Quantitative analysis and agricultural policy with special reference to animal breeding in Greece

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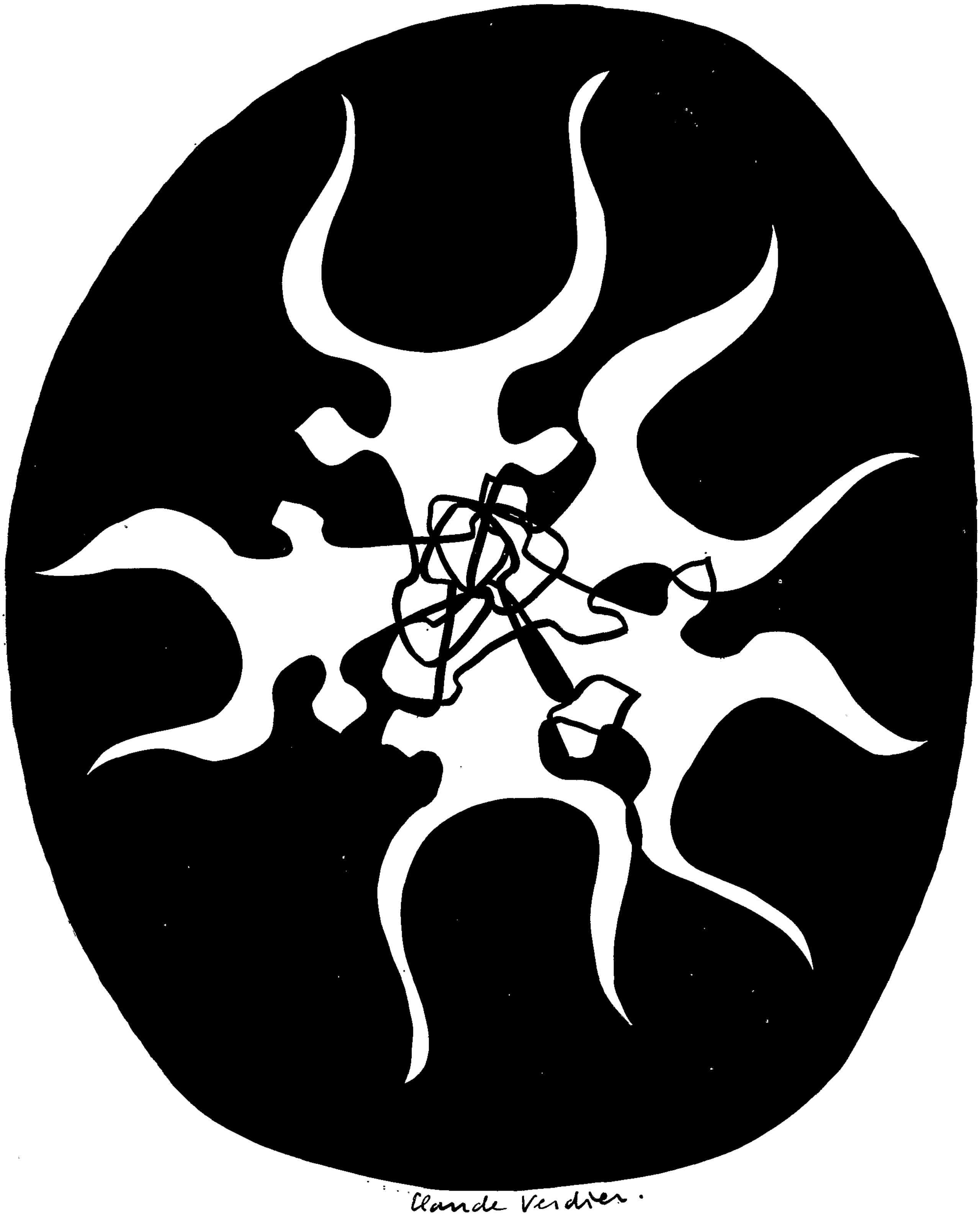

I. — THE PURPOSE AND THE NATURE OF THE STUDY

It has been widely discussed that agriculture differs from the non-farm sector of the economy, insofar as the uncertainty conditions in agriculture are much stronger than in the non-farm sector; environment plays a predominant role both on the level of production, and on income disparity between the farm and the non-farm sector. Social characteristics in the agricultural sector cannot be ignored by the Policy-Maker, even if he has to depart from certain economic principles.

