Multimarket Analysis of Agricultural Price Policies in an Operational Context: The Case of Cyprus

Avishay Braverman, Jeffrey S. Hammer, and Anne Gron

This article presents a method of analysis of agricultural price policies. Its basic features are (1) the incorporation of important supply and demand substitution possibilities; (2) a flexible structure which can account for institutional features of the agricultural sector and its relationships with the rest of the economy; and (3) a focused, policy-oriented approach. An application to Cyprus is presented which highlights the differences between this approach and analyses of single markets. The method incorporates supporting software on personal computers, with the longer-term objective of developing this type of approach as a standard tool in pricing policy analysis.

The idea that the economic world was a general system, with all parts interdependent, seemed (and seems) to me to be an essential of good analysis.

—KENNETH J. ARROW (1964)

The purpose of this article is to report on an operational methodology for analyzing the economic impact of agricultural price (tax/subsidy) policies. This technique accounts for the interaction of markets as relative prices change, a crucial element in agricultural production and pricing. The approach is intended to support the operational economist involved in formulating policy advice within the short time allowed for operational work. We explain below the rationale for using this methodology, briefly compare it with other techniques for analyzing agricultural price policies, and demonstrate its application in reducing animal feed subsidies to livestock producers in Cyprus.¹

¹. This method, and similar software for personal computers, has also been applied in conjunction with policy discussions for Hungary and Brazil; see Braverman, Hammer, and Morduch (1985) and Braverman, Hammer, and Brandao (forthcoming). Information about the software is available from the authors on written request. See Braverman, Hammer, and Ahn (forthcoming) and Braverman and Hammer (1986) for methodological discussion and references for other agricultural pricing studies in Cyprus, the Republic of Korea, Senegal, and Sierra Leone. See Kirchner, Singh, and Squire (1984) for an application to Malawi.

Avishay Braverman and Jeffrey S. Hammer are at the World Bank. Anne Gron is a graduate student at the Massachusetts Institute of Technology. The authors thank Angus Deaton, Jonathan Morduch, and many Cypriot officials and researchers for helpful discussions.

Copyright © 1987 by the International Bank for Reconstruction and Development / THE WORLD BANK.
This model is designed to answer questions frequently of concern to policymakers. While the critical questions vary by country, public debate on the impact of changes in price policy usually involves change in the government deficit, foreign exchange earnings (or requirements), and real incomes of various groups within society (for example, urban versus rural residents). Any economist expected to give responsible advice on agricultural pricing policy issues must also be concerned with these issues.

I. ALTERNATIVE METHODS

Standard tools of analysis which are currently in use have serious drawbacks for an operational economist who wants to include these considerations. Studies of comparative advantage—using effective protection rates (EPRS) or domestic resource cost (DRC) calculations—cannot be used either to answer questions about the distributional impact of policies or to determine the adjustment of quantities produced or consumed. Single market studies of producer and consumer surplus can address questions about the short-term impact of price changes on real income (though only on the functional distribution of income—that is, between producers and consumers of products). They are limited, however, in their ability to take into account important interactions between markets. Conversely, linear programming and large computable general equilibrium models may be appropriate as research tools, and for circumstances in which time is not limited and the data base is rich and reliable. These methods are seldom useful, however, for operational economists working on immediate policy prescriptions in developing countries which require incorporation of substantial institutional detail. The multimarket approach is often the most appropriate of these various tools for analysis in the very common circumstances we have described above. We elaborate further on these methods below.

Nominal and Effective Protection Rates

Calculation of these rates shows the relationship between domestic prices and world prices, with EPRS corrected for prices of intermediate goods. While these measures are appropriate for project evaluation, most of the issues mentioned above are not addressed, which limits their usefulness in a discussion of policy.

These numbers are also frequently used to measure "distortions" from a free trade position. There are two problems with this approach. First, completely free trade is often not within the realm of possible policy options, as governments will always intervene somewhere in the economy. In this second best (or nth best) world, it is not clear what information is contained in the EPR calculations. For example, with arbitrary distortions in other markets within the economy, it cannot be asserted that reducing the tariff on a good with a positive protection rate will improve welfare. Substitution possibilities with other goods which are protected may exacerbate the distortions in those markets, which
makes the net position worse. By the same token, priorities for liberalization cannot be made on the basis of relative \( EPRS \). Decreasing a tariff on a highly protected good is not necessarily better than decreasing one on a good with a lower \( EPR \), again due to possible differences in elasticities.\(^2\)

The second problem with these measures is that even if free trade is a possibility, it is unlikely to be a Pareto-improving policy (that is, someone is liable to get hurt). Policymakers may like to know the probable winners and losers in the policy change. If the poor are hurt, this information can be used in designing compensation schemes. These analytic tools do not provide any guidance in these questions.

