Journal of Development Economics 21 (1986) 65–87. North-Holland

A GENERAL EQUILIBRIUM ANALYSIS OF PRICE CONTROLS AND SUBSIDIES ON FOOD IN MEXICO

Timothy J. KEHOE*

Clare College, Cambridge, CB2 1TL, UK

Jaime SERRA-PUCHE*

El Colegio de México, Mexico 20, D.F., Mexico

Received September 1983, final version received October 1984

In this paper we present a general equilibrium model that permits a thorough analysis of the effects of government pricing policies. In particular, we study the effects of price controls and subsidies on agricultural and food items in Mexico. We analyze alternative policies for reducing the government deficit by cutting subsidies and increasing indirect taxes. Our results indicate that, although food subsidies need to be reduced, maintaining some subsidies would have a favorable impact on income distribution.

1. Introduction

Support prices for production and price ceilings for final consumption goods have effects on resource allocation and income distribution that can only be fully evaluated in a general equilibrium context. Usually, policy decision to adjust controlled prices are based on partial equilibrium analyses that are not appropriate for addressing the crucial issues of resource allocation and income distribution. Simple studies of partial equilibrium price elasticities are not enough to assess the whole impact of a policy change.

In this paper we present a general equilibrium model that permits a thorough analysis of the effects of government pricing policies. In particular, we study the effects of price controls and subsidies on agricultural and food items in Mexico. In the face of a major financial crisis, caused to a large extent by rapidly expanding government deficits, the Mexican government is currently attempting to cut expenditures and increase net revenues. This stabilization program requires drastic reductions in subsidy levels, increases

*We wish to thank Alfredo Pastor for helpful discussions and Pedro Noyola for research assistance. We are also grateful to an anonymous referee for helpful suggestions.

0304–3878/86/$3.50

in taxes, or both. There are many ways to achieve a given target of deficit reductions. We examine different alternatives to obtain government savings selectively reducing subsidies on the production and consumption of the agriculture and food sectors. Clearly, there are other sectors, with a lower social priority, that should be the target of stabilization policies before food and agriculture. An example of such a sector is energy, which has been subject to price subsidies for a long time. Kehoe and Serra-Puche (1983b) have argued that the recent energy policies followed in Mexico have not been beneficial in terms of income distribution.

The primary purpose of this paper is to analyze the welfare effects of alternative schemes for reducing the government deficit in Mexico. To appreciate the simulation results used in the policy analysis, however, it is necessary to understand the structure of the model that is used and its strengths and limitations. We begin by discussing some of the institutional features of the pricing policies and the subsidy schemes in the food and agricultural sectors in Mexico, pointing out those characteristics that our model is able to capture as well as those that it is not. We then describe the model and formally present the introduction of price controls in a static neoclassical general equilibrium model. Next, we present comparative statics simulations and their results, and, finally, we discuss policy recommendations and directions for improving the model.

2. Price controls and subsidies in the agricultural and food sectors

The Mexican government subsidizes food production and consumption by covering the difference between artificially high support producer prices and artificially low consumer prices. Through Conasupo (the government agency in charge of the food subsidies operation) the government buys the grain (for example, corn and wheat) from the farmers at an artificially high support price (*precio de garantia*) and sells it to the producers of the final goods (for example, tortillas and bread) at an artificially low price. Through this operation the government is able to introduce price ceilings in the final goods. The size of the subsidy obviously depends on the price difference times the quantity bought and sold. The total subsidy also includes the cost of the grain imports that can be made only by Conasupo, which sells them to the final goods producers, also at a price below cost.

There are three important issues that should be taken into account in any analysis of food subsidies: first, the effects that producer support prices have on production decisions; second, the effects that price controls on consumer prices have on consumer welfare; and, third, the effects that the subsidy program has on the macro economy through changes in the government deficit. We discuss all three of these issues below and point out the strengths of the model that we use in analyzing the second one. It is important, however, to understand the limitations of the model in analyzing the first and third issues when interpreting simulation results.