A considerably smaller rate of growth has been achieved in agriculture than in the non-agricultural sector in Greece. Indeed, during 1952-1965 the gross national product at constant 1958 prices increased at an average rate of growth of 5.7 per cent per annum, whereas agricultural income increased only 4.6 %, if, again, the constant 1958 prices are taken into account. Considering that over 40 % of the Greek population is dependent on agriculture, this disparity in growth rates becomes of much greater importance. The percentage of active labour force engaged in agriculture represented 52.6 per cent of the total in 1964, whereas the agricultural income was of the magnitude of 22.7 per cent of the total national income.

Distinction should be made between animal breeding and the crop-producing sector in Greece because of the accute differences between the two as far as the prevailing conditions in each are concerned. Indeed, separate policy must be implemented in the animal breeding industry because of the amount of foreign exchange spent on imports of meat and milk and milk products. A state of affairs then prevails under which Greece, although an agricultural country with the bulk of its exports consisting of agricultural products, nonetheless, imports a substantial part of its livestock and dairy products needed for consumption in the country, causing a balance of payments problem. This problem would not be so severe if imports of capital products were substituted for livestock and dairy products, thus contributing towards a more rapid development and industrialization of the economy with the result that a lesser burden would be imposed on agriculture, since the rest of the economy would employ more of the population, thus decreasing the difference between, agriculture and the non-agricultural sector, as far as per capita income is concerned (*).

Given the prevailing conditions in the animal breeding industry in Greece, for example, the obvious intention of any policy-maker should be to try and improve these conditions by expanding production utilizing the available idle resources and transfering part of the resources from the crop producing sector, where the increased production causes the purchasing of a number of products to be an acute problem for the Government, to the Animal Breeding Industry. Wheat production, for example, has become a severe problem, owing to the unwillingness of farmers to change their pattern of production by substituting either fodder crops or livestock for wheat production.

The most desirable situation would be the one of decreasing imports of livestock products as far as possible, moving towards self-sufficiency which would result in: 1) An improvement in the balance of payments situation; 2) an increase in underemployment within the agricultural sector, by employing more man-hours per year in the animal breeding industry; 3) a benefit to crop-agriculture, since livestock would act in a complementary way both by consuming part of its crop production in the farm and economizing middle-man' margins and by utilising by-products and crop-products which are of a too low quality to be accepted by trade. The result in any way would be an over all improvement, in that there would be a better re-allocation of resources, both within agriculture and between agriculture and the rest ot the economy. The concept of better reallocation of resources should not be over-emphasized and all the rigidities and uncertainties prevailing in agriculture should be borne in mind, as far, as the movement of population out of agriculture is concerned. 4) Because of the comparatively high income and price elasticity of demand for livestock and dairy products (**) by increasing production, with the simultaneous increase in the G.N.P., there would be a direct effect of increasing income in the agricultural sector, and consequently of lessening the gap between the per capita income in agriculture and that in the non-agricultural sector, and an indirect result of improving the balance of payments situation, assuming that their marginal propensity to consume foreign products is much smaller than that of consuming domestically produced agricultural products.

This improved income situation of farmers would lead to a more rapid development of the non-agricultural economy because of the increased effective demand

(*) J. R. Bellerby gives a detailed account of reasons keeping people in agriculture, although there is a great disparity between relative income in agriculture and the rest of the economy. See J. B. Bellerby, *Agriculture and Industry Relative Income,* Macmilan & Co Ltd, London, 1956.

(*) The reader should remember that each column of Π_5 shows, other things being equal, the effect of a unit change in each exogenous variable on each and every endogenous one in the following year.