**Single Market Analysis of Consumer and Producer Surplus**

Analysis of supply and demand, including calculations of producer and consumer surplus which are done market by market, can address some of the issues mentioned above. In this approach, foreign exchange earnings, government expenditures or revenue, and certain aspects of distributional effects are separately accounted for in each market. However, except in very particular (and in the case of agriculture very peculiar) circumstances, the results of such analyses will be misleading. Single market analysis will give the correct effects on budgets, foreign exchange, and welfare only if the crop in question is not a substitute or complement in supply or demand for any other good which is (a) taxed or subsidized (in budget analysis); (b) traded (in evaluating foreign exchange effects); or (c) subject to any distortion at all, either fiscal or from the private economy (in the study of welfare effects). The chance of such a good existing in agriculture is small. The errors can be substantial, to the extent of predicting even the wrong direction of a response with respect to a policy change. This is the risk run by ignoring the substitution effects between markets. While all this is known (for example, Harberger 1971 and Tolley, Thomas, and Wong 1982), the actual use of consumer and producer surplus analysis is often conducted using a single market framework.

**Linear Programming and Computable General Equilibrium Models**

At the other extreme, large computable general equilibrium (CGE) models and mathematical programming models are also limited as operational tools. Both of these methods deal with the intermarket connections emphasized here. For certain purposes, such as examining the introduction of a new production technique (in the linear programming case), these techniques can be important and appropriate. However, both have serious drawbacks as tools for policy analysis. First, elaborate models are essentially research tools which take a considerable amount of time and data to construct. Usually they cannot be done within the time horizon of operational work.

---

\(^2\) See Bhagwati and Srinivasan (1973) on the inadequacy of effective protection measures in the presence of general equilibrium interactions.
Second, their complexity makes the incorporation of institutional detail more difficult (though not impossible). Similarly, changes in the model parameters for sensitivity analysis purposes are difficult to effect.

Third, and perhaps most important, these models are frequently of such complexity that results are not intuitive—certainly not to a policymaker, and often not to the analyst! This lack of communicability of results can be a serious liability to the analysis. These methods can be considered complementary to the multimarket approach, however, in that ideas generated in one can be used in the construction of the other.

**Multimarket Method**

The multimarket method can be seen as filling the gap between the single market method and the sophisticated modeling exercises. It is a simulation tool which incorporates both interactions across markets and the economic, political, or technical constraints which policymakers face. Our method is intended to be as simple as possible, while capturing the essential features of the country in question, to allow the economist to understand and explain the consequences of policy. It is not, of course, necessary to have complete information about the extent of market interdependence to make good use of the multimarket approach we describe. The analyst must be sufficiently familiar, however, with a country’s agricultural economy to decide which interlinkages are critical and which indirect effects are insignificant. This approach is intended to consolidate the various bits and pieces of knowledge about the sector in a consistent framework, which allows the analyst to draw the logical implications of what is known about the sector and its interrelations with other sectors.\(^3\)

It is possible to “close” the model and make it a fully general equilibrium system. This generally entails including factor markets which link the sectors. If the important policy questions are essentially intersectoral, this would be the appropriate modeling strategy.

The earlier applications of our method were subject to some of the same drawbacks as the programming and CGE approaches. The studies relied on explicit functional forms for production and demand systems. The forms chosen were so-called flexible functional forms, so that a wide variety of behavioral responses could be accommodated.\(^4\) It was necessary in constructing the model, however, to reconcile observable data, the assumptions of the model (in terms of

---

\(^3\) Insights from this approach are derived from the farm household economy model (for example, Yotopoulos and Lau 1974; Barnum and Squire 1980).

\(^4\) We have used the Almost Ideal Demand system form developed by Deaton and Muellbauer (1980) for demand and the translog form (for example, Lau 1976) for supply. It should be noted that the more restrictive and frequently used functional forms (such as Cobb-Douglas in production and the linear expenditure system in consumption) are often the sole determinants of results rather than the data used (see Deaton 1984 on this point). In particular, the linear expenditure system does not allow for negative income elasticities, that is, inferior goods. Many basic foods (for example, rice and barley) become inferior for relevant income levels.
conditions which characterize an equilibrium), and the use of the particular functional forms used. This required the use of fairly complicated calibration procedures. The method of calibration is explained in Braverman, Hammer, and Ahn (forthcoming, appendix). The essential logic of the procedure was to choose the parameters of the model that correspond as closely as possible to observable levels for the variables and estimated or assumed values for the behavioral relations, while satisfying the features of the model and requirements of economic theory (such as symmetry of the Slutsky matrix in the demand system). This was done by solving an optimization problem in which the objective was to minimize the deviations from known values subject to the necessary constraints.

There are two problems in using this approach in operational work. First, the results are dependent on the particular analyst and are not easily replicable. The choice of weights in the optimization problem, for example, is based on the educated guess of the analyst. Even if such estimates are made explicit, the effects of these judgments on the final results are not obvious. Second, changes in the assumptions of the model often require a complete recalibration. This is sufficiently complicated and time consuming to preclude an operational economist from using the procedure directly.

The purpose of this article is to present a version of the method which avoids the pitfalls of the previous approach while maintaining the fundamental rationale. The new version does not require the calibration described above. It also does not require the use of specific functional forms which impose their own restrictions on the model (unrelated to economic reality) and which involve large numbers of nonintuitive parameter values which obscure the logic of the analysis. The method proceeds by assembling what is known about supply and demand for the important commodities, the institutional structures of government policies, and the mechanisms for market clearing. This information is arranged in a set of equations which is totally differentiated so that changes in the outcomes of interest can be solved in terms of changes in the available policy options (the equations are listed in the appendix).

