.

$$\begin{aligned} Qt = a_0 & (P_t + P_t.i + ,\dots,+ P_{t-5}) + \\ & + a, (Pt\text{-}i,2P_{t\cdot 2} +,\dots, + 5P_{t-5}) + \\ & + a_2 (P_t\text{-}i + 4P,., +, \dots, + 25P_t.s) + \\ & + a_3 (P_{t}\_i\ 8P_{t}\_2 +,\dots, + 125\ P_{t\cdot 5}) + E_t \end{aligned} \quad (3)$$

Any one of the K weight functions derived from (2) can be constrained to equal a desired value. This results in a reduction in the number of parameters to be estimated by one for each constraint imposed because one parameter becomes a linear combination of the others.

Common constraints imposed include: setting f (o) and / or f(ic) = o or requiring that

$$\sum_{i=1}^{k} f(i) = 1$$

Such constraints restrict the nature of the lag structure capable of being generated by the model and should be imposed only with an understanding of their effects and theoretical basis for imposing these effects.

A priori knowledge of theory and of the industry might dictate that either or both b_0 or b_n equals zero. One way to incorporate such knowledge into the model is by simply dropping P_t and/or P_t-i from the basic model and proceeding as before.

In practice, the information that either bo=0 and/or bn=0, or both, is transformed, by using the basic assumptions, into one or more restrictions on the a_s and then the resulting equation is estimated as it was explained above.

A second way to incorporate a priori knowledge in Almon' s method is for the researcher to know both the length of the lag structure and the degree of polynomial which gives the general pattern of bs. But, in reality, none of these are known with precision. To overcome that obstacle the researcher usually chooses a degree for the polynomial (e.g.n) that is high enough to include any reasonable pattern of bs. In most cases a third or fourth degree polynomial is sufficient to deal with the data at hand.

4. Selecting the Polynomial Lag Model.

In selection of the polynomial Lag model, the following procedure was used. First, an arbitrary degree of polynomial was chosen which had to account for the peculiarities of the data at hand. Then, for this arbitrarily chosen degree of polynomial different lag lengths were tried, and that one was selected which minimized the standard error of the regression. For that lag lenght different degrees of polynomial were tried, the one which minimized the standard error of the regression was chosen, and, finally, the necessary zero constraints were imposed.

5. Hypothesized Lag Structure: Number of Cows Slaughtered.

Given the biological production conditions of beef and the dual purpose nature of the national herd in Greece, we postulate that the initial reaction of producers to an increase in output prices i.e., price of beef, is to feed to heavier weights in order to approximately adjust the new and higher marginal value product function to marginal cost (output is defined here as the number of cows slaughtered). This results in a negative output response as cows are withheld from the slaughter market.

Eventually, as the retained beef cattle begin to produce increased numbers of cattle to be slaughtered, substantial output increase will occur. The rate and magnitude of thse responses will mainly depend on the following factors: a) the size of the beef price change, b) the size of the milk price change, c) the size of the feedstuffs price change, d) the size of the change in the ratio of beef and/or milk price to change in price of feedstuffs, e) the lag in recognizing that a price change has occurred and 0 the biological an climatic constraints.

A similar postulation (hypothesis) could be developed for the response of producers to an input price change.

Their initial reaction would be to feed to lower weights.

This would be followed by an increased number of cows going to slaughter and the withholding of fewer cows.

The use of the beef/ feedstuff and of the milk-feedstuff price ratios rather than that of beef and feedstuf prices deflated separately were used here since they helped to improve the model.

The above hypothesized responses to changes in the output/input price ratios provide some information about the expected lag structure or the weighting pattern for lagged prices. The hypothesis suggests that the largest weights would appear on prices lagged some four or more years. This allows for one to two years recognition lag followed by another one to two years gestation-maturation period lag. Hence, the earliest possible expansionary response would appear to be lagged some four years, with the peak response coming one to two years later. Contractionary response could occur in a shorter time since biological constraints are not at present.

6. Empirical Results: The Beef Cattle Slaughter (BCSLJ Equation.

With the above stated hypothesized responses as a priori knowledge, secon and third degrees constrained polynomials were tried with constraints which forced the weights at time year two and for the last period of the lag to be zero. The first zero constraint was put at time t=2 in accordance with the definition of a beef cattle in Greece, given earlier.

