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An EC Feed Grain Spatial Equilibrium Model for Policy Analysis

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Abstract

This paper presents a multicommodity price-endogenous spatial equilibrium model of the EC feed grain sector. The model incorporates nonintegrable feed grain demand functions which were estimated using a pseudodata approach based on a set of representative least-cost LP models of compound feed production in the EC. The price and quantity impacts of three "rebalancing" EC policies are investigated within a comparative statics framework: the abolition of the green rates or MCA system, a 10% cut in support prices for EC grains, and a 10% tax on the use of imported cereal substitutes. Both "short-run" (constant livestock output) and "long-run" (variable livestock output) results are reported at the EC level.

Introduction

This paper presents a static multicommodity model of spatial price equilibrium for the EC grain sector, specified at the level of the EC-9 member countries. The spatial model represents the processes of EC grain price formation and the balancing of demand and supply through intra- and extra-Community trade and public intervention buying. The model is used to examine the price and quantity impacts of alternative EC policy measures.

The paper is organized as follows. In the next section the basic features of the spatial model and its mathematical formulation are presented. Then, the data and specific assumptions underlying the empirical model are described, along with the method adopted to obtain feed grain demand parameters. The following sections are devoted to the outcomes of the base-run equilibrium solution of the model and the results of alternative policy simulations. The final section gives a summary and some concluding remarks with regard to the analysis.

Model

Basic features

The model constructed for the present analysis is specified as a Takayama-Judge quadratic programming (QP) problem (Takayama and Judge 1971). This specification implies that the analysis implicitly assumes that the EC (feed) grain sector behaves as a competitive spatial system. However, since domestic market prices in the EC are strongly influenced by the Common Agricultural Policy (CAP), the model also incorporates the central features of the CAP cereals regime. Therefore, the "traditional" Takayama-Judge specification has been adjusted (Thore 1986) to accommodate the price restrictions associated with the EC grain market organization.

The model developed is partial-equilibrium and comparative-static in nature, covering six major grains (maize, sorghum, soft wheat, barley, oats, rye) and the individual member states of EC-9 (Germany, France, Italy, the Netherlands, Belgium/Luxembourg, United Kingdom, Ireland, Denmark). The model includes linear price-dependent demand functions for the various grains used in livestock feeding, recognizing the existence of substitution and complementarity relationships between and among grains and non-grain feed resources. Separate demand functions are estimated for each EC member country. The intercept values of the demand functions can be modified to cope with changes in variables not explicitly embodied in the model (demand shifters, such as prices of cereal substitutes or livestock production). The EC member countries are spatially separated by transportation costs and Monetary Compensatory Amounts (MCAs).

Basically, the model reflects "short-run" relationships in the sense that both grain production and animal supply in each country are treated as fixed -- assuming a time horizon of one crop year. However, we will also introduce "long-run" responses by allowing livestock production to vary. The model is "partial" in the sense that the price formation of other (agricultural) products is not explicitly analyzed. For instance, whereas the model calculates equilibrium prices for grains, the (world) prices of competing non-grain feedstuffs are determined exogenously.

The present study is the first attempt to develop a multicommodity price-endogenous QP-model of the grain markets in the EC. Lückemeyer (1977) constructed a linear transportation model of the EC feed grain sector, assuming perfect substitutability among feed ingredients, with the latter restricted to the various feed grains and soybean meal (see also Guedry 1973). By incorporating price-elastic feed grain demand functions as well as extending the commodity coverage, the present model becomes much more realistic.

Mathematical formulation

The model specification is given in matrix notation. Vector elements relate to eight countries (member states of EC-9, with Belgium and Luxembourg treated as one single country) and six commodities (grains).

The following definitions are used:

y = vector of market demand quantities for grains used in livestock feeding;

a = vector of market demand intercepts;

B = (asymmetric) matrix of slope coefficients of market demand;

q = vector of market demand for grains for non-feed uses;

x = vector of total market supplies of grains;

p = vector of market prices of grains;

IP = vector of EC intervention prices;

TP = vector of EC threshold prices;

u = vector of excess supplies (intervention stocks and/or exports to third countries);

v = vector of excess demands (imports from third countries);

z = vector of intra-Community trade flows;

t = vector of intra-Community transportation costs;

MCA = vector of net MCAs applied to intra-Community trade;

A = (condensed) matrix of trade flow coefficients.

The endogenous variables of the model are y, u, v, z, p; the exogenous variables are x, q, t; the controllable policy variables are IP, TP, MCA. The set of (inverse) feed grain demand functions is

(1) $p = a - B.y$

A so-called "primal-dual" QP-model is used to handle the asymmetries in the estimated feed grain demand relationships. This leads to the formulation of the following net social revenue (NSR) problem (Takayama and Judge 1971, chap. 12):

(2) Max NSR

$$= (a-\Omega.y)'.y + (q-x)'.p + IP'.u - TP'.v - (t+MCA)'.z \quad \text{with} \quad \Omega = \tfrac{1}{2}(B + B')$$

subject to the following constraints:

(3) $p \geq a - B.y$

The market demand price of each grain in each country is greater than or equal to the corresponding equilibrium price.

(4) $A'.p \leq t + MCA$

The price difference for each grain between each demand country and each supply country is less than or equal to the corresponding inter-country transfer cost.

(5) $p \geq IP$

The market demand price of each grain in each country is greater than or equal to its effective intervention price.

(6) $p \leq TP$

The market demand price for each grain in each country is less than or equal to its effective threshold price.

(7) $x + A.z + v = y + q + u$

The sum of domestic market supply, net inshipments from other EC countries and imports from third countries (in case of deficit) for each grain in each country is exactly equal to the sum of domestic market demand for feed and non-feed uses and exports to third countries cum intervention stocks (in case of surplus) for the same grain in the same country. The different situations (surplus vs. deficit) can be depicted in a diagram as shown in Figure 1.

(8) $y, u, v, z, p \geq 0$

The variables in the optimal solution must be non-negative. Note further that the optimal solution must satisfy $u'.v = 0$ -- i.e., u and v cannot both be positive at the same time.

Data and specific assumptions

A consistent database has been developed for the 1984/85 grain marketing year. The choice of this year is due to the availability of data. When this study was initiated, the latest production and consumption data available were for the year 1984/85. For all model calculations, the ECU at central rates is used as a common currency.