Since the resulting model is linear, it can easily be solved on a personal computer. User friendly software has been written which facilitates the presentation of results and sensitivity analyses—a clear advantage. The cost is that the analysis is restricted to small changes. It is hoped that, through experimentation with various policy options and assumptions about the underlying parameters of the model, the analyst can develop a feel for the workings of the agricultural sector and its relation to the urban and external (export and import) sectors. The analysis has two principal limitations. First, it does not take intertemporal decisionmaking on the part of farmers into account. Second, it takes government decisions as exogenous. Full control over the relevant policy instruments is assumed, and any reaction in other parts of the government is ignored.

5. On how to adapt this method to analysis of large changes in prices, see section VI below.
Positive versus Normative Analysis

The multimarket method is essentially a positive approach. In contrast to both Harberger (1971) and the optimal tax tradition (for example, Atkinson and Stiglitz 1980), it emphasizes the positive analysis of consequences over the calculation of various social welfare aggregates. The position is often taken that, by counting dollars accrued to different groups identically, one avoids value judgments. However, the fact remains that this aggregation is a specific welfare evaluation giving identical weights to each group in the population; that is, the impact on the poor is not distinguished from the impact on the rich. The technical economist as policy analyst, in the midst of the political debate over economic policies, is often required to assess the impact of policy on different groups (for example, poor versus rich, rural versus urban). While ex ante aggregations often disguise social values for positive analysis, different aggregations can be made explicit ex post, including the impact on total real income emphasized by Harberger (see Braverman, Hammer, and Ahn, forthcoming, for Korea).

Besides evaluation of the effect of policy on private incomes, government deficit reduction, particularly in the presence of high inflation, has often been a high policy priority. To attribute a shadow price or ex ante “welfare weight” to reduction in the government deficit is difficult (see Stiglitz 1982 for such an attempt). Government revenue, foreign exchange, and other objectives which indirectly affect welfare should be looked at specifically.

II. The Policy Problem in Cyprus

In order to demonstrate an application of the analysis, the method described above is presented in the context of the problem of feedgrain subsidies in Cyprus. The Cypriot case is instructive for a variety of reasons. The policy problem is well defined and immediately suggests the market interactions most likely to be important. The government sells barley as an input to the livestock sector at £C33.9 per ton—a price which has not changed since 1978. Most of this grain is imported. In 1982 the price of grain on world markets was £C69 per ton, leading to a deficit of £C12.4 million. By 1984, this deficit had grown to approximately £C25 million, or 2 percent of gross domestic product (GDP).

The rationale for this policy is that the feedgrain subsidy is supposed to be an indirect consumer subsidy as the cost savings in the meat and milk industries are passed on in the final product. It is also argued that, while the foreign exchange

6. In Cyprus, issues of income distribution and the rural-urban distinctions were not considered to be major policy problems by the government or the World Bank. On these issues, see Braverman and Hammer (1986); Braverman, Hammer, and Ahn (forthcoming); and Braverman, Hammer, and Brandao (forthcoming). This application demonstrates the inclusion of a livestock sector in the multimarket analysis.
requirements of the grain trade appear substantial, they are smaller than the requirements implied by importing meat products rather than the inputs.

In addition to the main intervention through the feedgrain sale price, the government also subsidizes barley cultivation through higher prices for the barley it purchases domestically. These prices have been maintained at levels higher than the world prices, though the degree of subsidy has declined over time. Price supports are also provided to wheat producers. The producer subsidies are intended as income support for older, established farmers, and revision is not generally considered to be politically feasible. Finally, as a direct consumer subsidy, bread (of the traditional type) is sold at low prices. We thus consider four components of the government deficit: the feedgrain subsidy (by far the most expensive component), the two producer subsidies, and the direct consumer subsidy on bread.

The statement of the problem alone makes apparent the interaction of related markets. Increasing the cost of inputs to livestock will increase consumer prices. The degree of this rise depends on the elasticities of demand for the various goods whose prices would be affected, as well as their cross price effects. It also depends on how factors substitute in production and more generally on supply elasticities. For the assessment of the government's cost, the increase in the feedgrain price will induce substitution to hay consumption and (as there is no international trade in hay) to hay production. This implies less cultivation of wheat and barley, and hence lower production subsidy payments. By ignoring these intermarket effects, the analyst runs the risk of making serious misjudgments concerning the budgetary and welfare implications of policy change.

III. Structure of the Model

In this section we present the structure of the relevant markets and the interactions between them. The markets included in the model were those which would be most affected by increased grain costs. These are primarily the grains themselves, their substitutes, and the livestock products which use them as feed.

It is possible that there are other effects not reflected in the model. There may be substitution between food and manufactured consumer goods which are taxed so that the model would not give a complete description of the fiscal effects of the policies. It is always a matter of judgment—the "art" of modeling—as to where to cut off the analysis to maintain optimal operational simplicity while accurately reflecting the major significant relationships. Our judgment, and that of the Cypriots consulted in the model's formulation, is that the version presented here captures the most important effects.

When price policies change, the principal distinction between the ways the markets clear is whether prices are flexible or fixed, that is, whether prices or quantities adjust to clear the market. The adjustment of fixed price markets will influence the foreign exchange requirements resulting from the policies since the quantity adjustment is through imports and exports. The adjustment of flexible
price markets will determine the cost of living effects of proposed policies. The relative importance of these two types of markets will determine whether the costs of reducing subsidies are borne by producers and the trade balance on the one hand, or consumers on the other.