(**) It has been estimated that the livestock and dairy products in Greece have an elasti city as follows:

With respect to: Product	Elasticity	
	Income	Own price
Veal	2.71	—1.35
Beef	1.73	—0.16
Cowmilk	1.48	—0.90
Lamb	0.72	—0.62
Mutton	—0.43	—0.95
Sheep & goat Milk	0.57	—0.98

for its products which would, by the acceleration principle, increase the demand for capital goods (investments) in order that entrepreneurs producing consumption products would be able to meet this increased demand. Considering the comparatively low per capita level of income, which implies a high propensity to consume (***) the increased investments would, by the multiplier effect, increase production.

It is a commonly accepted notion that agriculture must be supported either by subsidization (in the form of grants and in accordance with the level of farm income), or by the introduction of a levy system, regarding farm income in conjunction with the competition from other countries. The existing system of agricultural support in Greece consists of both subsidization and import control; the former takes place according to either the factors of production used or the product produced; import control, on the other hand, consists of either imposing a levy per unit of imported product, or banning imports altogether, according to the conditions in the home market as far as prices and home production are concerned. The emphasis has been put on subsidization rather than on import control.

Unless a systematic quantitative study of the conditions in agriculture is made, there is no way of concluding what is the cause of the problem and, of course, what would be the remedy of it. The policy-maker needs to know the response of farmers and consumers to changing economic and non-economic conditions in the Greek Economy. He must know the effects on several target variables, such as production, consumption, imports, etc. exerted by the determinant ones, in order to direct the latter towards the best possible ends. These determinant variables may be either exogenous or endogenous. Public expenditure spent on the animal breeding industry, for example, is an exogenous variable, insofar as it is not influenced by the conditions in the industry-although the decisions taken by the policy-maker may depent upon the existing conditions in the industry-whereas it does influence the evolution of the endogenous variables. Prices are also decisive on production, consumption, imports, etc. At the same time, prices are formed by the supply and demand interaction, as well as by conditions outside the industry under consideration. There are, then, both the direct and indirect influences which must be assessed to give some guidance to the policy-maker as to what measures should be taken in order to lead the industry towards the desired targets of development.

This guidance to the policy-maker may be provided in the form of estimated statistical relationships amongst the relevant variables of the industry in question. A complete system of equations may be built for each sector or industry. The relevant structural parameters may be estimated by applying either the single equation method of Ordinary Least Squares, or any of the simultaneous equation methods, such as the Two Stages Least squares Method, or the Limited Information Maximum Likelyhood, underlying the relationships between the exogenous variables, on the one hand, and the endogenous one, on the other, as well as the relationships amongst the endogenous variables themselves.

The system of all the relations (equations) may be used in order to assess the direct and indirect influences of a change in any predetermined variable on all the endogenous ones simultaneously. Moreover, an appropriate matrix of short run reduced form coefficients may be provided showing the influence of a change in one predetermined variable on all the endogenous ones in the following year. Such a reduced form system of relations may be used for prediction purposes in the short run. Finally, the dynamic properties of such a system may be studied. In other words, the simultaneous evolution of all the endogenous variables as time passes and for a comparatively long period of time, may be calculated, showing the endogenous mechanism of the system stimulated by a unit change in one exogenous variable, under the assumption " other things being equal ".

II. — METHOD OF ANALYSIS

There are two methods of analysis; the Normative and the Positive. The first approach deals with how farmers or consumers can or might or ought to react to changing economic or non-economic conditions. Rational behaviour of both farmers and consumers is usually assumed when studies of a " qualitative " nature are carried out. The second examines the actual behaviour of farmers or consumers and it is sometimes called the " Quantitative Method ". In the normative method, the expected behaviour is determined by economic theory. The positive method depends on what actually occurs in the real world. The difference between the two approaches is caused by the particular circumstances predominating in the branch of economic activity concerned. In agriculture, weather conditions combined with price and income, uncertainty of farmers caused by the demand, inelasticity of most of the farm products, do affect farmers' reactions to changing economic or technological conditions. Even if the current price conditions were favourable, meat and milk production, for example, could not increase beyond a certain point if livestock numbers were not increased. Nonetheless, the cow population cannot increase before a minimum time period necessary for the decisions of farmers to be implemented. Indeed, if cows are to increase from domestic sources, there will be a period of at least four years before milk production is increased. Milk production can, of course, increase by increasing averag yield per cow milked. Nonetheless, yiel can increase by improving feeding condi tions only up to a certain extent. Beyon that point, yield can increase only b means of breed improvements of cows Special breeds, however, may not fit int the particular environment of the countr in question.