Regional demarcation

The spatial model of the EC grain sector includes the individual member countries of EC-9./1/ One or more geographical centers for each member country are identified in order to estimate the "distances" and transportation costs between the EC member countries.

Regional supplies

The EC supply of grains is not analyzed in this study. Production of grains is taken as given. The supply of grains on the market in each EC member country consists of the whole quantity of domestic grain production available for all uses at the beginning of the crop year minus the on-farm use of grains (including changes in farm stocks) plus private and public (intervention) stocks "carried in" from last year's supply.

Regional demands

The demand side of the system incorporates consumption of grains for feed and non-feed uses, as well as private stocks "carried out" to the following year.

The model includes linear demand functions for the various marketed grains used for livestock feeding in each EC member country. Due to data limitations, it is assumed that all marketed grains in the EC are used for the manufacturing of compounds./2/ The demand functions are constructed on the basis of estimated own- and cross-price elasticities of market demand and 1984/85 market prices and commercial feed grain consumption levels. The method by which the relevant elasticities are estimated will be described briefly in the next section.

Demand for grains for non-feed utilization (food, industry, seeds, losses), including private stocks (which are assumed to be solely determined by transaction motives), are fixed throughout the present analysis. In addition, on-farm use of grains, which directly affects market supply (see above), is treated as given.

Estimation of own- and cross-price elasticities

Market demand for feed grains (and other feedstuffs) in the EC is largely determined by the behavior and conditions of the compound feed industry in the EC. Hence, own- and cross-price demand elasticities for nine individual feed ingredients and three broad groups of feed ingredients (see Appendix Table A.1) are derived by simulating the cost-minimizing behavior of "typical" feed compounders in the EC member countries using the so-called pseudodata technique. This approach, which was introduced by Griffin (1977 and 1978), has been successfully employed by McKinzie et al. (1986) in estimating the elasticities for the Dutch compound feed industry. In adopting this technique, it is possible to capture the complex inter-relationships among the various feed grains and other feed items at a disaggregated level, while avoiding the statistical and methodological problems due to the inflexibility of the EC grain prices and the collinearity among the various feed prices.

In the present analysis, country-specific least-cost (LP) feed ration models for four types of livestock (cattle, pigs, layers, broilers) are used to generate the pseudodata./3/ Approximate regional 1984/85 feed prices are used to obtain base-case solutions. Subsequently, each price is parametrically varied by some multiples of the 1984/85 base values while holding constant all other prices. The prices of the ingredients belonging to one group are varied simultaneously. The price levels employed range from 50% to 200% of the 1984/1985 level./4/ The various LP formulations, then, are locally approximated or "summarized" by smooth translog cost functions fitted to the optimal solutions over the sample of the different feed prices for each EC member country. The coefficients of the translog cost functions are obtained by least-squares (Zellner) estimation of the systems of cost share equations.

Given the assumed cost-minimizing behavior, the estimated elasticities are "output-constant" demand elasticities -- that is, they correspond to a given level of compound feed demand. However, to construct the "conditional" feed grain demand functions below, the elasticities for the cattle ration are slightly adjusted to account for the possible "short-run" substitution toward home-grown feed resources (forages and cereals). The outcomes suggested, however, that the impact on the values of the estimated elasticities is in fact negligible. The "short-run" compound feed substitution is ignored for the other livestock categories, since there is relatively little scope to substitute home-grown feed resources for manufactured compounds in the more specialized pig and poultry subsectors (see also Surry 1987). Aggregate (mean) demand elasticities are calculated by weighting the elasticities for the individual livestock rations according to the percentage shares of the feed ingredients in each ration and the shares of the rations in total compound feed demand (production)./5/ The estimation results are broadly comparable with those of McKinzie et al. (1986) for the Netherlands. The estimated elasticities are reported in Appendix Table A.2.

Derivation of (conditional) demand equations

The feed grain demand functions are derived by taking the estimated mean elasticities and the price-quantity points in the base year 1984/85, then forming tangent linear curves. The demand schedules are "conditional" in the sense that they are defined for a given number of animals fed. In other words, it is implicitly assumed throughout the analysis that livestock inventory does not respond to changes in feed prices within the time horizon of one year./6/ Furthermore, it is implicitly assumed that the plane of nutrition in pig and poultry production is constant.

Regional CAP support prices

Domestic market prices in the EC move within a relatively narrow institutional price band which is determined by intervention prices, on the one hand, and threshold prices, on the other hand. For the present model, this implies that (a) the EC import demand schedules are horizontal (perfectly elastic) at the level of the threshold prices, and (b) the EC export supply schedules and/or intervention demand schedules are horizontal (perfectly elastic) at the level of the intervention prices. Since exports to third countries generally originate from EC surplus areas, it is assumed that the exporters' purchase prices are equal to the intervention prices. The CAP support prices included in the model (which take account of the monthly increments) are national prices denominated in ECU, thus reflecting the differences implied by the application of the so-called green conversion rates.

Interregional transfer costs

Interregional transfer costs are composed of (a) transportation costs and (b) MCAs. Transportation costs between all pairs of EC member countries are drawn from many different information sources. The model makes considerable use of estimated waterborne freight rates between countries, using statistically estimated (OLS) transportation cost functions. All transportation costs are assumed to be independent from the type and volume of grain transported. Intraregional flows are assumed to take place at zero cost. The matrix of estimated intra-EC transportation costs is given in Appendix Table A.3.

MCAs applied to intra-EC trade are taxes on trade flows from weak-currency countries (e.g., France or Italy) to strong-currency countries (e.g., Germany or the Netherlands), and subsidies in the opposite direction. The (average) net MCAs applicable in 1984/85 have to be added to (taxes) or subtracted from (subsidies) the estimated intra-EC transportation costs.

Base-run solution

The primal-dual QP-model of the EC grain markets is solved for the marketing year 1984/85./7/ The predicted values of the spatial model validate quite closely with the actual market figures. The results of the base-run solution and the corresponding actual market figures are not shown here, however, due to space limitations. They are available from the author upon request. Deviations of the equilibrium solution values from the data are merely considered as a rough indication of model performance./8/

Policy applications

In this section the spatial model is used for detailed policy analysis within a comparative statics framework. Three policy options are being simulated: Option 1 = abolition of the green rates or MCA system; Option 2 = a 10% cut in support prices for EC grains; Option 3 = a 10% tax on cereal substitutes (soybean meal, MGF, manioc, and other energy-rich products, mainly beet and citrus pulp). The policy options are relatively easy to simulate with the spatial model by adapting (a) interregional transfer costs (Options 1 and 2), (b) the imposed price restrictions (Options 1 and 2), and/or (c) the intercept values of the various feed grain demand functions (Option 3). Of course, various other policy changes could be analyzed with the model. The base-run solution serves as a reference mark against which the effects of the various EC policy changes are being assessed.