In our earlier work (Braveman, Hammer, and Jorgensen 1985) explicit functional forms were chosen for the underlying supply and demand functions. In the present application, the starting point is the market clearing conditions, which require fewer restrictions on the behavior of economic agents than the mathematical requirements of the functional forms. While some of the parameter values for the present version were chosen to be consistent with our previous nonlinear study, they are essentially independent exercises.

On the production side, it is assumed that producers are profit maximizers and that a well-behaved profit function can characterize their responses. On the demand side, the comparable concept is the indirect utility function for consumers. From producer theory (see, for example, McFadden 1978), the supply of the commodity is the derivative of the profit function with respect to output price. The demand for factors of production is the derivative with respect to input price. For the case in which there are fixed factors of production, the profit function includes the levels of these factors. With this framework in mind, the arguments in the supply function should be the same as those in the profit function. Also, certain characteristics of well-behaved profit functions, such as symmetry of cross price effects, are incorporated into the supply functions.

Similarly, on the consumer side, demand is a function only of prices, with appropriate restrictions imposed by theory. The income argument in demand is suppressed. The reason for this is that only a single demand function is defined for each commodity market. The only component of income nationwide which could vary endogenously in the model is agricultural profits. This is a very small fraction of aggregate income in Cyprus and can thus be ignored without detriment to the basic analysis.

Besides incorporating basic theory into the analysis, the restrictions imposed serve the additional purpose of limiting the number of free parameters which must be determined by empirical work or expert opinion.

Commodity Market Characteristics

Beef and frozen lamb are traded internationally at fixed world prices, and therefore markets are assumed to clear via changes in imports. In the frozen lamb case there is no domestic production, so imports are equal to demand. Fresh lamb (not a close substitute for frozen) and milk are not traded internationally, so markets clear through domestic prices moving to equate supply and demand.

Beyond this, each of the markets has characteristics specific to it which can be mentioned briefly. Products of ruminant animals (cows and sheep) are characterized by joint production of milk and meat. An increase in milk prices, say, could increase beef production as a by-product of increased herd size. This is modeled
by including a term for size of stock in the profit and supply equation (making the former a “restricted” profit function). Changes in the stock itself are endogenous. We assume that the livestock industry is sufficiently well integrated into the rest of the economy that investments in animals are treated the same as any other investment. We also assume that the livestock sector is small relative to the rest of the economy, so that the rate of return on investments is determined outside this sector. The equilibrium condition for stocks, then, is that the rate of profit on an additional cow or sheep is equal to some constant value. The constant would be a risk-adjusted rate of return to capital. The rate of profit on a marginal animal is composed of the marginal profit in the meat industry plus the marginal profit in the milk industry.7

The markets for cow and sheep products are also linked on the output side, as milk from the two sources can be approximately perfectly substituted. The milk supply is thus the sum of production from the two sources.

Two versions of the pork and poultry market were modeled—the first assuming fixed prices with imports clearing the market and the second without trade with prices clearing the market. If costs of production are allowed to rise with the removal of the feed subsidy, the question arises as to whether the government will exclude imports and allow the price of meat to rise or will allow imports, which will limit product price increases with more severe consequences for the pork and poultry industry. Both possibilities are modeled (the without-trade case is shown in table 1 below).

Barley, wheat, and hay can all be grown on the same land, and we assume that farmers maximize profits by allocating land between them. Therefore a single, multiproduct profit function is assumed to underly the supply relations. Wheat and barley producer prices in the supply function are fixed by the government. Similarly, on the demand side, barley feedgrain prices and bread prices are also policy instruments. Demand for barley is a derived demand from the production of animal products. Both barley and wheat markets clear via imports.

Hay demand is also derived from ruminant animal production. On the supply side there are two components: hay, which is planted, and straw, which is a by-product of both wheat and barley. There is no international trade in hay, so its price varies to equate domestic supply and demand.

Policy Factors

The variables can be divided into those which are instruments of policy (exogenous) and those which are determined by the working of the system (endogenous). These elements can be solved in terms of quantities that an economist familiar with the agricultural sector is likely to know. These include the supply elasticities and actual levels of output and prices (on the supply side) and demand elasticities, consumption, and consumer prices (on the demand side). The equations and the form for solving the system are delineated in the appendix.

7. For an alternative formulation of joint products, see Deaton (1984).
Once the prices and quantities of the basic commodities are found from the model, these can be used to determine the effects on the government accounts, the foreign exchange needs, and the welfare of different groups.

The government runs a deficit in its agricultural accounts. This can be divided into four components:

1. Barley consumer deficit: this is the largest component of the deficit and consists of the difference between the sale price of barley to livestock producers and the world price (opportunity cost of acquisition), multiplied by the total feed demand for barley.

2. Barley producer deficit: this is the difference between the producer price and the world price of barley multiplied by domestic production.

3. Bread consumer deficit: this consists of the difference between world and domestic prices of bread, multiplied by total consumer demand.

4. The wheat producer deficit is calculated in the same way as the barley deficit.

Total foreign exchange requirements to support agricultural production and consumption consist of the value, at world prices, of total imports of the above commodities.