III. — A MODEL FOR CATTLE IN GREECE

There will follow a simultaneous equa tion model of supply and demand for th cattle industry. In matrix notation th system of equations will be as follows

$$A + BY + \Gamma Z + U = 0 \quad (1)$$

Where :

A = A 20 × 1 column vector of twent constant terms, corresponding to th 20 structural equations.

B = A 20 × 20 matrix of structural coeffi cients showing the interrelation ships amongst all the endogenou variables. The typical element β_i shows the amount of change in th ith endogenous variable as a result o a unit change in the jth endogenou variable; it may be either zero o different from zero.

Y = A column vector of twenty endoge nous variables, namely $y_1, y_2, y_3, \ldots$ y_{20}.

Γ = A 20 × 28 matrix of structural coe fficients pointing out the effects of a the 28 predetermined variables o the 20 endogenous ones simulta neously. Its typical element γ_i shows the effect on the ith endoge nous variable exerted by a uni change in the jth predetermined va riable under the assumption o " other things being equal ".

Z = A column vector of 28 predetermine variables, namely $x_1, x_2, \ldots, x_1$ and thirteen endogenous variable appearing with a time lag.

U = A column vector of 20 × 1 structura residuals, $u_1, u_2, \ldots, u_{20}$.

List of Variables

A. *Endogenous:*

Y_1 = Number of Calves-Bullocks Slaugh tered.
Y_2 = Yield per Calf-Bullock slaughtered
Y_3 = Production of Veal.
Y_4 = Number of adult Cattle Slaugh tered.
Y_5 = Yield per adult Cattle Slaughtered
Y_6 = Production of Beef.
Y_7 = Import of Veal.
Y_8 = Imports of Beef.
Y_9 = Retail Price of Veal.
Y_{10} = Retail Price of Beef.
Y_{11} = Farm Price of Veal.
Y_{12} = Farm Price of Beef.
Y_{13} = Number of Cows Milked.
Y_{14} = Yield per Cow milked.
Y_{15} = Production of Milk.
Y_{16} = Blend Retail Price of Milk.
Y_{17} = Blend Farm Price of Milk.

(***) The argument seems to be contradicting the Permanent Income Hypothesis (Friedman's hypothesis). Nonetheless, it has been estimated that the marginal propensity to consume out of farm income is higher than the M. P. to consume out of non-farm income (0.81 and 0.54 respectively).

Y_{18} = Per Capita Consumption of Veal.
Y_{19} = Per Capita Consumption of Beef.
Y_{19} = Per Capita Consumption of Cow Milk.

B. *Predetermined:*

X_1 = Price of feedstuffs.
X_2 = Subsidy of two drachmas per kilogramme of liveweight paid to animals weighting more than 250 kilo.
X_3 = Subsidy paid to acreage used for feed Production.
X_4 = Linear Time Trend measured in years, taking the value 1, 2, ..., 14 for the years 1952, 1953, ..., 1955 respectively.
X_5 = Percentage of cows in milk bred artificially with a three year lag.
X_6 = Retail Price of Mutton.
X_7 = Per Capita Gross National Product at constant 1958 prices (1958 = 100).
X_8 = Farm Price of Beef Cattle in the Netherlands; in U.S.A. cent/kg.
X_9 = Farm Price of Fluid Milk in the Netherlands; in U.S.A. dollars/hl.
X_{10} = Farm price of cheese computed as a weighted average of prices of soft and hard cheese.
X_{11} = Retail Price Index for Foodstuffs (1952 = 100).
X_{12} = Wholesale Price Index for Foodstuffs (1952 = 100).
X_{13} = Retail Price of Fish.
X_{14} = Retail Price of Refreshments.
X_{15} = Population of Greece.