Movements in world prices

The analysis must take into account the possible "terms-of-trade effects" of EC grain policy changes, since the EC claims a substantial share of world trade in feed grains and grain substitutes. Changing world prices may have far-reaching consequences for the internal as well as external effects of the policy measures, since they determine the position of the demand functions for feed grains in the various EC member countries. In analyzing the impacts of EC grain policy changes, different scenarios with respect to the adjustment of world prices may be considered. For the purpose of this study -- and in view of the uncertainty with respect to the true world market price changes in response to EC grain policy measures -- results are calculated for two different scenarios: Scenario 1 = world prices of grains and non-grains are constant; Scenario 2 = world prices of grains and non-grains are variable.

Scenario 1 must be regarded as a "benchmark" rather than as a realistic assumption (sensitivity analysis). Both scenarios are analyzed for Options 2 and 3; for Option 1 world price changes are left unconsidered. The assumed world price changes for Scenario 2 are as follows: grains +2.75%; soybean meal -1.25%; MGF -2%; manioc -5%; other energy-rich feed items -5%; other protein-rich feed items "no change"./9/ The choice of these values is influenced by results reported in EEC (1988). The exogenous movements in world prices are specified in terms of parallel vertical shifts in the feed grain demand functions included in the spatial model. Note that the "terms-of-trade effects" for grains do not radiate into domestic markets due to the variable levy system applicable on EC grain imports.

Results of policy simulations

The quantification of the impacts of the policy changes is accomplished by employing (comparative static) multiplier analysis. Spatial equilibrium multipliers are obtained for each endogenous variable by taking the percent difference between the base-run and the policy-simulated values./10/ Due to space limitations, results are only presented for the EC. The results at member country level are available from the author upon request. The percentage multipliers for the price and quantity variables at EC-level are summarized in Table 1, columns [1.1], [2.1] and [2.2], [3.1] and [3.2], where [i.j] denotes Option i, Scenario j.

With regard to the EC demand for soybean meal, two sets of results are presented: Set (1) is based on the estimated elasticities used in the construction of the demand functions; Set (2) is based on (smaller) elasticities which were obtained by incorporating more stringent inclusion restrictions for soybean meal in the feedmix models for cattle used in the simulation process. The same policy-induced EC grain price changes are assumed, however, for both sets of results. Consequently, Set (2) results for soybean meal are subject to some (minor) bias -- although, overall, they seem to be more reasonable.

Adjustments in livestock production: expansion effect

It is instructive to differentiate the "short-run" or conditional effects of a policy change on price and quantity variables, holding livestock output (inventory) constant, from the "long-run" policy effects, allowing livestock producers to make structural adjustments to their livestock holdings in response to changing (compound) feed prices. Taking the difference between the two permits the calculation of the expansion or contraction effect of EC policy changes. It has implicitly been assumed that EC policies towards animal products remain unaltered.

The expansion or contraction of livestock output induced by EC grain policy changes will not only influence the demand for compounds and, hence, the market demand for the various feed grains, but also the on-farm use of feed grains. Consequently, adjustments in the animal sector should be represented within the spatial model by two distinct modifications: first, horizontal shifts in the estimated feed grain demand functions (in direct proportion to the change in the demand for compounds); second, changes in the domestic market supply data for the various grains. However, due to the lack of knowledge about the possible changes in the on-farm use (or marketings) of feed grains, the present analysis is confined to the first mechanism. An overview of the assumed parameters and implied elasticities used in the analysis is given in Appendix Table A.4. The long-run animal supply or livestock inventory elasticities with respect to compound feed prices, β, which by assumption also implicitly reflect the changes occurring in livestock and livestock product prices, are derived from a review of estimates used or obtained in other studies (for example, Mahé 1987 and Surry 1988). The low supply elasticity for beef/dairy is a reflection of (a) the fact that this animal sector is still predominantly a grass-based activity in the EC and (b) the operation of the policy-determined milk quota. The values assumed for the output elasticities, ξ, and the long-run ("uncompensated") own-price elasticities, η^*, of compounds are broadly comparable with those obtained by Surry (1988) for the French compound feed industry./11/

The results with respect to the "long-run" effects of EC grain policy changes on the use of feed grains and imported feed ingredients at EC-level are set out in Table 1, columns [1.1]*, [2.2]* and [3.2]*. The results in Table 1 clearly illustrate the relative importance of the substitution ("short-run") and expansion effects. In the case of the MCA abolition, the output effect on EC feed grain consumption is negligible. In the case of a 10% price cut, both the substitution effect and the expansion effect on EC feed grain demand are positive. In the case of a 10% tax, the substitution effect on EC feed grain demand is positive, but the expansion effect is negative (contraction); the total effect still remains positive, however. In other words, the difference between the impacts of Option 2 vs. Option 3 has been amplified by the introduction of the expansion and contraction effects; the contraction of livestock production due to increased feeding costs implied by Option 3 further reduces the relatively low favorable effect on EC feed grain consumption. Total use or production of compound feeds increases by 3.8% (decreases by 1.4%) under Option 2 (Option 3), due to the induced changes in livestock production. These effects are smaller than generally expected./12/ Furthermore, with a 10% cut in support prices the EC demand for soybean meal increases by nearly 1%. As a result, soybean meal and EC grains can be considered as gross-complements in the livestock feeding in many EC countries (in fact, soybean meal demand would drop only in Germany and the Netherlands). Surry (1987) obtained a similar result for the French compound feed industry. In addition, EC imports of MGF (from the U.S.) are only slightly hurt by the price cut measure when the expansion of the animal sector is taken into account. With a 10% tax, on the other hand, imports of soybean meal, MGF and manioc are all severely and adversely affected.

