SHORT AND LONG RUN TRENDS IN PRODUCTION AND CONSUMPTION PATTERNS OF TWO LIVESTOCK PRODUCTS IN THE EU

CHRISTOS A. BATZIOS (*) - KEVIN A. LAWLER - MARCUS C. LING (**) - ELENI KATSOULI (***) - KONSTANTINOS GALANOPOULOS (****)

ABSTRACT

The livestock sector in the EU absorbs a large proportion of the CAP subsidies budget, while the consumption patterns of most livestock products have changed considerably in the last few years. In this study, two livestock products, namely eggs and milk, are examined in order to determine long and short run consumption and production relationships.
A model for the "normal" product determination is developed and estimated using the cointegration analysis and the Error Correction Models technique.
Results indicate that there is a long-run equilibrium relationship between levels of output, per capita income and population, while the "normal" production is influenced by population and income, reflecting the size and the level of growth of the EU market, respectively.
Population is the major determinant for both products, generating positive effects on the production of eggs and negative on the milk production.

RÉSUMÉ

Le secteur de l'élevage dans l'Union Europénne absorbe une grande proportion des subventions budgétaires, alors que les modèles de consommation pour la plupart des produits de l'élevages ont changé considérablement au cours de ces dernières années. Dans cette étude, deux produits, notamment les oeufs et le lait, sont examinés pour déterminer la consommation et les relations de production à long et court terme. L'auteur a développé et estimé un modèle pour la détermination «normale» des produits en utilisant l'analyse de la co-intégration et la technique des Modèles de Correction des Erreurs. Les résultats indiquent qu'il existe une relation d'équilibre à long terme entre les niveaux de production, le revenu par personne et la population, tandis que la production «normale» est influencée par la population et le revenu, en refléchissant la taille et le niveau de croissance du marché de l'Union Européenne, respectivement. La population est le déterminant majeur pour les deux produits, et elle engendre des effets positifs sur la production des oeufs et des effets négatifs sur la production de lait.

Over the recent years, consumption patterns of livestock products have changed considerably in the European Union (EU). New dietary preferences have developed as a result of an increasing consumer awareness of more health-oriented diets and less fat and calories intakes. Consequently, the consumption of certain livestock products has been seriously affected by this trend. Even the consumption of milk and eggs —which are not the most "unhealthy" livestock products —has followed a negative trend in the last decade. Problems related to salmonellas infections from egg consumption have caused a sensitivity on the behalf of the consumers and may explain the reduced consumption, while for milk the most apparent reasons are the declining number of infant births and the consumers' preference for low fat milk. In general, European consumers are becoming more "health" conscientious rather than price sensitive and this evidence could be constructed against the continued advance in living standards within the EU. On the supply side, discussion in the EU about reform of the Common Agricultural Policy (CAP) are endemic. A large portion of agricultural income in the EU countries is attributed directly to CAP subsidies. Several measures that have already been introduced in the dairy sector (milk quotas, co-responsibility of the farmers, etc.) have triggered disputes among Member States regarding the levels of subsidies. In addition, policy makers are debating on further reducing farm assistance programmes, particularly in the dairy sector.

Within this context, and given the considerate magnitude of CAP expenditures for livestock products, especially for milk(1), it is worth examining both long run and short run relationships for the production and demand of such products, in order to assess the relative importance of certain key factors, such as income and market size, on the levels of production and consumption.

Thus, the main objective of this paper is to analyse the production and consumption patterns of two livestock products, namely milk(2) and eggs so as to identify long and short run relationships between key variables.

The cointegration technique is employed for this purpose.

The paper is organised as follows. In the next session, a brief descriptive overview of the EU market for the chosen products is provided, while the rationale for the model used is addressed in the third section.

The methodology and the estimation procedures, as well as the empirical results are presented and discussed in the fourth sector. Finally, the concluding section provides some summary comments on the major results and highlights certain policy implementations.

(*) Laboratory of Animal Production Economics, Faculty of Veterinary Medicine, Aristotle University of Thessaloniki, Greece.
(**) Business School, University of Sunderland, Sunderland, UK.
(***) Department of Applied Informatics, University of Macedonia, Thessaloniki, Greece.
(****) Agricultural Economics and Social Research Institute, Athens, Greece.

(1) Milk output was estimated to account for 15.6% of final agricultural output by using series in Purchasing Power Parities, PPSs (OECD, 1994).
(2) Milk production is defined as the quantity of milk obtained through human milking, manual or mechanical (OECD, 1994).