Calculation of the net effect of the policy interventions must take into account the fact that government wages are fully indexed to the cost of living. Therefore, if consumer prices rise as a result of subsidy reductions, some of the budgetary savings will be eroded by automatic increases in salaries.

For small changes in prices, the change in welfare of any group in society can be calculated in terms of compensating variations of income. This can be expressed as a fraction of base income necessary to compensate the consumer for any price increase.

Still problematic is the choice of parameter values in both the supply and demand systems. For own price effects, these values may be known or obtainable through simple methods. More difficult to obtain are the cross price effects, which require more carefully conducted econometric studies. For the case of Cyprus, we were fortunate in having such a study by the Agricultural Research Institute (Panayiotou 1983) available to us. This was supplemented by our own econometric analyses presented in the earlier study. In other applications this information may not be available. Sensitivity analysis can be used as a means of overcoming data limitation in such cases and is briefly discussed in section V below.

IV. RESULTS AND COMPARISONS WITH SINGLE MARKET ANALYSIS

The principal policy option to be briefly examined here is the reduction of the subsidy to livestock producers by increasing the sales price of barley.8 Table 1

8. A more comprehensive presentation of the detailed results of the Cypriot case is presented in Braverman, Hammer, and Jorgensen (1985).
Table 1. Effects of a 1 Percent Increase in the Barley Feedgrain Price (percentage change)

<table>
<thead>
<tr>
<th>Parameter assumption</th>
<th>Barley</th>
<th>Pork and poultry*</th>
<th>Fresh lamb</th>
<th>Milk</th>
<th>Beef</th>
<th>Bread</th>
<th>Frozen lamb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>-0.46</td>
<td>-0.28</td>
<td>-0.33</td>
<td>-0.27</td>
<td>0.26</td>
<td>0.01</td>
<td>1.14</td>
</tr>
<tr>
<td>Alternativesb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>-0.45</td>
<td>-0.28</td>
<td>-0.34</td>
<td>-0.27</td>
<td>0.26</td>
<td>0.01</td>
<td>1.17</td>
</tr>
<tr>
<td>II</td>
<td>-0.48</td>
<td>-0.27</td>
<td>-0.37</td>
<td>-0.30</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>III</td>
<td>-0.72</td>
<td>-0.27</td>
<td>-0.21</td>
<td>-0.28</td>
<td>0.19</td>
<td>0.01</td>
<td>0.86</td>
</tr>
<tr>
<td>IV</td>
<td>-0.37</td>
<td>-0.28</td>
<td>-0.41</td>
<td>-0.31</td>
<td>0.31</td>
<td>0.01</td>
<td>1.41</td>
</tr>
</tbody>
</table>

Domestic Supply

<table>
<thead>
<tr>
<th>Parameter assumption</th>
<th>Barley</th>
<th>Wheat</th>
<th>Hay</th>
<th>Beef</th>
<th>Fresh lamb</th>
<th>Milk</th>
<th>Beef</th>
<th>Bread</th>
<th>Frozen lamb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>-0.03</td>
<td>-0.34</td>
<td>0.98</td>
<td>-1.72</td>
<td>0.13</td>
<td>0.25</td>
<td>0.11</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Alternativesb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>-0.84</td>
<td>-0.84</td>
<td>0.97</td>
<td>-1.74</td>
<td>0.14</td>
<td>0.26</td>
<td>0.11</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>-0.03</td>
<td>-0.32</td>
<td>0.93</td>
<td>-1.73</td>
<td>0.13</td>
<td>0.25</td>
<td>0.11</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>-0.01</td>
<td>-0.11</td>
<td>0.31</td>
<td>-1.03</td>
<td>0.09</td>
<td>0.25</td>
<td>0.11</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>-0.03</td>
<td>-0.32</td>
<td>0.94</td>
<td>-1.77</td>
<td>0.17</td>
<td>0.29</td>
<td>0.11</td>
<td>0.30</td>
<td></td>
</tr>
</tbody>
</table>

Trade accounts: Government accounts

<table>
<thead>
<tr>
<th>Parameter assumption</th>
<th>Foreign exchange requirements</th>
<th>Grain commission deficits</th>
<th>Government wage bill</th>
<th>Total government deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>0.34</td>
<td>-1.13</td>
<td>0.012</td>
<td>-1.02</td>
</tr>
<tr>
<td>Alternativesb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>0.64</td>
<td>-1.41</td>
<td>0.012</td>
<td>-1.29</td>
</tr>
<tr>
<td>II</td>
<td>0.12</td>
<td>-1.14</td>
<td>0.012</td>
<td>-1.03</td>
</tr>
<tr>
<td>III</td>
<td>-0.03</td>
<td>-1.25</td>
<td>0.018</td>
<td>-1.14</td>
</tr>
<tr>
<td>IV</td>
<td>0.46</td>
<td>-1.09</td>
<td>0.013</td>
<td>-0.96</td>
</tr>
</tbody>
</table>

a. Based on the nontraded scenario.

b. I—maximum crop substitution in supply; II—no substitution in demand; III—livestock supply elasticities are unity; IV—field crop elasticities equal one-fourth the base elasticities.