Polynomially distributed weights were estimated simultaneously within a single function for the variables farm price of milk/feedgrain ratio (FPMK/FPFG) and the farm price of beef/feedgrain ratio (FPB/FPFG).

The estimated parameters and statistics of the function are listed in Tables 1 and 2. Plots of each variable's weight distributions are shown in Figures 1 and 2 and calculated cumulative (e) elasticities plots are shown in figure 3.

TABLE 1.

POLYNOMIAL LAG MOBEL PARAMETERS AND STATISTICAL RESULTS
SECOND DEGREE CONSTRAINED POLYNOMIAL. TIME LAG: TEN YEARS

Time Period	Dependent Variable $BCSL_{t^{004}}$	Regression Coefficients, t-values, d*, Standard Error of Regression (SER)					
		Intercept	Explanatory Variables				
			FPMK FPFG	FPB FPFG	$R^{0.13}_{2}$	d*	SER
		126.766 (21.390)			0.72	1.06	15.68
t-1			0.0654 (5.82)	−0.9216 (6.19)			
t-2			0.1157 (5.82)	−1.659 (6.19)			
t-3			0.1570 (5.82)	−2.212 (6.19)			
t-4			0.1832 (5.82)	−2.581 (6.19)			
t-5			0.1962 (5.82)	−2.765 (6.19)			
t-6			0.1962 (5.82)	−2.765 (6.19)			
t-7			0.1832 (5.82)	−2.581 (6.19)			
t-8			0.1570 (5.82)	−2.212 (6.19)			
t-9			0.1170 (5.82)	1.659 (6.19)			
t-10			0.0654 (5.82)	−0.9216 (6.19)			

* Serial Correlation in a polynomial model does not raise the problem of inconsistent parameters estimates (Meilke et. al. 1974, p. 28).

TABLE 2.

POLYNOMIAL LAG MODEL SIMPLE AND CUMULATIVE (e) ELASTICITIES
(n = 2, K=10)

Time Period	Dependent Variable $BCSL_{t^{004}}$	FPMK FPFG	Explanatory Variables		
			ė	FPB FPFG	ė
t-1		0.13	0.13	−0.14	−0.14
t-2		0.23	0.36	−0.26	−0.40
t-3		0.31	0.67	−0.34	−0.76
t-4		0.36	1.03	−0.40	−1.16
t-5		0.38	1.41	−0.43	−1.59
t-6		0.38	1.79	−0.43	−0.02
t-7		0.36	2.15	−0.40	−2.42
t-8		0.31	2.46	−0.34	−2.76
t-9		0.23	2.69	−0.26	−3.02
t-10		0.13	2.82	−0.14	−3.16

$BCSL_t^{004}$ Beef Cattle Slaughtered, è: cumulative elasticity. FPMK: Farm Price of Milk, FPEG: Farm Price of Feed Grain (index). FPB: Farm Price of Beef.

When the function parameters and statistics are observed several points are worth mentioned. The distributed weights associated with milk/feed price ratio are all positive;

hoever, the first weight and the last weight are rather small but still significant by the t-value criterion. All weights give a good statistical level of significance when the-t-value criterion is employed. Hence, it may be concluded that significant response is indicated to milk-feed price ratio for the fourth year and unwards up to the eighth lagged year. This responses is not surprising under the average typical situation prevailing in Greece where farmers used to keep their cattle even somewhat beyond its economic life.

Since milk was mostly consumed on the farm by the family, the time lag-for the sample period (1951-1972) — seems to be an appropriate one.

With regard to beef/feed price ratio distributed weights it can be observed that they are all negative. This result may seem to be a little puzzling to those who are familiar with pure business oriented cattle operations.

The collected data reveals, however, that farm price of beef had followed a kind of erratic movement (experiencing ups and downs). Thus, for an upward movement of beef price, farmers' elasticity of expectation was negative;

they perceived this upward beef price movement as a permanent one and decreased the number of beef cows going for slaughtering. Given the fact that prices of feed-gram were more stable, any farmer's response was attributed to changes in the price of beef.

The corrected multiple regression coefficient $R^{013}{}_{2}$ was found to be 0.72 and is taken to be rather high, considering the fact that only two variables participate in the model.