THE DIMENSIONS OF THE EU MARKET FOR EGGS AND MILK

The EU has been self-sufficient both in eggs as well as in milk production, over the last twenty-five years, exhibiting a rate of self-sufficiency ranging from 100 to 102 percent and 100 to 104 percent, respectively (**table 1**). The per capita availability ranged from 14.1 to 15.3 kg/head/year for eggs, while for milk it ranged from 310.7 to 362.2 kg/head/year.

In **table 2** the per capita availability of the products under study in each EU Member State is depicted. It can be clearly seen, that while for eggs there is a certain homogeneity (with the exemption of Portugal), in the case of milk a wide diversity is existent. For instance, per capita milk availability for Portugal in 1992 was only 169 kg/year, whereas the corresponding figure for Ireland is 1485 kg/year. In general, the Mediterranean countries (Portugal, Spain, Italy and Greece) exhibit the lowest figures, in contrast to the Northern countries, particularly Ireland, Denmark and the Netherlands. This evidence may also account for the large quantities of milk being stored by some North European countries as a result of excess production.

THE "NORMAL" PRODUCT DEFINITION

The model used in this paper is the function of a "normal" product as developed by Chenery (1960) and modified by Katos (1980) which, when simplified for estimation purposes, can be reduced to give total domestic production as a function of per capita income and population(3). The long run model used for estimation is specified as follows:

$$Q_{jt} = f(Y_t, P_t) \qquad (1)$$

where Q = production, j = products (E = eggs and M = milk), Y = per capita Gross Domestic Product in 1985 PPS, P = Population and t refers to time.

By expressing all variables in natural logarithms, the resulting coefficients for income and population represent the "growth" and "size" elasticities, respectively. Hence, equation (1) incorporates both supply and demand effects on egg and milk production in the EU. The levels of production and demand will vary with rising income (growth elasticities), and with growing domestic market (size elasticities). In other words, an increase in the per capita income in the EU will bring upon a variation in the production and demand. Similarly, a larger market size may affect production costs, selling prices and final demand of these products in the EU market.

DATA AND EMPIRICAL ANALYSIS

Cointegration and error correction techniques are used to estimate the long run and short run relationships between the variables of the above function following the methodology suggested by Johansen (1988) and Johansen and Joselius (1990). In order to minimise possible sources of bias, resulting from the inclusion in the model of non-directly comparable data from different countries, Gross Domestic Product (GDP) data for the EU are used and expressed in Purchasing Power Parities (PPSs).

The data employed in this study are annual observations for the sample period 1970 to 1994 for eggs and milk in the EU12 obtained by the FAO Statistical Database. All variables were transformed to natural logarithms prior to estimation and then a standard testing procedure was used which involves the following steps: First, Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) unit root tests are employed, to test

Table 1 ***The EU market of eggs and milk.***

	Year	Total Production (000 t)	Total Availability (000 t)	Per Capita Availability (kg/head/year)	Self Sufficiency Rate*(%)
Eggs	1970	4566,4	4524,8	14,112	100,92
	1975	4805,3	4788,4	14,554	100,35
	1980	5164,7	5052,4	15,083	102,22
	1985	5262,9	5155,3	15,247	102,09
	1990	4963,7	4833,7	14,196	101,64
	1994	5075,8	4953,9[1]	14,195	102,46
Milk	1970	101000	99646,4	310,781	101,358
	1975	108000	105937,5	321,994	101,947
	1980	122000	117513,3	350,817	103,818
	1985	127000	122488,8	362,263	103,683
	1990	121000	116220,3	337,823	104,112
	1994	115000	114695,5[1]	328,686	100,265

Source: FAO Database accessible via WWW.
[1] For 1994, availability was calculated according to the identity: Production + Import - Export ± Stock Changes* (Production / Availabity) x 100.

Table 2 ***Per capita availability of eggs and milk in EU countries (kg/head/year).***

	Eggs			Milk		
	1970	1980	1992	1970	1980	1992
Bel/Lux	14	14	13	394	372	295
Denmark	13	14	17	827	918	743
France	13	15	16	438	487	422
Germany	16	17	14	364	396	324
Greece	10	12	11	174	205	202
Ireland	13	12	10	989	1.311	1.485
Italy	11	12	12	188	218	228
Netherlands	15	14	14	542	680	663
Portugal	4	6	8	81	90	169
Spain	13	17	16	168	179	171
UK	16	14	11	233	276	244
EU12	14	15	14	310	350	317

Source: FAO Database accessible via WWW.