c. Because percentage changes in the Grain Commission deficits and the government wage bill are calculated from their respective base values, the sum of these two changes will not equal the change in the total government deficit.

presents the results for the base case discussed here (and for four alternative formulations described in section V below). The policy examined is an increase of 1 percent in the price of barley. Entries are percentage changes in the indicated variable and, since the policy is a 1 percent change, these figures can be considered as elasticities. Since the model solutions simulate market equilibrium conditions, changes in supply equal those for demand for the nontraded commodities (hay, milk, fresh lamb, pork, and poultry). These results are therefore shown either under supply or demand in table 1, not under both.
The basic results can be seen in the rows labeled “Base case.” The analysis indicates a distinction between traded and nontraded livestock products for the pattern of supply and demand. All animal products suffer a reduction in output. Since nontraded commodities will experience a price rise as the cost of production increases, the reduction in supply is moderated relative to that of the traded commodities. The cost of living rises due to the increase in the price of nontraded goods; foreign exchange requirements rise due to the decline in domestic production of traded livestock products.

The hay market provides the link between the livestock and field crop sectors. As hay replaces barley in the mix of feedstuff, its price rises, causing the production of the competing grains to be reduced. The higher price of hay also moderates the reduction in demand for barley.

The principal effect on the deficit is the savings in the barley subsidy. Lower per unit subsidies as well as the reduction in feedgrain used lead to a 1.13 percent savings in Grain Commission costs. This main effect can be captured using a single market analysis, but some of the indirect effects would be overlooked. Using the factor demand elasticities assumed in the multimarket model, calculations were made for a single market analysis which predict a deficit reduction of -1.21 percent from a 1 percent increase in barley prices. In a multimarket framework, the two effects operating through the hay market influence the deficit calculations. The higher hay price reduces the elasticity of demand for barley, thereby limiting the Grain Commission savings. Counteracting this effect, the increased production of hay reduces the output of both wheat and barley, which are subsidized. The incorporation of the hay market effects creates a net reduction in budgetary savings from the 1.21 found in the single market analysis to 1.13 percent. Due to the complete indexation of government wages to the cost of living, however, the increased prices in fresh lamb, milk, pork, and poultry lead to automatic pay increases, which further reduce the savings in government revenue to the 1.02 percent shown in table 1. Therefore, ignoring multimarket effects would lead to an overstatement of government revenue savings of nearly 20 percent.

In the foreign exchange calculation, the differences between the single and multimarket approaches are more pronounced. In the single market analysis, attention would be limited to the barley market. The 1 percent increase in price of barley would reduce total foreign exchange requirements in agriculture by 0.43 percent. The reduction in domestic production of meat, wheat, and barley, however, increases imports of these goods and increases foreign exchange requirements by 0.34 percent. It should be noted that this analysis does not give a complete account of foreign exchange earnings for the whole economy. The reduction in farm output releases labor and investment funds to the rest of the economy. Some substantial fraction of that resource flow will be converted into export earnings, although precise calculations of this effect require more detailed information on the nonagricultural sector.

The principal arguments against reducing the livestock subsidies were (1) that
they were really an effective consumer subsidy, and (2) that Cyprus would either import grain or import meat, which was more expensive than grain. This analysis indicates that the first reason is ill-founded since the effect on the cost of living is quite small (0.012 percent). There does appear to be some justification for the second claim, although overall export earnings are sensitive to the export earning capabilities of labor in nonagricultural sectors. Studies by others show a large number of part-time farmers, and substantial integration of the rural and urban labor force (see Ansell, Bishop, and Upton 1983). Therefore, one would expect released labor to find alternative employment, possibly in the export sector. If these released workers earn the net average export earnings of workers in the nonagricultural sectors, then the reservation concerning foreign exchange becomes much weaker.9

V. Sensitivity Analysis

All of the behavioral parameters (elasticities of supply and demand) are subject to error due to econometric estimation error or inadequacies of the data. Therefore, it is important to examine the sensitivity of the results to changes in assumptions concerning these values. Four variants of the model are described here which either are based on assumptions which might be used in the absence of data (versions I and II) or which probe aspects of the base model that, while based on data, may be questioned on empirical grounds (versions III and IV).

The first two scenarios were developed because cross price elasticities are notoriously hard to estimate and simple rules of thumb may have to be used at times in the choice of parameters. The first variant uses the “base case” values of the own price elasticities of supply of field crops but alters the cross price terms. Under the assumption of fixed yields per acre, it is assumed that an increase in supply and therefore acreage of one crop reduces the acreage and supply of competing crops in equal proportions. This yields the maximum possible substitutability in crops for a given supply elasticity consistent with the convexity of the profit function. Since barley, wheat, and hay are close substitutes, this special case is more relevant than the alternative of minimum (that is, zero) substitution between crops.

The second scenario concerns the demand side of the model but makes the opposite assumption concerning cross price effects. In this case, all off-diagonal elements of the matrix of price elasticities are set equal to zero, which implies no substitution between these goods in demand. This minimizes all intercommodity effects on the demand side and would be a natural assumption to use if all econometric information were lacking.

Due to the limited importance of fixed factors and thus the low reported profit levels in the livestock sector, the base model has relatively high supply elasticities. Discussions with experts in the Ministry of Agriculture in Cyprus indicated

9. See Braverman, Hammer, and Jorgensen (1985) for calculations to this effect.
that these parameters may be incorrect due to underreporting and data problems. The third variant of the model therefore examines a case with supply elasticities of unity for all livestock products, with consistent cross term effects.