The support price is intended to encourage production by ensuring a minimum of profits. There are, however, serious externalities that act against this objective of the price support. On one hand, there are many farmers that do not produce enough for their own consumption. Since the support prices tend to push the average rural market prices upwards, this policy leaves these farmers, who are net buyers of grain, worse off. On the other hand, during such high inflationary periods as that from 1977 to 1983 the behavior of the real support price is very erratic. The nominal price is constant for long periods of time and is then adjusted from one day to the other. This stepwise behavior introduces a great deal of uncertainty, since the relative price shows large fluctuations. This uncertainty has systematically frightened resources away from agricultural production. Fig. 1 shows the stylized

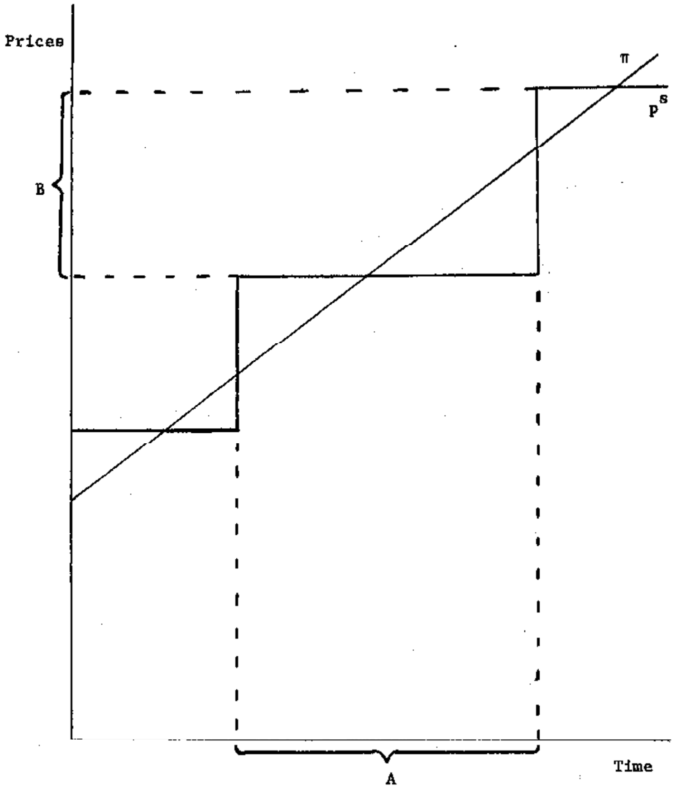

Fig. 1

behavior of support prices. Here π represents the consumer price index and p^s the support price. Although there are institutional agreements on how often the price is revised (the size of A), there is a tremendous degree of uncertainty about the size of the adjustment (the size of B), thus leading to uncertain behavior of the support price in real terms, which results in lower activity levels.

The general equilibrium model used in this research does not account for the existence of farmers who are net buyers of grain, since the relevant information is not available. Nor does it incorporate uncertainty of any kind since it is a deterministic model. In short, the support price in this model deals with the ideal and desired reaction of economic agents. Furthermore, due to the lack of reliable information on the use of intermediate inputs in the different agricultural activities, the agricultural production is treated in a very aggregated fashion. The government sets support prices for a very aggregated agricultural sector and for a sugar production sector. Although our analysis incorporates these support prices, our emphasis is on controlled consumer prices. For a collection of studies that focus on agricultural production and explicitly allow for uncertainty on the part of producers, see Norton and Solis (1983).

The price ceilings on final consumption goods are intended to provide goods with large shares in the consumption baskets of the poorest groups at low prices. Every agent in the economy, however, regardless of his income level, has access to subsidized food. Subsidies through price controls are unable to discriminate among consumers. Although the relative weights in the consumption baskets of the poorer groups are higher than in those of the rich, food still appears in the baskets of the rich. Price controls, therefore, are not the most efficient tools for the redistribution of income.