(3) Chenery (1960) has shown that, from a production function $Q_j = D_j + W_j + X_j - M_j$ (where Q_j is production of commodity j, D is final consumption, W is intermediate usage, X is exports and M is imports) it is possible to derive to a function where the only explanatory variables are income and size.

whether each variable is integrated of order one [I(1)], i.e. they are non-stationary at the level, yet they turn stationary when they are first differenced, which is a necessary condition for the existence of a cointegrating equation. Next, the variables are tested for a long-run cointegrated relationship. All equations and tests are estimated using Microfit 3.1 (Pesaran and Pesaran 1991).
In **table 3** results obtained from the unit root tests are presented. It can be seen that all variables are integrated of order one, hence they can be further examined for the existence (or not) of a equilibrium (cointegrated) relationship that keeps the variables involved in the function (1) bound together in the long-run.
The results of the tests for cointegration, derived from the Johansen technique are presented in **table 4**. They are based on the maximal eigenvalue test and the trace test of the stochastic matrix, used to determine the number of cointegration vectors and to estimate the presented long run normalised coefficients, for the function (1) regarding eggs and milk market in the EU.
In the case of eggs, the results strongly suggest that the variables are indeed cointegrated, being bound together by one or more long-run equilibrium relationships, while in the case of milk, the hypothesis of the existence of a cointegrating equation can only be accepted at the 90% significance level.
Hence, there are two cointegrating vectors in the case of eggs production and one in the case of milk production.
The analysis of the estimated long-run coefficients shows that population is the major determinant of the "normal" product given by function (1) for both products under study. In particular for milk production, population has a strong influence and is, surprisingly, of negative sign.
Small rates of population growth and the resulting limited proportion of infants in the EU might be the key explanatory factor.
Income on the other hand, has a completely different impact on each product:
While for the milk market in the EU it affects the "normal" product positively, for the egg market it has a negative effect.
In other words, as income in the EU increases, consumers tend to reduce the consumption of eggs (possibly due to dietary reasons) and purchase other products of higher perceived value and sharper image.
The positive effect of income on milk can be attributed to the increased advertising and generic promotion expenditures and the fact that some South European countries exhibit relatively low rates of self-sufficiency in milk.
Recalling the long run production model of equation (1), its specific functional form can be expressed as follows:

$$Q_t = A P_t^{\beta_1} Y_t^{\beta_2} \qquad (2)$$

where β_1 and β_2 represent long run elasticities with respect to population and income respectively and A is a constant term.
The natural logarithmic form of (2) can be written as:

$$Q_t = \beta_0 + \beta_1 P_t + \beta_2 Y_t \qquad (3)$$

where log A = β_0.
In order to incorporate the dynamics of production in different livestock product sectors, error correction models (ECMs) are next employed. By taking first order differences for equation (3), a standard short run ECM is produced, as shown by equation (4):

$$\Delta Q_t = \gamma_1 \Delta P_t + \gamma_2 \Delta Y_t - \gamma_3 (Q_{t-1} - \beta_0 - \beta_1 P_{t-1} - \beta_2 Y_{t-1}) + U_t \qquad (4)$$

where U_t is a disturbance term.
Assuming that the ECM is correctly specified, Ut should be "white noise".
The bracketed term refers to the error correction mechanism, that is included so as to correct errors experienced in the previous time period. The value of γ_3 indicates both the direction as well as the magnitude of the adjustment mechanism for the ECM. A high absolute value for γ_3 implies that a large proportion of modelling error encountered in the previous time period will be

Table 3 ***Tests for unit root.***

	DF Test	ADF test
LQE	–1.9108	–2.2821
LQM	–2.3259	–2.5505
LY	–1.8108	–1.6062
LP	–2.5480	0.3414

H_0 is that the variable in question is I(1). Critical values (95%) –2.9907 (DF), –2.997 (ADF).

Table 4 ***Cointegration tests for variables in function 1: Egg and milk production.***

Maximal Eigenvalue of the Stochastic Matrix				
	Egg Production	Milk Production	Critical Values	
H_0	LR	LR	95%	90%
r = 0	43,09**	20,71*	20,97	18,60
r ≤ 1	16,95**	8,05	14,07	12,07
r ≤ 2	0,96	0,04	3,76	2,69
Trace of the Stochastic Matrix				
r = 0	60,99**	28,80*	29,68	26,78
r ≤ 1	17,90**	8,09	15,41	13,32
r ≤ 2	0,96	0,04	3,76	2,69
Estimated Cointegrating Vectors (Coefficients normalised)				
Eggs	Vector 2:	LQE = –0.81326* LY + 1.3264* LP		
Milk	Vector 1:	LQM = 3.3459* LY – 15.6041* LP		

(*) (**) Rejection of H_0 at 90% (95%) significance level.

rectified in the current period. As the absolute value for γ_3 is less than unity, the resulting error in each successive period is systematically narrowed down until a stable equilibrium is ultimately achieved. Moreover, the sign of γ_3 indicates the relative relationship between normal estimations and actual production values. If a positive γ_3 is recorded, normal production figures are on average below the actual production ones and vice versa.