Summary and conclusions

This paper presented a spatial price equilibrium model of the EC grain markets, and illustrated how this model can be used for policy analysis. The model provides a theoretically consistent and detailed representation of the main linkages characterizing the EC (feed) grain sector. The model includes structural feed grain demand functions and strategic policy parameters of the EC grain sector. The incorporation of the demand functions into the spatial model permitted the simultaneous solution of prices and quantities, and allowed for the examination of cross-commodity effects of alternative policy scenarios. The effects of three policy changes were examined within a comparative statics framework: (a) the abolition of the MCA system, (b) a 10% cut in EC grain support prices, and (c) a 10% tax on the use of (imported) grain substitutes.

In general, the numerical results of the policy simulations are quite plausible. They show that the inter-commodity substitution effects in animal feeding are very important. On the other hand, the expansion or contraction effects due to changes in livestock production are relatively moderate (although they are unequal in magnitude for the individual EC member countries, as a result of both varying structures of total livestock production and different ration compositions). The results further clearly suggest that a 10% price cut is far more effective in restoring market balance in the EC than a 10% tax on grain substitutes. The analysis has also indicated that the pattern of intra-EC grain flows remains strongly dominated by the French export position (which may be significantly affected, though, by a dismantling of the MCA system). Any move towards a rebalancing of the EC feed markets invariably leads to an increase in the imports of "deficit grains" (maize and sorghum) at the expense of the intra-Community trade for these grains, as well as to an increase in the intra-Community trade of "surplus grains" (wheat, barley, and oats). Moreover, the EC imports of soybean meal and MGF are only slightly affected in the long run by general price support cuts in the EC.

The present study of the EC feed grain markets has several appealing and distinctive qualities. First, the analysis contributes largely to improve the knowledge of the substitution elasticities of feed grain demand. Such elasticities are crucial to any sector modeling and provide a solid foundation for policy analysis. Second, the specification of the spatial model of the EC grain sector as a primal-dual QP-problem facilitates the direct inclusion of various policy-determined (price and quantity) restrictions. This flexibility provides a strong argument for using QP to solve any linear trade model./13/ Third, the sensitivity of the policy impact multipliers to changes in world prices of the major cereal substitutes can easily be examined by simply shifting the feed grain demand functions included in the spatial model. Fourth, since the model is "regionalized" at the level of the EC member countries, it is well suited for studying the geographical distribution (national consequences) of the effects of uniform or "horizontal" EC policy changes.

Despite some inevitable shortcomings and simplifications, the present analysis provides information which may be important to both EC and U.S. policymakers. It is hoped that this study may add to the modeling apparatus available for analyzing various rebalancing CAP reforms and their impacts on EC-U.S. agricultural trade.

Notes

1. The "new" member countries Greece, Spain, and Portugal are excluded, because either they were not EC members in 1984/85 or the necessary data were not available.
2. Although this situation appears to be prevailing only in the Netherlands, the estimates are likely to be representative of a substantial part (about 70% on average) of the total market for feed grains in the EC.
3. Most of the data on feedmix models and feed ingredient prices were available from the Dutch Ministry of Agriculture. The feedmix models take into account various nutritional and technical restrictions, as well as some behavioral restrictions (i.e., observed ingredient usage patterns).
4. The actual multiples used are as follows: 0.5, 0.667, 0.8, 0.909, 0.952, 1.05, 1.1, 1.25, 1.5, 2.0, with most of the observations restricted to the ±25% range (see also Griffin 1978, p.382). It should be noted that the vectors of 1984/85 feed prices reflect the relative price structures prevailing in the various EC member countries, taking also into account the variations in MCAs and transportation costs.
5. In view of the fact that international trade in manufactured compounds is nearly non-existent, a perfect match is assumed between the use and production of compound feeds.
6. The justification for this assumption is twofold, and relates to either biological or economic constraints. First, with cattle there are significant biological time-lags, such as the gestation and fattening periods. Second, with the pig and poultry industries, there are the heavy inputs of fixed (capital) equipment and the high costs associated with the under-utilization of the existing production capacity.
7. The primal-dual QP-model of the EC grain markets is solved with MINOS 5.1 (Murtagh and Saunders 1987). The iterative QP procedure recommended by Irwin and Yang (1982) failed to converge.
8. No normative connotation is attached to the base-run equilibrium solution, given the static nature of the analysis and the underlying assumptions of perfect competition (e.g., product homogeneity, perfect information in the markets, no barriers or capacity restrictions to interregional and/or external trade, etc.) excluding, for example, cross-hauling, trade diversification, and transshipments.
9. As a result, the net price changes on the European market for policy Option 3 are: soybean meal +8.75%; MGF +8%; manioc +5%; other energy-rich feed items +5%.
10. Reduced-form impact or equilibrium multipliers can also be derived directly by applying sensitivity analysis results for variational inequalities developed by Tobin (1987). However, empirical results clearly highlighted the inherent limitations of this approach.

11. Surry (1988) calculated the following "uncompensated" price elasticities of compound feed demand in France: dairy cows -0.72; beef cattle -1.47; pigs -0.53; layers -0.93; broilers -0.66.

12. Moreover, one must realize that these figures are an approximation (overestimation) of the "true" equilibrium multipliers, since they are based on the assumption of a locally horizontal industry supply of compounds. However, the error involved would probably be small or even negligible given the actual horizontal shape of the supply schedules for the major feed grains (maize, wheat, barley) in most of the EC member countries and the exogenously fixed world prices of non-grain feedstuffs.

13. The limitations of using QP spatial models are well-documented in the literature. They are, therefore, not discussed in this paper.