Price ceilings introduce undesirable distortions. The most dramatic effects in Mexico show up in the energy sector where gasoline has been subject to price controls, leading to overconsumption with serious consequences in traffic and pollution. In the case of food items, price ceilings have led, many times, to subsidies to other sectors. For example, livestock farmers have been known to use such subsidized processed food as tortillas as animal feed. Clearly, this misallocation of resources acts against the original purpose of providing large quantities of low-cost food to the poorest groups of society.

Although the purpose of Conasupo's pricing policies is to encourage agricultural production and redistribute income in both the production and the consumption stages, the distortions in relative prices induce agents to perverse behavior, defeating the objective of the policies. There are other tools to achieve these goals. For instance, Conasupo has a system of retailing activities that provide subsidized food. If these retailing establishments are located in the appropriate locations, they can be very effective in redistributing income. Kehoe, Serra-Puche and Solis (1984) have illustrated the relative efficiency of this system. The resources currently dedicated by Conasupo to pursue pricing policies are, however, several times larger than the resources dedicated to retailing.

In addition to the distributional effects, policymakers in Mexico also consider the short-run macroeconomic impact when assessing pricing policies. In particular, they are concerned about the inflationary effects of price controls. Mistakenly, the predominant belief is that to adjust prices upwards is inflationary and not to adjust them is anti-inflationary. This unfortunate interpretation has led to a tremendous inertia in pricing policies in Mexico, deteriorating the relative prices of goods subject to control and increasing substantially the amount of subsidies and thus the size of the government deficit. Any upward adjustment in controlled prices would indeed have an immediate impact on the price index. At the same time, however, it would reduce the government deficit, lowering aggregate demand pressures on inflation later on. A less myopic appreciation of this phenomenon would lead to a more flexible policy, minimizing distortions and perverse behavior that defeat the purpose of the policy.

Furthermore, Garcia-Alba and Serra-Puche (1983) have shown that an increasing share of total relative price variability is explained by the variability of relative prices subject to control. The variability of controlled prices is obvious from the data: between 1977 and 1981 prices of foods subject to price controls fell by 13.6% relative to the composite consumer price index; between 1981 and 1983 they rose by 13.9%. Causality tests show a very strong relationship between the variance of relative prices due to price controls and inflation. The causality works in both directions, and thus suggests that price controls are not an effective tool for inflation management. The short-run economic arguments in favor of price controls seem, therefore, to be rather weak. Nevertheless, the past inertia of controlled prices turns every single price adjustment into a major political issue. The decision of price adjustment becomes a difficult one. The strength of the model is its ability to analyze the impact of pricing policies of resource allocation and income distribution.

The present model concentrates on the medium and long-run effects of pricing policies. It does not analyze short-run phenomena and, although it captures the effect of the subsidies on the government deficit, it ignores the inflationary aspects of the policies. Even though our model is intended to analyze long-run micro issues rather than short-run macro issues, however, macroeconomic phenomena are so closely intertwined with income distribution and resource allocation that it is impossible to concentrate on one set of issues at the expense of ignoring the other. On one hand, the specification of the macroeconomic environment is crucial to the microeconomic results of general equilibrium simulations. On the other, every major macroeconomic policy decision has in impact on income distribution and resource allocation. For a country like Mexico where improvements in income distribution are badly needed it would be poor analysis indeed that ignored the impact of government policy on relative prices.

In specifying the macroeconomic environment of our model there has been a tension between a need to make it as realistic as possible, so as not to bias the results, and a need to make it as simple as possible, so as to keep the focus on relative prices and income distribution. Our macroeconomic closure is neoclassical in that, for example, there is no unemployment of labor nor underutilization of capacity and consumers' savings decisions determine investment. Although care must be taken in interpreting our results, this specification is consistent with our beliefs about long-run economic behavior. We should point out, however, that Gibson, Lustig and Taylor (1982) have developed a general equilibrium model of Mexico that utilizes two alternative macroeconomic closures, one that they call Marxian and another that they call Keynesian. See Sen (1963) and Taylor and Lysy (1979) for general discussions of the significance of alternative closure rules.