The base model also has relatively high own and cross price supply elasticities in the field crops. As mentioned, these three crops are close substitutes. However, the fourth scenario reduces all of the elasticities to one-fourth of their base values to offer some contrast to variant I and to suggest the extent of change likely if intercrop substitution is more difficult.

Rather than discuss each version in detail, a few overall comments are possible. Many aspects of the model do not appear especially sensitive to quite large changes in the parameters. The structure of the model and the specific linkages between markets appear to determine much of the outcome of policy experimentation. In those places where the sensitivity of the model is indicated, a few interesting features of the model are highlighted.

The interaction of field crop and livestock production is the most interesting channel of multimarket effects. When the supply elasticities of field crops are low (version IV), the increased demand for hay due to reduced subsidies results in higher hay prices which are not strongly offset by subsequent increases in hay output. Prices of nontraded meat (fresh lamb) and imports of traded meats rise faster, so the cost of living and the foreign exchange requirements both rise relative to the base. The hay price increase also moderates the reduction in barley demand, which makes the deficit saving smaller as well. Conversely, when cross price elasticities are high (variant I), the deficit saving is higher due to greater reduction in the production of subsidized grains. The policy of livestock subsidy reduction looks best (that is, has fewer negative consequences on the cost of living and the government deficit) when the field crop sector is most flexible (that is, has high own and cross price elasticities).

The most sensitive aspect of the results is the effect on foreign exchange requirements. This varies from quite high extra requirements (variant I) to a slight reduction (variant III). The versions giving lower requirements than the base are alternatives II and III. In variant II there is no substitution in demand and thus no spillover demand from high-priced, nontraded meats to imported meats. In the low supply elasticity case (version III), there is a much smaller supply decline in response to the input price rise so that much less of the meat demand needs to be met through imports. The two versions yielding higher total import values are (1) the case with high cross price elasticity for field crops (version I), in which large reductions in barley and wheat output are good for the deficit but require further imports, and (2) the case of low overall supply elasticity of field crops, which generates high hay prices and more substitution of traded for nontraded meats.

The results for foreign exchange earnings vary substantially among the different versions. Because the experts consulted believe that the supply elasticities derived are higher than actual values, variant III, which estimates the effects of livestock elasticities of unity, is likely to most closely approximate the actual
Cypriot case. As shown in table 1, the reduction in the barley subsidy in that scenario slightly reduces foreign exchange requirements. Added to these savings are the potential foreign exchange earnings of displaced agricultural labor in alternative employment. Therefore, the support for reducing the barley subsidy is also strong on the foreign exchange account. (See Braverman, Hammer, and Jorgensen 1985 for further details of the Cyprus case.)

VI. ANALYSIS OF LARGE CHANGES IN POLICIES

All of the above results are valid for small changes in policy instruments but may give obviously wrong answers when large changes are contemplated. This is due to the linear nature of the model. For example, if the price of barley were to be raised to actual world price levels, the supply of beef would be negative in the above model. In the earlier, nonlinear version of the model, this problem does not arise since the functional forms prevent nonnegative values from occurring. This brings out a fundamental dilemma in the use of economic theory in policy analysis. We generally know very little about supply and demand functions other than their behavior near observed equilibria. Each of the functional forms used in empirical analysis—even the so-called flexible ones—has inherent implications for the behavior of demand over large price movements which have little to do with actual behavior (see Caves and Laurits 1980). Therefore, while a nonlinear model may give superficially more plausible results, it is not based more firmly on any economic principles. In either case, confidence can only be placed in small deviations from the status quo, or in other words, in the direction of change of the economy.

Conversely, policymakers often may want or need to know something about the outcome of policy reforms which create large changes in important economic variables. In Cyprus, the consumer price of feed is often less than half the world price, and the consequences of completely removing the subsidy might be just such a change. In this case, only very approximate answers should be given (and even then, not by the faint of heart). One possible way of handling large changes in policy is in the context of the sensitivity analysis. For large changes in prices, the relevant elasticities would be the arc elasticities between relatively distant points on the supply or demand curves. While direct evidence on these values is difficult to come by, a variety can be used. The choice may be guided by specific functional forms. The simplest example would be the constant elasticity form by which the arc elasticity, $e$, corresponding to a point elasticity, $e$, over a price range of $P_0$ to $P_1$ would be calculated as

$$e = \frac{\left(\frac{P_1}{P_0}\right)^e - 1}{\frac{P_1}{P_0} - 1}$$
In the Cyprus case, if the price of barley doubles, the arc elasticity of demand should be changed to 0.52 in order to correspond to a point elasticity of 0.6 estimated at the new (doubled) price. Other functional forms might be used or, alternatively, generous bounds might be placed on the parameters in the sensitivity analysis. A second way to approximate larger policy changes is to solve the model iteratively. A small change can be made and followed by a recalculation of levels of variables and possibly of elasticities corresponding to a particular chosen functional form before a second step is taken. This can be repeated for more small steps until the desired policy change is reached. Subsequent work will examine the possibility of implementing this method in the software.