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Figure 1. Grain market for a single EC member country in (a) surplus and (b) deficit

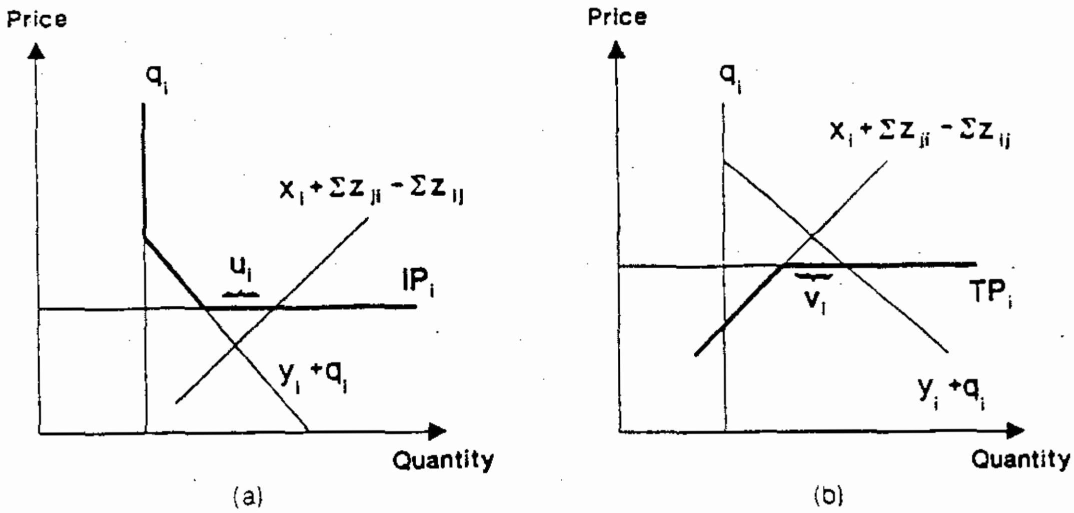

Table 1. Percentage multipliers for the various policy simulations (EC-level)

EC-9	Base values	[1.1]	[1.1]*	[2.1]	[2.2]	[2.2]*	[3.1]	[3.2]	[3.2]*
	(1000t)	-----	-----	-----	(%)	-----	-----	-----	-----
Feed demand (market)									
Maize	11251	-3.1	-3.6	7.4	4.5	8.2	6.2	3.8	2.2
Sorghum	333	9.0	9.0	61.9	23.4	30.3	45.0	5.4	4.2
Wheat	14853	1.0	1.0	14.1	10.6	15.4	10.6	7.0	5.8
Barley	10592	1.0	0.7	39.7	27.8	33.3	30.8	18.8	17.3
Oats	1302	0.0	0.0	16.7	4.0	7.9	0.0	0.1	0.1
Rye	419	32.0	33.9	51.3	35.8	40.8	44.6	28.4	27.2
Total	38750	0.2	0.0	20.1	13.7	18.4	15.1	9.3	7.9
Total demand/a/									
Maize	19115	-1.8	-2.1	4.4	2.6	4.8	3.6	2.2	1.3
Sorghum	361	8.3	8.3	57.1	21.6	27.9	41.5	5.0	3.9
Wheat	42617	0.3	0.3	4.9	3.7	5.4	3.7	2.4	2.0
Barley	18450	0.6	0.4	22.8	16.0	19.1	17.7	10.8	9.9
Oats	2240	0.0	0.0	9.7	2.3	4.6	0.0	0.1	0.1
Rye	2058	6.5	6.9	10.4	7.3	8.3	9.1	5.8	5.5
Total	84841	0.1	0.0	9.2	6.3	8.4	6.9	4.2	3.6
Surplus (exports to third countries/intervention stocks)									
Wheat	24504	-0.6	-0.6	-8.5	-6.5	-9.3	-6.4	-4.3	-3.5
Barley	10336	-1.0	-0.7	-40.7	-28.5	-34.1	-31.6	-19.2	-17.7
Rye	642	-21.0	-22.3	-33.6	-23.7	-26.9	-29.3	-18.8	-18.1
Total	35482	-1.1	-1.0	-18.4	-13.2	-16.9	-14.2	-8.9	-7.9
Deficit (imports from third countries)									
Maize	2143	-16.4	-18.8	39.0	23.6	43.3	32.4	19.8	11.5
Sorghum	35	91.4	88.6	591.4	225.7	294.3	431.4	54.3	42.9
Total	2178	-14.6	-17.1	67.9/b/	31.6/b/	52.0/b/	38.8	20.3	12.0
Intra-EC trade (net exports)									
Maize	4611	-0.5	0.2	-3.0	-2.6	-4.4	-2.4	-2.5	0.0
Sorghum	257	-0.4	-0.4	-15.2	-7.4	-8.2	-7.8	-0.4	-0.4
Wheat	4688	0.2	-0.2	13.7	9.4	13.0	12.1	7.7	6.3
Barley	2751	-11.7	-12.3	102.5	63.4	74.8	82.1	42.6	38.6
Oats	786	-1.5	-1.8	0.0	-2.2	-1.1	0.0	0.1	0.1
Rye	199	8.0	8.0	20.1	12.1	15.1	19.1	10.6	9.5
Total	13292	-2.5	-2.6	25.0	15.5	18.5	20.6	10.8	10.4
Imports (use) of cereal substitutes									
Soymeal(1)	16400	n.a.	n.a.	-18.4	-15.2	-12.1	-38.1	-35.2	-36.2
(2)	16450	n.a.	n.a.	-5.8	-3.1	0.7	-19.9	-17.5	-18.5
MGF	3617	n.a.	n.a.	-11.4	-2.0	-0.4	-34.6	-25.4	-28.5
Manioc	5911	n.a.	n.a.	-21.3	-9.4	-4.2	-23.8	-12.3	-12.7
Production (demand) of compounds									
Cattle	32661/c/	0.0	0.4	0.0	0.0	5.5	0.0	0.0	-1.7
Pigs	26729/c/	0.0	0.0	0.0	0.0	2.5	0.0	0.0	-1.0
Layers		0.0	-0.4	0.0	0.0	3.1	0.0	0.0	-0.8
and Broilers	21191/c/	0.0	-0.2	0.0	0.0	2.6	0.0	0.0	-1.6
Total	80581/c/	0.0	0.1	0.0	0.0	3.8	0.0	0.0	-1.4
	(ECU/t)	-----	-----	-----	(%)	-----	-----	-----	-----
Prices of grains									
Maize	242.2	2.3	2.3	-9.0	-9.3	-9.1	1.1	0.6	0.6
Sorghum	249.8	0.6	0.6	-8.8	-8.7	-8.8	1.4	1.4	1.4
Wheat	202.5	0.5	0.5	-9.7	-9.7	-9.8	0.1	0.0	0.0
Barley	204.0	-0.3	-0.2	-9.1	-9.2	-9.2	0.7	0.5	0.5
Oats	211.8	-0.3	-0.3	-3.9	-4.9	-4.7	4.9	3.1	3.0
Rye	210.4	-3.9	-3.9	-9.9	-9.9	-9.9	0.1	0.1	0.0
Total	212.4	0.6	0.6	-9.3	-9.5	-9.4	0.5	0.3	0.3
Prices of compounds									
Cattle	n.a.	-0.3	n.a.	-3.8	-4.4	n.a.	2.0	1.4	n.a.
Pigs	n.a.	0.0	n.a.	-3.3	-4.1	n.a.	2.6	1.7	n.a.
Layers	n.a.	0.5	n.a.	-4.3	-4.7	n.a.	1.6	1.1	n.a.
Broilers	n.a.	0.3	n.a.	-3.1	-3.9	n.a.	3.3	2.4	n.a.
Total	n.a.	-0.1	n.a.	-3.6	-4.3	n.a.	2.3	1.6	n.a.