It seems that the inclusion of farm price of feed-grain in the calculation of both price rations contributes somewhat to the problem of serial correlation. To correct for the presence of serial correlation, the Cochrane-Orcutt procedure was used (D. Cochrane and G.H. Orcutt, 1949).

A clear-cut way of summarizing the impact over time of a given price change is to observe the cumulative elasticity of output response to changes in a given price. Cumulative elasticities were calculated for each period and are presented in Table 2 and are displayed in Figure 3. Negative beef/feed price ratio elasticities have been converted to positive values in Figure 3 to provide easier graphical comparisons. The cumulative elasticities for the final period can be interpreted as the total or long-run elasticity, while those for intermediate years represent varying degrees of short-run elasticities.

7. **Third Degree Constrained Polynomial (n=3), Time Lag Ten Years (K=10).**

What follows is a brief comparison between the second degree polynomial and the third degree polynomial for the same length of run. It seems that in terms of signs of response of the variables involved the two degrees of polynomials give the same result consistent with each other. Thus, a positive sign was obtained in both of them in terms of all estimated coefficients of the milk/feed price ratio and a negative sign was obtained for all estimated coefficients of the beef/feed price ratio.

This finding seems to verify the hypothesized lag structure about the output/input price ratio response.

In terms of significance of the estimated coefficients-when the t-statistic is employed — it seems that in the second degree polynomial all of the estimated coefficients are significant. However, in the third degree polynomial estimated coefficients corresponding to t-8, t-9, t-10 years appear not to be statistically significant by the t-value criterion. This result led to the employment of a third degree polynomial with eight years length of run whose results are not given here.

In terms of R^{01i}, . , , , . , , ..., ^{2}s, it seems that the third degree polynomial gives higher value (R^{013} ^{2}=.84) compared with that of the second degree polynomial ($R^{013}{}_2$_ . terms of standard error of regression the third degree polynomial seems to give standard errors of regression of a lower value than the second degree polynomial (12.31 and 15.68 respectively).

From Tables 2 and 4 it is revealed that the intermediate short-run elasticities, although they look the same, they differ; and so do the final long-run elasticities of the two variables involved. The beef/feed price ratio cumulative elasticity rises faster than the milk/feed price ratio cumulative elasticity which may indicate that output prices cause greater fluctuations in the number of beefcattle going to slaughter. While this happens when a second degree polynomial is employed, events occur in the reverse when a third degree polynomial is employed (see Table 4). Table 4 reveals that the short-run elasticities of the milk /feed price ratio are higher than those of beef/feed price ratio in the first four years and they become equal at the fifth year; the beef/feed price ratio elasticities begin to rise faster thereafter, i.e., after the sixth year.

Table 3 shows the estimated parameters and the other statistical results for the third degree polynomial. The t-values underneath the estimated regression coefficients show that parameters corresponding to years t-8, t-9, t-10 are not statistically significant for the milk/feed price ratio, while the same parameters are significant for the beef/feed price ratio. The non-significance of the parameters corresponding to above mentioned years for the milk/feed price ratio is in accord with other findings elsewhere where it was found that milk-cows which yield an average of 1501-2000 kg of milk per year (local unemproved cows) have an average economic life 6 to 7 years (Kitsopanidis G., 1970).

The results of the third degree polynomial are given in Tables 3 and 4 and the graphical presentations are depicted in Figures, 4,5 and 6 below.

8. Policy Considerations.

Accepting the EEC's Common Agricultural Policy, the kinds of shifts available to Greek farmers are, again, through the price mechanism and they are related to relative prices of beef, milk and/or feedgrain. EEC is still in deficit as far as beef production is concerned. Hence, Greek policy following EEC's CAP should have either to increase beef prices in relation to veal, which could encourage keeping of more calves for beef and increased slaughter weights for both; or, if milk prices are high relative to veal, increased amounts of milk may be produced which along with EEC's surluses in dairy products will contribute to increase already existing problems in disposing of dairy products.

Thus, the supply response for beef production to price changes is, we believe, of great value to the decision makers both in Athens (Greece) and in Brussels. Furthermore the present distributed lag analysis shows that the «reaction path» of beef producers is a rather long one. It takes at least two years for a cattle to become a beef production unit (gestation period). Given this datum, beef producers start thinking for a course of action to be taken at t+3 year and thereafter. They need time too, called «recognition lag», before these producers have a firmly established perception about the course of action they should take. Thus, one who starts at t year as a beef producer has a temporary vision of the world during t+3 year (due to gestation period) and so has he at t+3 and t+4 years due to «recognition lag» and a permanent vision of the world is held by him thereafter. Thus, the effect of any shock or disturbance (such as changes in feed prices, changes in beef and/or milk prices, changes in the prices of other livestock products, a subsidy program policy, etc) are visible in two to three years ahead.