VII. USE IN POLICY DIALOGUE

The discussion of sensitivity analysis and of large policy changes underscores the importance of being able to do repeated policy experiments in order to get the feel of the effects of policy. This intuitive understanding is essential in policy analysis both as a check on the realism of calculated effects and as a way to explain the policy consequences to noneconomists. We have developed user friendly software for use on personal computers which allows these sensitivity analyses to be performed quickly and easily without requiring great familiarity with computers. These models should not and are not to be perceived as forecasting tools.

A valuable use of this type of model is to facilitate an informed discussion of policy outcomes between people with different points of view. If the basic structure of the economy can be agreed upon, the different assumptions necessary to support different expected outcomes can be made explicit. This can be used to focus discussion between World Bank economists, between ministries within the country, or between government and Bank economists. Of course, numbers can be used out of context, and the abuse of models by political advocates is frequent. However, our judgment is that the advantages of our approach in providing a consistent framework and quantitative structure for discussion greatly outweigh the drawbacks from such possible misuse.

APPENDIX

Market Equilibrium Conditions

Variables for equations which follow:

- Superscripts and subscripts:
  - \( l \) = lamb (or sheep)
  - \( b \) = beef (or cows)
  - \( m \) = milk
  - \( cm \) = cow’s milk
  - \( sm \) = sheep’s milk
\[
\begin{align*}
\rho &= \text{pork and poultry} \\
\omega &= \text{wheat (or bread)} \\
F &= \text{frozen lamb} \\
B &= \text{barley} \\
H &= \text{hay} \\
P_i &= \text{price of commodity } i \\
\bar{P}_i &= \text{producer price of } i \text{ (if different from consumer price)} \\
P^*_i &= \text{world price of } i \\
D_i &= \text{consumer demand for } i \\
S_i &= \text{supply of } i \\
M_i &= \text{imports of } i \\
K_i &= \text{stock of animal } i \\
D^j_i &= \text{factor demand for commodity } i \text{ in the production of } j \\
\pi_i &= \text{total profit in activity } i \\
\theta &= \text{returns to scale parameter} \\
r &= \text{rate of return to capital (constant)} \\
q &= \text{conversion factor of wheat and barley to straw} \\
a &= \text{conversion factor of sheep to cow's milk equivalent} \\
a_i &= \text{Laspeyre index weights in government cost of living calculation for commodity } i \\
\nu_i &= \text{share of consumer budget spent on } i \\
WB &= \text{government wage bill} \\
dC/Y &= \text{compensatory variation as proportion of income.}
\end{align*}
\]

**Beef:**
\[
S_b(P_b, P_E, P_H, K_b) + M_b = D_b(P_t, P_b, P_m, P_r, P_w, P_F)
\]

**Fresh lamb:**
\[
S_f(P_t, P_b, P_H, K_I) = D_f(P_t, P_b, P_m, P_p, P_w, P_F)
\]

**Frozen lamb:**
\[
M_F = D_F(P_t, P_b, P_m, P_p, P_w, P_F)
\]

**Milk:**
\[
S_{cm}(P_m, P_H, P_B, K_I) + aS_{cm}(P_m, P_H, P_B, K_I) = D(P_t, P_b, P_m, P_p, P_w, P_F)
\]

**Livestock equilibrium:**
\[
\frac{\theta \pi_b}{K_b} + \frac{\theta \pi_m}{K_b} = r
\]
Pork and poultry:

version I:

\[ S_P(P_p, P_B) = D_P(P_t, P_b, P_m, P_p, P_w, P_F) \]

version II:

\[ S_P(P_p, P_B) + M_p = D_P(P_t, P_b, P_m, P_p, P_w, P_F) \]

Wheat:

\[ S_W(P_B, P_W, P_T) + M_w = D_W(P_B, P_b, P_m, P_p, P_w, P_F) \]

Barley:

\[ S_B(P_B, P_W, P_T) + M_B = D_B(P_B, P_b, P_m, P_p, P_w, P_F) \]

\[ + D_B'(P_m, P_b, P_T, K_B) + D_B''(P_m, P_B, P_T, K_B) \]

Hay:

\[ S_H(P_B, P_W, P_T) + qS_B(P_B, P_w, P_T) + qS_w(P_B, P_w, P_T) = D_H(P_B, P_b, P_T, K_T) \]

\[ + D_H'(P_B, P_b, P_T, K_B) + D_H''(P_m, P_B, P_T, K_B) \]

The system is solved by totally differentiating the equations with respect to both exogenous and endogenous variables.

**Government Accounts**

Barley consumer deficit:

\[ (P_B' - P_B) (D_B + D_B' + D_B'' + D_B'') \]

Barley producer deficit:

\[ (P_B - P_B') S_B \]

Wheat consumer deficit:

\[ (P_w - P_w) D_w \]

Wheat producer deficit:

\[ (P_w - P_w') S_w \]

Change in government wage bill:

\[ \Delta WB = \left( \frac{\Sigma a_i P_i}{\Sigma a_i P_i'} - 1 \right) WB \]

Cost of living:

\[ \Sigma w_i \frac{dP_i}{P_i} = \frac{dC}{Y} \]
References


McFadden, Daniel. 1978. “Cost, Revenue and Profit Functions.” In D. McFadden and