/a/ Incl. on-farm use -- /b/ Incl. Italian imports of oats -- /c/ Actual data (average 1984-1985)

Appendix

Table A.1. Feed grains and other feed items used in least-cost (LP) feedmix models

1. Maize
2. Sorghum
3. Soft wheat
4. Barley
5. Oats
6. Rye
7. Soybean meal
8. Maize gluten feed (MGF)
9. Manioc
10. Other energy products: Middlings of maize; Maize oilcakes; Palmkernels; Linseed; Beet and cane molasses; Lactoserum; Beet and citrus pulp; Animal oils and fats
11. Other protein products: Soybeans; Toasted soybeans; Oil cakes of: Copra, Palmkernel, Linseed, Cottonseed, Rapeseed, Groundnut, Sunflower, Babassus, Sesam; Middlings of: Wheat, Rice; Dry fodder peas; Broad beans; Other beans; Potato pulp; Lucerne meal; Vinasse; Skimmed milk powder; Feathermeal; Animal meal; Fish meal
12. Additional ingredients: Calcium; Phosphorus; etc.

Table A.2. Estimated aggregate (mean) elasticities of demand for compound feed ingredients in the EC member countries

D	Maize	Sorghum	Wheat	Barley	Oats	Rye	Soya	MGF	Manioc	Energy	Protein	Other	Average % of ration
Maize	-4.252	0.895	0.791	0.197	0.048	0.139	0.311	0.321	1.098	0.353	0.087	-0.037	8.4
Sorghum	9.455	-26.673	2.957	2.401	0.884	1.339	0.892	1.162	3.458	3.356	1.146	-0.704	0.9
Wheat	0.610	0.196	-3.744	0.673	0.031	0.048	0.058	0.664	0.496	0.623	0.124	-0.041	11.8
Barley	0.579	0.702	3.001	-11.075	0.084	0.472	1.501	0.679	2.731	0.243	0.815	-0.036	3.1
Oats	3.152	5.465	3.054	1.853	-38.370	3.887	4.907	-1.081	7.496	6.673	2.072	0.163	0.2
Rye	3.276	3.081	1.698	3.565	1.408	-24.504	2.079	1.686	4.446	0.965	1.752	-0.145	0.4
Soya	0.298	0.091	0.104	0.407	0.070	0.080	-4.366	0.416	0.080	0.859	1.787	0.081	8.2
MGF	0.470	0.170	1.493	0.336	-0.019	0.114	0.643	-3.476	-0.683	-1.026	0.964	0.060	5.4
Manioc	0.673	0.184	0.381	0.481	0.061	0.100	0.025	-0.244	-1.883	-0.066	0.092	-0.002	17.1
Energy	0.127	0.136	0.417	0.036	0.046	0.018	0.382	-0.307	-0.045	-1.325	-0.293	0.002	18.3
Protein	0.031	0.030	0.007	0.129	0.010	0.022	0.632	0.230	0.042	-0.248	-1.576	0.043	23.8
Other	-0.632	-0.151	-0.531	-0.407	-0.078	-0.013	0.084	0.659	-0.155	0.112	1.249	-0.344	2.3

F	Maize	Sorghum	Wheat	Barley	Oats	Rye	Soya	MGF	Manioc	Energy	Protein	Other	Average % of ration
Maize	-2.566	0.244	1.249	0.696	-0.009	-0.010	0.143	-0.028	0.103	0.314	-0.097	-0.069	14.3
Sorghum	4.395	-22.104	3.839	3.905	2.975	0.462	-0.104	0.694	2.977	3.050	-0.251	-0.238	0.8
Wheat	0.936	0.138	-2.036	0.125	-0.194	0.145	0.105	0.057	0.080	-0.012	0.059	0.010	20.5
Barley	0.867	0.229	0.207	-2.938	0.311	0.329	0.140	-0.008	0.142	-0.020	0.301	0.015	12.7
Oats	1.705	1.906	1.190	0.461	-13.172	1.403	1.658	0.190	1.755	-0.232	2.289	0.383	9.4
Rye	-0.126	0.804	6.090	8.362	0.515	-15.599	0.058	-1.534	1.213	0.462	-1.409	0.345	0.5
Soya	0.181	-0.010	0.192	0.156	-0.128	0.002	-2.421	0.456	-0.084	0.080	0.989	0.054	7.1
MGF	-0.131	0.235	0.551	-0.035	0.753	-0.343	2.320	-4.503	0.084	0.269	0.435	0.101	2.0
Manioc	5.186	4.138	5.920	1.295	0.879	0.847	-1.114	0.133	-15.324	-1.486	-0.695	0.177	1.9
Energy	0.732	0.342	0.055	0.015	0.174	0.046	0.066	0.129	0.020	-1.771	-0.072	-0.073	4.9
Protein	-0.139	-0.004	0.099	0.254	0.167	-0.059	0.738	0.022	0.032	-0.060	-1.373	0.054	13.2
Other	-0.348	-0.166	0.026	0.026	0.016	0.061	0.218	0.156	-0.035	-0.232	0.240	-0.191	3.0