3. The model

The model used in this study is a static Walrasian general equilibrium model. It is a modified version of that described by Serra-Puche (1984) and Kehoe and Serra-Puche (1983a). The description of the model that follows concentrates on the modifications that have been made to make this model appropriate for analyzing price controls and subsidies. The model determines vectors of relative prices and of activity levels, the revenue from indirect and direct taxation, and the level of subsidies. The prices of agriculture (1), sugar (8), bread (20), tortillas (21), milk (23), eggs (24), and non-alcoholic beverages (29) are exogenously fixed and the implicit subsidy is included in the government deficit.

There are 37 goods in the model: 15 production sectors, three sectors of non-consumption demand (government services, imports–exports, and investment), 16 consumption goods, and three factors of production. The aggregation has been chosen with an emphasis on agriculture and food sectors in mind. Each of the first 34 goods is produced by a constant-returns production function that employs the other produced goods as intermediate inputs. In addition, the first 15 goods, the production sectors, and the government sector employ the final three goods as factors of production. The three factors of production are perfectly mobile across sectors.

Intermediate inputs enter the specification of the production function in fixed coefficients. Value added is produced by rural labor, urban labor, and capital, with the possibility of substitution governed by a Cobb–Douglas production function that differs from sector to sector. The advantage of this specification is that it allows us to use an activity analysis matrix to describe both the intermediate and value-added transactions in production.

Table 1
List of sectors.

Production	
1. Agriculture	9. Food products
2. Livestock	10. Mining
3. Forestry	11. Manufacturing
4. Fishing	12. Commerce
5. Alcoholic beverages	13. Transportation
6. Non-alcoholic beverages	14. Services
7. Tobacco	15. Construction
8. Sugar	16. Petroleum and electricity
Non-consumption demand	
17. Government	
18. Imports–exports	
19. Investment	
Consumption demand	
20. Bread	28. Fish
21. Tortillas	29. Non-alcoholic beverages
22. Cereals	30. Alcoholic beverages
23. Milk	31. Tobacco
24. Eggs	32. Household and personal articles
25. Other groceries	33. Transportation
26. Fresh fruit and vegetables	34. Services
27. Meat	
Factors of production	
35. Rural labor	
36. Urban labor	
37. Capital	

The 37×37 activity analysis matrix is of the form

$$B(p)=\begin{bmatrix} A & -Z \\ 0 & D \\ F(p) & 0 \end{bmatrix}. \tag{1}$$

A is a 19×19 input–output matrix that dictates intermediate transactions for the production sectors and non-consumption demand sectors. Z is a 19×15 matrix that converts demand for consumption goods into demand for production goods. D is a 15×15 matrix with total consumption of the consumption goods on the diagonal and zeros elsewhere. A, Z, and D all have fixed coefficients. The role of Z and D is to transform the aggregation of goods use on the production side of the model into the aggregation used on the consumption side. $F(p)$ is a 3×19 matrix of derived factor demands that vary with relative prices. Producers demand factors of production in proportions that minimize costs given the Cobb–Douglas production functions for value added in each sector. The elements of $F(p)$ are naturally continuous and homogeneous of degree zero in factor prices; demands for factors remain unchanged if all prices change proportionately.

The price of agriculture (1) is fixed exogenously and represents an index of the government support prices to agriculture. The level of activity of each sector is typically determined endogenously in response to the price vector. Price supports to agricultural producers are intended to elicit a greater supply. It is unclear, however, whether or not they have a major impact. Indeed, in spite of large increases in subsidies, much of the fluctuation in the supply of agricultural produce in recent years has been due to such exogenous factors as the weather. Due to lack of information about the elasticity of supply in the agricultural sector we simulate two alternative scenarios: in the first, the supply of agriculture adjusts to equal demand; in the second, the supply of agriculture is fixed, and any difference between supply and demand is met by imports, or exports. The price of sugar (8) is also fixed exogenously. Its activity level, however, is always determined endogenously.