HE ÉCONOMIC MODEL

The twenty structural equations are as follows:

1. $Y_{1 \cdot t} = f_1(Y_{2 \cdot t}, Y_{13 \cdot t-1}, Y_{1 \cdot t-1}, \sum_{i=-1}^{-3} Y_{11 \cdot t-1} / \sum_{i=-1}^{-3} X_{1 \cdot t-1}, u_{1 \cdot t})$ (2)
2. $Y_{2 \cdot t} = f_2(Y_{11 \cdot t}/Y_{17 \cdot t}, X_{5 \cdot t-3}, X_{3 \cdot t}, X_{4 \cdot t}, u_{2 \cdot t})$ (3)
3. $Y_{3 \cdot t} = Y_{1 \cdot t\, x}\, Y_{2 \cdot t}$ (4)
4. $Y_{4 \cdot t} = f_4(100\, Y_{12 \cdot t-4}/X_{1 \cdot t-4}, Y_{13 \cdot t-1}, X_{2 \cdot t}, X_{4 \cdot t}, u_{4 \cdot t})$ (5)
5. $Y_{5 \cdot t} = f_5(Y_{12 \cdot t-4}/X_{1 \cdot t-4}, X_{2 \cdot t}, X_{4 \cdot t}, u_{5 \cdot t})$ (6)
6. $Y_{6 \cdot t} = Y_{4 \cdot t\, x}\, Y_{5 \cdot t}$ (7)
7. $Y_{7 \cdot t} = f_7(Y_{9 \cdot t}, \frac{1}{2}(X_{7 \cdot t} + X_{7 \cdot t-1}), Y_{2 \cdot t-1}, Y_{7 \cdot t-1}, u_{7 \cdot t})$ (8)
8. $Y_{8 \cdot t} = f_8(Y_{10 \cdot t}, X_{4 \cdot t}, X_{7 \cdot t}, Y_{8 \cdot t-1}, u_{8 \cdot t})$ (9)
9. $Y_{11 \cdot t} = f_{11}(X_{8 \cdot t}, X_{10 \cdot t}, X_{12 \cdot t}, u_{11 \cdot t})$ (10)
10. $Y_{12 \cdot t} = f_{12}(Y_{10 \cdot t}, X_{10 \cdot t}, u_{12 \cdot t})$ (11)
11. $Y_{13 \cdot t} = f_{13}(X_{\cdot t2}, Y_{17 \cdot t}, Y_{14 \cdot t}, X_{4 \cdot t}, Y_{17 \cdot t-4}, u_{13 \cdot t})$ (12)
12. $Y_{14 \cdot t} = f_{14}(100\, Y_{17 \cdot t-4}/X_{1 \cdot t-4}, X_{4 \cdot t}, Y_{13 \cdot t}, u_{14 \cdot t})$ (13)
13. $Y_{15 \cdot t} = Y_{13 \cdot t\, x}\, Y_{14 \cdot t}$ (14)
14. $Y_{17 \cdot t} = f_{17}(X_{10 \cdot t}, X_{9 \cdot t}, Y_{20 \cdot t}, u_{17 \cdot t})$ (15)
15. $Y_{18 \cdot t} = f_{18}(Y_{9 \cdot t}, X_{7 \cdot t}, X_{13 \cdot t}, u_{18 \cdot t})$ (16)
16. $Y_{19 \cdot t} = f_{19}(Y_{10 \cdot t}, X_{7 \cdot t}, X_{6 \cdot t}, X_{11 \cdot t}, u_{19 \cdot t})$ (17)
17. $Y_{20 \cdot t} = f_{20}(Y_{16 \cdot t}, \frac{1}{2}(X_{7 \cdot t} + X_{7 \cdot t-1}), X_{14 \cdot t}, u_{20 \cdot t})$ (18)

There remain three more equations, e.g. the equation of the retail price of veal, the equation of the retail price of beef and that of the retail price of milk. They may be estimated by solving the following identities, according to which the supply of and the demand for all the three products concerned, namely veal beef and milk, are equal.