I	Maize	Sorghum	Wheat	Barley	Oats	Rye	Soya	MGF	Manioc	Energy	Protein	Other	Average % of ration
Maize	-1.857	0.665	0.388	0.065	0.009	0.032	0.145	-0.011	0.336	0.213	-0.028	0.010	29.6
Sorghum	10.184	-14.848	1.644	1.082	0.101	0.741	0.746	-0.027	0.756	0.898	-1.298	-0.223	2.2
Wheat	1.383	0.379	-4.256	0.233	0.018	0.152	0.691	-0.105	0.632	0.269	-0.239	-0.094	8.6
Barley	1.351	1.318	1.187	-13.282	0.214	0.507	2.637	-0.206	1.306	3.203	1.025	-0.072	1.8
Oats	1.671	1.254	0.813	2.116	-28.894	-0.397	3.489	4.372	1.612	4.508	8.099	0.647	0.2
Rye	2.682	3.952	3.658	2.347	-0.152	-19.720	3.062	0.556	2.546	0.892	-0.506	-0.075	0.4
Soya	0.588	0.932	2.653	2.335	0.304	0.487	-13.249	2.802	-0.028	0.601	2.210	0.051	13.8
MGF	-0.035	-0.006	-0.159	-0.058	0.116	0.032	0.903	-1.928	-0.089	-0.137	0.382	0.005	5.9
Manioc	3.101	0.438	1.527	0.591	0.077	0.268	-0.473	-0.131	-4.729	-1.396	0.732	-0.129	3.9
Energy	0.346	0.123	0.174	0.371	0.047	0.020	0.049	-0.053	-0.288	-1.557	0.007	-0.022	15.3
Protein	-0.114	-0.164	-0.139	0.104	0.098	-0.016	0.511	0.112	0.216	0.012	-1.001	0.036	14.3
Other	-0.067	-0.077	-0.194	0.067	0.098	0.010	0.234	0.070	-0.084	-0.311	0.169	-0.194	3.8

NL	Maize	Sorghum	Wheat	Barley	Oats	Rye	Soya	MGF	Manioc	Energy	Protein	Other	Average % of ration
Maize	-3.153	0.501	0.738	0.280	0.071	0.101	0.098	0.003	0.726	0.330	0.302	-0.020	9.5
Sorghum	7.964	-30.016	4.665	3.731	0.851	1.844	0.920	-0.017	3.632	3.273	3.320	-0.492	0.7
Wheat	1.288	0.568	-5.437	0.742	0.116	0.186	0.547	-0.013	0.988	0.334	0.546	-0.030	5.4
Barley	1.791	1.637	2.791	-18.024	0.345	0.632	1.214	-0.135	3.840	0.568	5.492	-0.375	1.6
Oats	3.291	2.656	3.014	2.450	-32.004	3.709	3.723	0.038	2.981	2.791	7.293	-0.667	0.3
Rye	3.440	4.360	3.586	3.351	2.728	-28.865	2.542	-0.205	3.304	3.334	2.496	-0.622	0.3
Soya	0.114	0.081	0.325	0.213	0.079	0.085	-2.272	0.019	-0.231	0.169	1.230	0.142	7.4
MGF	0.020	-0.001	0.001	-0.032	0.002	-0.007	0.058	-1.283	-0.249	-0.042	0.627	-0.009	5.1
Manioc	0.515	0.159	0.379	0.396	0.039	0.061	-0.134	-0.091	-1.849	0.248	0.253	-0.012	16.6
Energy	0.108	0.074	0.068	0.036	0.027	0.039	0.057	-0.006	0.167	-1.019	-0.303	-0.006	20.4
Protein	0.088	0.071	0.108	0.266	0.049	0.023	0.347	0.098	0.122	-0.236	-1.414	0.028	29.4
Other	-0.164	-0.128	-0.148	-0.234	-0.027	-0.028	0.357	-0.030	-0.070	-0.098	0.435	-0.163	3.2

Table A.2. (continued)

BLEU	Maize	Sorghum	Wheat	Barley	Oats	Rye	Soya	MGF	Manioc	Energy	Protein	Other	Average % of ration
Maize	-4.561	1.195	0.746	0.375	0.059	0.192	0.022	0.093	1.157	0.543	0.229	-0.077	7.5
Sorghum	10.685	-25.013	4.021	2.947	0.508	1.740	-0.703	0.590	4.104	1.809	-0.306	-0.601	0.9
Wheat	0.387	0.241	-3.042	0.750	0.028	0.031	0.156	0.268	0.452	0.581	0.050	0.016	14.0
Barley	0.951	0.830	3.636	-10.116	0.253	0.340	0.854	-0.177	1.895	0.597	0.902	-0.098	3.3
Oats	2.687	2.589	2.626	4.357	-32.127	2.272	3.480	-1.119	5.804	2.499	5.846	0.450	0.3
Rye	3.431	3.665	1.203	2.460	0.908	-19.596	2.653	0.033	2.777	2.309	-0.384	0.013	0.5
Soya	0.045	-0.080	0.280	0.321	0.071	0.136	-2.650	0.181	-0.074	-0.246	1.809	0.160	6.4
MGF	0.183	0.134	0.944	-0.094	-0.041	0.017	0.368	-4.444	-0.172	0.338	1.772	0.043	3.8
Manioc	0.590	0.247	0.451	0.399	0.075	0.082	-0.040	-0.059	-2.033	0.017	0.271	-0.008	16.0
Energy	0.164	0.070	0.411	0.089	0.019	0.047	-0.090	0.071	0.020	-1.448	-0.027	-0.019	19.4
Protein	0.057	-0.008	0.021	0.094	0.033	-0.007	0.502	0.267	0.138	-0.018	-1.526	0.051	25.8
Other	-0.258	-0.166	0.095	-0.088	0.085	0.022	0.477	0.095	-0.069	-0.626	0.731	-0.358	2.2

UK	Maize	Sorghum	Wheat	Barley	Oats	Rye	Soya	MGF	Manioc	Energy	Protein	Other	Average % of ration
Maize	-1.872	0.638	0.545	0.265	0.022	0.056	0.185	-0.017	0.074	0.127	-0.018	-0.024	16.2
Sorghum	11.207	-23.180	4.770	2.880	0.537	1.180	0.065	-0.800	1.768	1.179	0.448	-0.367	1.0
Wheat	0.381	0.191	-2.118	0.252	0.033	0.037	0.359	0.188	0.124	0.174	-0.237	-0.027	24.4
Barley	0.359	0.199	0.480	-2.963	0.054	0.060	0.203	0.016	0.296	0.358	0.371	0.013	13.3
Oats	1.342	1.967	3.201	2.739	-26.148	1.967	0.221	0.138	2.110	0.404	10.237	0.923	0.3
Rye	4.646	6.017	5.236	4.533	2.742	-39.370	3.347	0.952	4.054	3.287	3.444	0.378	0.2
Soya	0.313	-0.025	1.011	0.305	0.000	0.068	-3.626	0.170	-0.153	-0.125	1.747	0.091	6.8
MGF	-0.201	-0.524	3.441	0.160	0.028	0.135	1.110	-10.279	0.108	-0.535	5.396	0.210	1.3
Manioc	1.173	1.562	2.741	3.407	0.576	0.754	-1.139	0.140	-10.283	0.322	0.778	-0.177	1.2
Energy	0.292	0.223	0.828	0.897	0.017	0.107	-0.200	-0.146	0.055	-2.395	-0.141	-0.038	5.6
Protein	-0.012	0.011	-0.231	0.153	0.098	0.021	0.524	0.250	0.026	-0.027	-1.508	0.021	25.9
Other	-0.165	-0.103	-0.395	0.117	0.116	-0.008	0.213	0.261	-0.066	-0.213	0.148	-0.333	3.7