For the already established producers things are not that much complicated. They have to look at changes either in the relative prices of milk, beef and/or feedgrain or at their price rations or still at the prices of dairy products other than milk such as cheese, butter etc. By using appropriate polynomial lags a better understanding of this complicated world is given to the decision-maker since he can now see the resulting consequences of his policy going through the biological and the psychological reaction path of beef producers and results are expected to be seen two to three years later.

TABLE 3

POLYNOMIAL LAG PARAMETERS AND STATISTICAL RESULTS FOR THE THIRD DEGREE CONSTRAINED POLYNOMIAL
(n=3, K=10)

Time Period	Regression Coefficients, t-values, d*, and SER					
	Intecrept	FPMK / FPFG	FPB / FPFG	$\bar{R}^2$	D*	SER
	125.813			.84	1.83	12.31
t-1		0.0900	−0.1172			
		(1.622)	(.164)			
t-2		0.1465	−0.4656			
		(1.907)	(.470)			
t-3		0.1745	−0.9603			
		(2.419)	(1.026)			
t-4		0.1795	−1.516			
		(3.531)	(2.255)			
t-5		0.1665	−2.049			
		(5.670)	(4.984)			
t-6		0.1405	−2.473			
		(3.289)	(4.377)			
t-7		0.1070	−2.705			
		(1.497)	(2.942)			
t-8		0.0709	−2.658			
		(.413)	(1.929)			
t-9		0.03776	−2.248			
		(.413)	(1.929)			
t-10		0.0123	−1.390			
		(.193)	(1.714)			

TABLE 4.

POLYNOMIAL LAG MODEL SIMPLE AND CUMULATIVE (è' ELASTICITIES THIRD DEGREE CONSTRAINED POLYNOMIAL. TIME RERIOD 10YEARS

Time Period	Dependent Variable $BCSL_t$	FPMK FPFD	è	FPB FPFG	è
t-1		1.17	0.17	−0.02	−0.02
t-2		0.28	0.45	−0.07	−0.09
t-3		0.34	0.79	−0.15	−0.24
t-4		0.35	1.14	−0.24	−0.48
t-5		0.32	1.46	−0.32	−0.80
t-6		0.27	1.73	−0.38	−1.18
τ-7		0.21	1.94	−0.42	−1.50
Tt-8		0.14	2.08	−0.41	−1.91
t-9		0.07	2.15	−0.35	−2.26
t-10		0.02	2.17	−0.22	−2.48

9. Summary

In mathematics, there is a theorem stating that, under general conditions, a curve may be approximated by a polynomial.
Almon's method is based exactly on that theorem. The Almon distributed lag model appears to be a viable alternative model. Its flexibility makes it capable of approximating a number of different lag structures. The model, in general, gives a good statistical fit in comparison with other types of models such as geometric lag models for example.
We want to make some observations at this point concerning the use of the Almon Lag procedure. First, it is more complex and difficult to specify and work with than any other lag models. Second, it requires more degrees of freedom than any other lag model. The degrees of freedom lost become a function of the length of run and of the degree of the polynomial. The longer the length of run and the higher the degree of the polynomial the more degrees of freedom are lost. Third, in practice neither the length of run is known nor the pattern of the b's; hence, knowledge of the lag structure and a good knowledge of the industry is required. Fourth, the flexibility of both constrained and unconstrained polynomials is open to the researcher. Fifth, relatively high multicollinearity exists between the weighted price variables used in an n-th degree polynomial. Beyond these points what accounts for the use of the Almon lag is its ability to approximate the logicl lag structure and provide a large amount of information about the nature of lagged production responses.
In closing this paper we point out that Greek beef producers responded to price changes (price incentives) and they made their decisions which tend to maximize returns to scarce resources. This finding is in accordance with T. Schultz' s (1974) and Welsh's (1965) findings elsewhere for other countries experiencing the same more or less stage of economic development as Greece.

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