Equation (4) can be rearranged in order to facilitate its estimation by the OLS procedure. In such a case it is written as:

$$\Delta Q_t + \gamma_0 + \gamma_1 \Delta P_t + \gamma_2 \Delta Y_t - \gamma_3 (Q_{t-1} - Q^*_{t-1}) \quad (5)$$

The term $(Q_{t-1} - Q^*_{t-1})$ is an error correction mechanism which incorporates the differences (residuals) between estimated and actual production. The residuals from the "normal" production, derived to from the long run modelling procedure are used for this short run dynamic estimation. The ECMs are produced by using a Hendry-type estimation procedure (the so-called testing down procedure) (Hendry 1993). This procedure involves placing all lagged variables into an initial equation for estimation and iteratively eliminating the most insignificant ones until only a set of significant variables is left to capture the dynamic situation. **Table 5** reports the final ECMs obtained for each livestock product under study. For the hen egg sector, income variables in the short-run, similarly to the long-run model, produce negative effects on production, but are statistically insignificant. Hence, intuitively it can be argued that in the short-run, income does not significantly affect the level of production of eggs and therefore, it does not cause (in the Granger sense)(4) changes in the production level. Enlightening further the particular function of eggs, a few additional aspects should be stressed: The overall performance of the model is generally satisfactory, as indicated by the obtained results from all diagnostic tests. Therefore, if the income variables are dropped, the explanatory efficiency of the model will be greatly reduced. The test statistics for serial correlation (3.74) barely exceed the corresponding 95% critical value, indicating that serial correlation between explanatory and dependent variables cannot be rejected. Significant impacts for the population variables are recorded in t-2 and t-4 time periods, which indicate elastic responses with respect to population changes in different time periods. Moreover, the negative ECM variable that is obtained, suggests that the estimated egg production (LQE_{t-1}) is greater than the actual egg production (LQE^*_{t-1}). The short-run model for the milk sector is fairly simple, since there is only one explanatory variable and an ECM variable incorporated in the equation. Hence, it is not surprising that a rather low R^2 value is obtained. Nevertheless, the explanatory variables are significant according to the corresponding t-statistics. The positive value of the ECM variable indicates that the predicted production (LQM_{t-1}) is less than the actual production (LQM^*_{t-1}). However, it is worth noting that the population variable in the short run, differs from the one obtained in the long run, a fact which should be attributed to the lack of a relevant short run income effect, due to the absence of any income variables in this model. In general, the estimation parameters obtained by the short-run models differ from those provided by the corresponding long-run ones. A number of reasons can be mentioned, such as the dynamic nature of the estimation method itself and the model's parameters which are influenced by the error correction technique. Moreover, it should be stressed that all variables used are aggregate data. Indeed, the long run aggregate market environment could be significantly altered by the implementation of new EU legislative measures and other mainstream agricultural policy changes. Hence, the long run estimations of the coefficients produce clearer indications of trends. On the other hand, the short run aggregative responses are more difficult to analyse, since many socio-economic factors (i.e. local elections, structural employment, welfare issues) and other agriculture specific factors (i.e. weather variations, movements of labour, transfers of farming capital and changes in agricultural land prices) may change at any time within different EU countries. Nevertheless, the interpretation of the modelling procedures employed in this paper is still noteworthy, as they provide some crucial benchmark values for the integrated community which can be used for meaningful comparisons at the international level, especially with other major agricultural trading markets. Equally important, these findings can also facilitate the investigation of relative production efficiencies among different EU countries so as to identify national comparative advantages.

Conclusions

The livestock sector in the EU absorbs a large proportion of the CAP subsidies budget and as the current EU agricultural policy aims at reducing the subsidies expenditure, acrimonious disputes among individual Member States are generated. On the other hand, certain trends in consumer life-styles and consumption patterns have led to decreasing purchasing quantities of

(4) It should be noted, that Granger-causality does not imply "causality" in its strict sense, but rather "precedence" (In and Menon 1996). Within this context, income changes appear not to proceed production changes.