There are ten consumer groups that represent aggregates of households in the Mexican economy and are divided into five income groups in both the urban and the rural sectors. Each of these consumer groups is endowed with stocks of capital and labor. Urban labor and rural labor are considered to be separate factors of production. The aggregation of factors of production is a weak point of this model: it would be preferable to have a specification that allowed heterogeneous capital and labor. Data constraints have forced us to adopt the specification that we use here.

Table 2
List of consumers – net household income in pesos per month ($23 1977 Mex. = $1 1977 U.S.).

1.	Urban poor ($0–1800)
2.	Rural poor ($0–1800)
3.	Urban low income ($1801–3150)
4.	Rural low income ($1801–3150)
5.	Urban low-middle income ($3151–5275)
6.	Rural low-middle income ($3151–5275)
7.	Urban middle income ($5276–13,400)
8.	Rural middle income ($5276–13,400)
9.	Urban upper income ($13,401–)
10.	Rural upper income ($13,401–)

Each of the ten consumer groups can be thought of as a single consumer whose demand functions are derived by solving the problem of maximizing a utility function subject to a budget constraint. The income of group h is the value of its initial endowments net of income tax

$$Y^h = \sum_{i=35}^{37} p_i w_i^h (1 - i^h), \tag{2}$$

where p_i is the price of the ith good and w_i^h is the initial endowment of this good held by group h, and i^h is the income tax rate faced by consumer h. This income is used to finance the purchase of a consumption bundle made up of goods 20 through 34 in the model. In addition, the consumer saves a constant fraction of income, which, in effect, becomes a purchase of the investment good (19).

Due to data constraints, the utility function of the consumer is assumed to be Cobb–Douglas, which implies a constant proportion of income spent on each good. The demand functions are derived by maximizing this utility function subject to the income constraint (2). Letting the income proportions be denoted α_i^h, $i = 19, \ldots, 34$, we can express the demand of consumer h for good i as

$$x_i^h = \alpha_i^h Y^h / p_i. \tag{3}$$

The government in this model taxes production, imports, consumer income, and sales. It also earns a return on some of the physical capital that it owns. It uses this revenue to purchase goods and services and to invest. The tax rates used in the model are the effective average tax rates. Any tax evasion is assumed to be neutral; in other words, independent of the source and level of income as well as of the type of the good. The lack of information about evasion and its distribution makes it difficult to look for non-neutral criteria to distribute the effect of evasion when computing the effective tax rates.

The government differs from other consumers in the model in that it issues endogenously determined debt. In addition, the government acts as a producer in producing a public good, government services, using the 17th column of the activity analysis matrix $B(p)$. These services are bought by the government in its capacity as a consumer. When the government demands these services, it actually demands, through the intermediate requirements of this activity, from every sector of the economy.

Each consumer group h, with income Y^h, faces an income tax rate i^h. The income tax revenue received by the government is

$$I = \sum_{h=1}^{10} i^h Y^h. \tag{4}$$

Let c_i be the ad valorem tax rate paid by the producer of good i, $i=1,\ldots,19$, on sales. These tax rates are computed as the weighted sums of taxes on all goods aggregated into good i in the model. The total revenue collected from these taxes is

$$C=\sum_{i=1}^{34} p_i c_i a_{ii} y_i. \tag{5}$$

Here a_{ii} is the diagonal element of the input–output matrix and y_i is the associated activity level.