18. $(Y_{3 \cdot t}/X_{15 \cdot t}) + Y_{7 \cdot t} = Y_{18 \cdot t}$ (19)
19. $(Y_{6 \cdot t}/X_{15 \cdot t}) + Y_{8 \cdot t} = Y_{19 \cdot t}$ (20)
20. $(Y_{15 \cdot t}/X_{15 \cdot t}) = Y_{20 \cdot t}$ (21)

The identities (19), (20), and (21) are solved for Y_{9t}., $Y_{10 \cdot t}$, and $Y_{16 \cdot t}$ respectively, since $Y_{9 \cdot t}$, $Y_{10 \cdot t}$, and $Y_{16 \cdot t}$ are included as explanatory variables in the equations (15), (16) and (17) respectively.

From the above mathematical formulation of the system of 20 simultaneous equations, one understands that there are three distinct relations considered. Firstly, the supply of livestock and dairy products; secondly, the demand for livestock and dairy products; and thirdly, the price movements of those products, both at the farm level and at the retail market. Owing to the lack of self-sufficiency of Greece, as regards animal breeding, influences of international economic changes are taken into account. This is done firstly, by specifying two import equations, one for beef and one for veal, and estimating their parameters. Secondly, by considering the price movements in the international market and their repercussions on prices in the domestic market. In all cases, cross effects are seriously taken into account by introducing what is believed to be an alternative possible use of resources, or an alternative consumer commodity.

There have been specified as many equations as the number of the endogenous variables. In more detail, there are fourteen behavioural equations and six identities, pointing out firstly, that output is equal to the number of units of activity multiplied by yieldper unit of activity, i.e. production of veal = number of calves slaughtered × yield of meat per calf slaughtered and secondly, that production plus imports are equal to consumption, so that an equilibrium is reached, assuming that stock changes are unimportant.

In order to take account of all the interrelationships amongst the endogenous variables, one must solve all the equations simultaneously. The method that should be used for the estimation of the parameters of an equation-member of such a system of equations depends on the purpose of the investigation; if the purpose of the researcher is to estimate the parameters of an equation independently of any other relations, the Ordinary Least Squares may be regarded as the most appropriate method, under several assumptions concerning the behaviour of the structural disturbances. When, on the other hand, the equation belongs to a " family " of interdependent equations, the application of OLS leads to biased and inconsistentestimators. The Two Stage Least Squares may be used, since it gives unbised and consistent estimates.

In several equations there are endogenous variables appearing as explanatory ones thus causing the regression coefficients to be biased and inconsistent, since all the endogenous variables of the system are not independent of the residuals. For, the residual term in any structural equation shows those factors within the industry under consideration which affect the dependent variable, but which cannot be measured. Considering equation (1), one understands that Y and U are not independent of each other, a presupposition which must be fulfilled so that the coefficients B and Γ will be unbised estimates of the population parameters.

As stated already, what the policy-maker needs to know is the total effect exerted by the predetermined variables on all the endogenous ones simultaneously, since the former are not affected by the latter, whereas they do affect the endo, genous variables. In mathematical terms-equation (1) must be solved for Y expressed as a function of Z and U as follows:

$$Y = - B^{-1}A - B^{-1}\Gamma Z - B^{-1}U \quad (22)$$

from which it is easily seen that Z and U determine Y. Since, however, the investigator works with sample data, U is not known and hence equation (22) will be as follows:

$$Y = - B^{-1}A - B^{-1}\Gamma Z \quad (22a)$$

Equation (22*a*) can be easily derived from equation (1), since B, A and Γ have all been estimated by using multiple regression analysis, provided, of course, that there exists such a solution, i.e. that $|B| \neq 0$.