IRL	Maize	Sorghum	Wheat	Barley	Oats	Rye	Soya	MGF	Manioc	Energy	Protein	Other	Average % of ration
Maize	-3.520	0.908	1.135	0.730	-0.298	0.197	0.311	0.251	0.089	0.346	-0.158	-0.042	8.2
Sorghum	9.562	-27.651	6.146	3.056	0.006	1.304	0.477	3.149	0.420	2.636	0.995	-0.586	0.9
Wheat	0.414	0.204	-2.293	0.312	-0.283	0.398	0.271	0.131	0.108	0.160	-0.078	-0.009	22.8
Barley	0.257	0.094	0.307	-2.345	0.414	-0.022	0.481	-0.343	0.254	0.136	0.039	0.013	24.5
Oats	-0.982	0.032	-3.248	4.901	-4.907	0.357	-0.733	2.105	0.415	-0.113	1.289	-0.099	2.2
Rye	0.716	0.409	4.234	-0.173	0.293	-5.639	0.229	-0.437	0.956	0.286	-0.287	0.083	2.5
Soya	0.147	0.007	0.456	0.827	-0.112	0.044	-3.244	0.672	-0.099	-0.011	0.714	0.061	9.9
MGF	0.175	0.226	0.312	-0.816	0.426	-0.094	0.931	-2.508	0.012	0.186	0.103	0.051	8.8
Manioc	0.846	0.402	2.579	5.911	1.083	2.490	-1.061	0.108	-12.635	0.089	0.357	-0.310	1.1
Energy	0.452	0.383	0.723	0.622	-0.052	0.120	-0.026	0.360	0.012	-2.993	-0.136	-0.079	5.5
Protein	-0.084	0.036	-0.188	0.006	0.246	-0.069	0.795	0.064	0.025	-0.068	-1.475	0.036	10.9
Other	-0.572	-0.217	-0.219	0.671	-0.712	0.278	0.093	1.329	-0.248	-0.986	0.520	-0.493	2.6

DK	Maize	Sorghum	Wheat	Barley	Oats	Rye	Soya	MGF	Manioc	Energy	Protein	Other	Average % of ration
Maize	-4.035	0.854	1.624	0.815	0.090	0.361	0.139	-0.061	0.120	0.232	-0.111	-0.065	7.6
Sorghum	9.148	-27.275	7.071	2.701	0.937	2.853	-1.349	0.362	1.250	1.508	3.130	-0.696	0.8
Wheat	0.498	0.191	-1.991	0.056	-0.037	0.172	0.280	0.037	0.134	0.073	0.099	-0.001	26.3
Barley	0.315	0.086	0.069	-2.261	0.065	-0.067	0.175	0.322	0.569	0.266	0.023	0.005	22.6
Oats	1.556	1.372	-1.922	3.272	-15.994	1.217	-0.727	1.230	2.657	1.567	4.763	0.150	0.6
Rye	0.750	0.535	1.372	-0.369	0.149	-3.992	0.500	-0.046	0.862	0.172	-0.085	0.006	4.0
Soya	0.068	-0.108	0.736	0.350	-0.050	0.183	-3.600	0.615	-0.219	0.335	1.311	0.108	7.7
MGF	-0.062	0.053	0.193	1.281	0.107	-0.019	1.118	-3.321	0.039	-0.846	0.466	0.047	5.1
Manioc	0.532	0.531	1.864	6.219	0.765	1.738	-1.146	0.097	-9.411	0.119	-1.161	-0.221	2.2
Energy	0.243	0.187	0.316	0.987	0.119	0.103	0.586	-0.821	0.031	-2.084	-0.120	-0.003	6.3
Protein	-0.039	0.110	0.131	-0.050	0.155	-0.049	0.790	0.179	-0.101	-0.052	-1.685	0.037	14.5
Other	-0.456	-0.029	0.145	-0.341	-0.261	0.071	-0.065	0.588	-0.325	0.009	0.612	-0.364	2.4

Table A.3. Estimated transportation costs applicable on intra-EC grain trade (ECU/t)

Destination Origin	D	F	I	NL	BLEU	UK	IRL	DK
D	-	10.4	23.6	5.4	6.2	9.2	16.2	4.4
F/a/		-	20.7	9.8	6.6	11.9	11.9	15.3
I			-	20.4	20.4	29.4	29.4	27.9
NL	3.2			-	2.7	8.0	13.8	8.0
BLEU	4.2				-	8.0	13.8	8.6
UK		(symmetry)				-	5.8	9.4
IRL							-	16.2
DK								-

/a/ Transportation costs for maize and sorghum are slightly higher (except for trade with Italy), since these grains are mostly grown in the southern parts of France.

Table A.4. Assumed parameters for the calculation of the 'long-run' expansion effect (EC)

	ν	α	β	ξ	η^*
Cattle	0.17	-0.45	-0.0765	3.4	-1.26
Pigs	0.50	-0.80	-0.40	1.5	-0.60
Poultry	0.70	-0.80	-0.56	1.2	-0.67

Definitions: ν is the share of compounds in the total feed ration; α is the elasticity of livestock production (inventory) with respect to the price of the total feed ration; β is the elasticity of livestock production (inventory) with respect to the price of the compound feed ration ($\nu.\alpha$); ξ is the elasticity of compound feed demand with respect to livestock production (inventory), which in this study is calculated as ½(1+1/ν), and which tends towards 1 as the share of compounds in the total feed ration approaches 100%; η^* is the 'long-run' own-price elasticity of compound feed demand ($\beta.\xi$), with $|\eta^*| \geq |\eta^\circ|$.