Imports, other than those of agricultural produce, are assumed to be a single homogeneous good. This good is obtained from the export column of the activity analysis matrix $B(p)$, denoted a_M. The model has an aggregate tariff that applies to this good when used as an input. All those activities that use imports as inputs to the production process face this aggregate tariff. The revenue from taxing imports is

$$T=p_M t_M \sum_{j=1}^{34} |a_{Mj}| y_j, \tag{6}$$

where a_{Mj} is the non-positive number that denotes use of imports by activity j, $j \neq M$, p_M is the price index for the aggregate import good, and t_M is the tariff rate. As well as collecting taxes, the government pays a subsidy to producers of food in order to impose price ceilings on final consumption,

$$\Phi=\sum_{i=1}^{34} p_i s_i a_{ii} y_i, \tag{7}$$

where s_i is the ad valorem subsidy rate paid to producers of good i. This rate is equal to zero for all goods but 1, 8, 20, 21, 23, 24, and 28. The government's net revenue R is the sum

$$R=I+C+T-\Phi. \tag{8}$$

The composition and level of government expenditure are viewed as independent policy decisions. In the absence of simulated changes, our behavioral assumption is that they stay fixed in real terms. The government can be thought of as maximizing a fixed proportions utility function constrained by a budget constraint of the form

$$Y^G=p_V w_V^G+p_K w_K^G+R \tag{9}$$

where p_V and w_V^G are the price and endowment of bonds held by the government, and p_K and w_K^G are the price and the government's endowment of physical capital. Consumers regard government bonds as perfect substitutes for physical capital when making savings decisions. The government's utility function has only two non-zero coefficients: demand for government services and demand for investment.

An interesting feature of the model is that the government may spend more than it receives in revenues. Such a deficit appears endogenously above as a positive endowment of bonds in the government's budget constraint. As the government revenue and subsidies vary we allow the deficit to adjust so that the level of government expenditure remains fixed.

The specification of the foreign sector is very simplistic. Nevertheless, it captures the structure of balance of trade and the corresponding capital flows. It also introduces the possibility of agricultural imports in the presence of a positive excess demand for agricultural goods (or exports in the presence of negative excess demand). Under the scenario of a fixed supply in agriculture, the government imports grain to make up for the difference between domestic demand and domestic supply. The rest of the imports are a non-competitive, homogeneous good that is demanded as an intermediate input in the production process. Final consumption of imports is, of course, accounted for within the fixed coefficient structure of the activity analysis matrix. Likewise, the physical composition of exports is fixed.

The relationship between exports and imports is given by the 18th column and row of matrix $B(p)$. A coefficient in this row, a_{Mj}, represents the physical input of the non-competitive import per a_{jj} units of output in sector j. A coefficient in the column a_{iM} represents the total exports of sector i. Implicitly, the economy generates foreign exchange that it uses to finance imports.

We define one more consumer, the rest of the world, that allows us to explain what happens to the flows that make up for the balance of trade. This consumer can be thought of as demanding exports in fixed proportions, so that the coefficients of the 18th column of matrix $B(p)$ represent his demand function. In return for these exports he provides an amount of the import good given by the diagonal element of this column. By changing this element we are able to simulate changes in the terms of trade between Mexico and the rest of the world. The rest of the world is also endowed with an amount of imports that is equal to the trade deficit.

Although our model is static, we must account for the investment that takes place during the period of analysis. We introduce an activity that produces the investment good, represented by the 19th column, a_V, of matrix $B(p)$, where a_{iV}, $i \neq V$, is a non-positive number that represents the investment purchases from sector i per a_{VV} units of total investment. Total physical investment in the economy is

$$V = S + GI + TD - GD, \tag{10}$$

where S is total savings by consumers, GI is government investment, TD is the trade deficit, and GD is the government deficit. The specification of how the components of this investment identity are determined is what constitutes the macroeconomic closure for this model. We later explain the role this closure plays in our simulation results. It should be emphasized, however, that this model is not intended to produce forecasts of macroeconomic fluctuations.