From equation (22*a*) it is clear that

$$- B^{-1}\Gamma = \Pi = \frac{\partial Y}{\partial Z} \text{ or } \dot{Y} = \Pi \dot{Z} \quad (23)$$

since the constant term of (22), i.e. — $B^{-1}A$ vanishes when (22*a*) is differentiated with respect to Z; Π, then, is clearly a matrix of coefficients indicating a relationship between

$$\dot{Y} = Y_t - Y_{t-1} \quad \text{and} \quad \dot{Z} = Z_t - Z_{t-1}$$

i.e. the amount of change in Y when Z changes by one. The typical element Π_{ij} shows the response of the ith endogenous variable to a change in the jth predetermined one which occurs in the first year, under the assumption " other things being equal ".

Equation (23) can be used for short run prediction purposes only, since among the predetermined variables, there are lagged endogenous ones which are not independent of the conditions in the industry in question as far as the long period is concerned, although they may be regarded as independent in the short run. For prediction purposes in the long run, one must proceed further towards solving the system for all the endogenous variables (current and lagged) in terms of all the pure exogenous. In mathematical terms, equation (22*a*) is partitioned as follows:

$$Y = C + \Pi_1 Y_{-1} + \Pi_2 Y_{-2} + \Pi_3 Y_{-3} + \Pi_4 Y_{-4} + \Pi_5 X + \Pi_6 X_{-1} \qquad (24)$$

If lags are disregarded completely and terms rearranged, equation (24) will be as follows:

$$(I - \Pi_1 - \Pi_2 - \Pi_3 - \Pi_4)\, Y = C + (\Pi_5 + \Pi_6)\, X \qquad (25)$$

If both sides of (25) are premultiplied by $(I - \Pi_1 - \Pi_2 - \Pi_3 - \Pi_4)^{-1}$, equation (25) will be as follows:

$$Y = (I - \Pi_1 - \Pi_2 - \Pi_3 - \Pi_4)^{-1} C + (I - \Pi_1 - \Pi_2 - \Pi_3 - \Pi_4)^{-1} (\Pi_5 + \Pi_6)\, X \qquad (26)$$

assuming that there exist such a solution, i.e. that

$$I - \Pi_1 - \Pi_2 - \Pi_3 - \Pi_4 \neq 0$$

IV. — CYCLICAL FLUCTUATIONS OF CATTLE IN GREECE

In any system of simultaneous equations of the form indicated in equation (22*a*), both lagged endogenous and current or lagged exogenous variables constitute the so-called " predetermined " variables. All that is needed for policy and decision-making purposes, however, is the impact on the endogenous variables exerted by changes in those variables which may be influenced by the policy-maker, and may not be influenced by the prevailing conditions in the industry in question. For, lagged endogenous variables, although predetermined in the sense that they are independent of the structural disturbances of the system at a particular point in time, are, nonetheless, determined by the working of the industry under consideration.

Regarding equation (23), i.e. the system of structural equations expressed in terms of first differences.

$$\dot{Y} = \dot{Z},$$

the vector of predetermined variables (Z) may be partitioned into subvectors of pure exobenous variables, current and lagged, with one, two, three, etc. year lags and of lagged endogenous variables with one, two, three and four year lags as follows:

$$\dot{Y}_t = [\Pi_1 \Pi_2 \Pi_3 \Pi_5 \Pi_6] \begin{bmatrix} \dot{Y}_{t-1} \\ \dot{Y}_{t-2} \\ \dot{Y}_{t-3} \\ \dot{Y}_{t-4} \\ \dot{X}_t \\ \dot{X}_{t-1} \end{bmatrix} \qquad (27)$$