Table 5 ***Empirical short run estimations on "normal" quantities for eggs and milk produced in the EU.***

$$\Delta LQE_t = 1.706 - 0.353\Delta LY_{t-1} - 0.280\Delta LY_{t-2} - 0.377\Delta LY_{t-3} + 12.958\Delta LP_{t-2} - 13.353\ \Delta LP_{t-4} - 0.276ECM_{t-1}$$

3.283† 1.609 1.007 1.393 2.122 2.212 3.315

$$\Delta LQM_t = -23.508 + 7.221\Delta LP_{t-1} + 0.126ECM_{t-1}$$

3.874 2.973 3.873

Statistics	Eggs ECM equation	Milk ECM equation
R^2	0.5986	0.47648
F-test	F(6,13) = 3.231	F(2,20) = 9.1016
Serial Correlation	x2 (1) = 3.7394 [0.053] ††	x2 (1) = 0.78265 [0.376]
Functional Form	x2 (1) = 1.5067 [0.220]	x2 (1) = 0.23952 [0.625]
Normality	x2 (2) = 0.9644 [0.617]	x2 (2) = 0.2414 [0.886]
Heteroscedasticity	x2 (1) = 0.1579 [0.691]	x2 (1) = 0.47184 [0.492]

† t-ratios †† significance levels

some livestock products. In this study, two livestock products, namely eggs and milk were examined by employing the cointegration analysis and the ECM technique. Results implicitly indicate that in the long-run, their output, per capita income and population in the EU, are variables that have common trends and are bound together with an equilibrium relationship. While for the case of milk this is only weakly supported, in the case of eggs it is apparent from the results that the level of output is indeed bound together in long-term equilibrium relationships with the other two variables. This implies that despite certain deviations that may occur in the short-run, evidently in the long-run their trend is related. The "normal" product in both markets is significantly determined by variables reflecting the level of growth (income) and the size of the market (population). Although the main determinant of the "normal" product is, in both cases, the population, its magnitude differs significantly. Both explanatory variables, population and income, affect eggs production in the short-run, but only the former plays a significant role on the milk production in the short-run. The application of the ECM suggests that in the short-run, income does not significantly affect the production level of either of the two products (i.e. statistical insignificance of the explanatory variables). On the other hand, it seems safe to argue that population does Granger-cause the output level, while the statistical significance of the lagged error correction term indicates that the level of output is endogenously adjusted in the short-run to its long-term equilibrium relationship with the other cointegrating variables (Masih and Masih 1996). Finally, in the case of eggs, the negative ECM variable that is obtained, suggests that the predicted egg production is greater than the actual, while the opposite holds in the case of milk. The variability of livestock production, such as the products under study, is strongly associated with the biological nature of the production. Agricultural policy authorities could improve their decision-making environment taking into account the estimates of this paper. For example, the observation obtained, that the major determinant of the "normal product" is the population, may explain the excess growth of milk production volumes, particularly in northern Europe. By contrast, south European countries do not possess this glaring feature, a fact which exacerbates debate. Hence, a reallocation of the EU subsidy budget in favour of the south European countries could trim and make more efficient the agricultural policy of the EU.

Still, we think that further investigation of the eggs and milk markets, both at the EU level as well as at individual countries, will reveal additional useful information for agricultural policy makers. ●

Reference

Chenery H.B. (1960) - Patterns of Industrial Growth. American Economic Review, 50, 624-653.

Hendry D.F. (1993) - Econometrics: Alchemy of Science. Blackwell.

In, F. and Menon, J. (1996) - The Long-Run Relationship between the Real Exchange Rate and Terms of Trade in OECD Countries. Applied Economics, 28, 1075-1080.

Johansen S. (1988) - Statistical Analysis of Cointegrating Vectors. Journal of Economic Dynamics and Control 17, 231-254.

Johansen, S. and Juselius, K. (1990) - Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand of Money. Oxford Bulletin of Statistics, 52(2), 169-210.

Katos A.V. (1980) - Portugal, Spain and Greece: On the Dynamic Effects of Joining the EEC. Journal of Economic Studies 7(2), 87-98.

Masih, A.M.M. and Masih, R. (1996) - Temporal Causality and the Dynamics of Different Categories of Crime and their Socioeconomic Determinants: Evidence from Australia. Applied Economics, 28, 1093-1104.

OECD (1994) - Dairy Sector Indicators. OECD Publications, Paris, France.

Pesaran M.H. and Pesaran B. (1991) - Microfit 3: An Interactive Econometric Package. Oxford University Press.