What we want to know is the time path of changes in the endogenous variables, exerted by a change in one of the exogenous ones at a particular point in time, under the assumption that the exogenous variable in question would be sustained at its new level in the future and for an infinitely long period and that all other exogenous variables would be kept constant. As a result of this stimulus, there would be a series of future effects on the current endogenous variables exerted by changes in the endogenous variables themselves, at previous points in time. Indeed, if the kth element of X in equation (27) was set equal to, say, one with all other elements and $\dot{Y}_{t-1}$, $\dot{Y}_{t-2}$, $\dot{Y}_{t-3}$, $\dot{Y}_{t-4}$ and $\dot{X}_{t-1}$ equal to zero, $\dot{Y}_t$ would equal the kth column of Π_5, corresponding to the kth current exogenous variable, in the following year (*). In year $t + 1$ all elements of X_t would be zeros, since there would be no further exogenous stimuli. Hence for the first year, equation (27) would be as follows:

$$\dot{Y}_1 = \Pi_5 \dot{X}_t \qquad (28)$$

In the second year, for the same reasons as in the first year, equation (27) will be of the following form:

$$\dot{Y}_2 = [\Pi_6 + \Pi_1] \begin{bmatrix} \dot{X}_{t-1} \\ \dot{Y}_1 \end{bmatrix} = \Pi_6 \dot{X}_{t-1} + \Pi_1 \Pi_5 \dot{X}_t \qquad (29)$$

In the third year period equation (17) will be:

$$\begin{aligned} \dot{Y}_3 &= [\Pi_1\, \Pi_2] \begin{bmatrix} \dot{Y}_2 \\ \dot{Y}_1 \end{bmatrix} \\ &= \Pi_1(\Pi_6 \dot{X}_{t-1} + \Pi_1 \Pi_5 \dot{X}_t) + \Pi_2 \Pi_5 X_t \\ &= \Pi_1 \Pi_6 \dot{X}_{t-1} + \Pi_1 \Pi_5 \dot{X}_t + \Pi_2 \Pi_5 \dot{X}_t \\ &= \Pi_1 \Pi_6 \dot{X}_{t-1} + (\Pi_1 \Pi_5 + \Pi_2 \Pi_5) \dot{X}_t \end{aligned} \qquad (30)$$

For the estimation of the changes in the endogenous variables in the fourth year, equation (27) will be reformed as follows:

$$\dot{Y}_4 = \Pi_1 \dot{Y}_3 + \Pi_2 \dot{Y}_2 + \Pi_3 \dot{Y}_1,$$

which will be reduced to:

$$Y_4 = (\Pi_1^2 \Pi_6 + \Pi_2 \Pi_6) X_{t-1} + (\Pi_1^3 \Pi_5 + \Pi_1 \Pi_2 \Pi_5 + \Pi_1 \Pi_5 + \Pi_3 \Pi_5) \dot{X}_t \qquad (31)$$

The same procedure will be followed for the estimation of the changes in the endogenous variables for any number of years.

With reference to our cattle model considered, and supposing that the policy-maker would prefer to implement a certain kind of policy, in connection with the future path followed by the twenty endogenous variables simultaneously, all he needs to know is which exogenous variables to influence and by what amount. Moreover, when more than one exogenous variables are to be used as stimuli simultaneously, there is no problem, since the total effect on the endogenous variables may be easily calculated by adding the individual responses as calculated by the above formulae, because of one useful property of linear systems of equations, namely that responses of this kind are additive.

The above equations have been solved and the value of Y calculated for a number of 15 years. The original " shock " was given by changing several exogenous variables by one unit, such as per capita income, Subsidy of two drachmas per kilogramme of liveweight, percentage of cows in milk served by artificial insemination, etc. The results of the calculations have clearly shown that the endogenous mechanism of the system causes the endogenous variables to fluctuate in a more or less regular way. Then fluctuations of the endogenous variables are of a convergent nature, although the time period needed is rather long and as a consequence will eventually lead the system to stability. The important conclusion to be reached, as a result of the calculation of the time path of changes in the system due to an original " push " is that the inherent characteristics of the system are its oscillatory changes; the cycle moves in a regular oscillatory but, nonetheless, damped pattern, with an eight year duration.

In trying to explain the cyclical movements of the system, one must be careful not to attempt to use the simple Price-Quantity Cobweb-Theorem analysis. It is the exogenous variables and hence the initial " push " of the system, which must be regarded as the determina factor on both quantities and prices, as well as on the generation of a whole series of interrelationships amongst the endogenous variables, since it determines the initial point of departure.