4. Definition and computation of equilibrium in the presence of price controls

Some of the prices in the model are controlled by the government, others are determined in the market. Define the matrix $\bar{B}(p,s)$ by the rule

$$\bar{b}_{ij} = b_{ij} - t_{ij}|b_{ij}| + s_{ij}|b_{ij}|. \tag{11}$$

Here t_{ij} denotes the ad valorem tax rate on the sales or purchases of good i by sector j; these tax rates include the rates c_i and t_M discussed previously. Similarly s_{ij} is the ad valorem subsidy rate. In this notation $p'\bar{B}(p,s)y$ represents the aggregate after-tax profitability of the production plan $B(p)y$, where p is the 37×1 vector of prices, and y is the 34×1 vector of activity levels, and s is the 8×1 vector of non-zero subsidy rates. The total of taxes net of subsidies is $p'(B(p)-\bar{B}(p,s))y$.

Consumers' demands vary with prices and incomes, which in turn vary with prices. The income of the government also varies with tax receipts R and the government deficit GD. The income of the rest of the world varies with the trade deficit TD. Demands are aggregated into excess functions $E_i(p,R,GD,TD)$, $i=1,\dots,37$. These functions are continuous, at least for strictly positive prices, and homogeneous of degree zero in all its arguments. This is because a proportional increase in all nominal variables leaves real behavior unchanged. Let $I(p)$ be the total of income taxes paid by consumers. This function is continuous and homogeneous of degree one since tax payments are themselves denominated in nominal terms. Furthermore, E_i and I jointly satisfy the following version of Walras's law:

$$\sum_{i=1}^{37} p_i E_i(p,R,GD,TD) + I(p) \equiv R. \tag{12}$$

This identity can be derived by summing up the budget constraints of all the consumers including the government and the rest of the world.

An equilibrium of this model is defined as a vector of 37 prices p^*, eight subsidy rates s^*, 34 activity levels y^*, and levels of government revenue R^*, government deficit GD^*, and trade deficit TD^* with the following characteristics. First, all activities must make zero profits net of taxes paid and subsidies received,

$$\sum_{i=1}^{37} p_i^* \bar{b}_{ij}(p^*, s^*) = 0, \qquad j = 1, \ldots, 34. \tag{13}$$

Second, the subsidy rates on agriculture (1), sugar (8), bread (20), tortillas (21), milk (23), eggs (24), and non-alcoholic beverages (29) vary to keep their market price fixed in real terms,

$$p_j^* = \sum_{i=35}^{37} \gamma_i p_i^*, \qquad j = 1, 8, 20, 21, 23, 24, 29. \tag{14}$$

Here γ_i is the weight of factor i in national income in 1977. Third, demand equals supply for all goods,

$$E(p^*, R^*, GD^*, TD^*) = B(p^*)y^*. \tag{15}$$

Fourth, the tax receipts that enter the government budget constraint are equal to its actual collections,

$$R^* = I(p^*) + p^{*\prime}(B(p^*) - \bar{B}(p^*, s^*))y^*. \tag{16}$$

Fifth, we fix the levels of government expenditures and of total investment,

$$y_j^* = \bar{y}_j, \qquad j = 17, 19. \tag{17}$$

Sixth, and finally, we require that prices satisfy

$$\sum_{i=35}^{37} \gamma_i p_i^* = 1, \tag{18}$$

where the weights γ_i are the same as in (14). This is just a price normalization that we are permitted by the homogeneity of E, I, and B.

We are able to compute an equilibrium of this model using a Quasi-Newton method for solving systems of non-linear equations. Alternatively, we could use a fixed point algorithm. In fact, the applicability of this latter method provides a constructive proof of the existence of an equilibrium [see, for example, Kehoe and Serra-Puche (1983a)]. Kehoe (1985) contains a proof of the existence of equilibrium for this type of model and a discussion of the issues involved in proving existence for a model with subsidies.

Rather than describe in detail the computational procedure, let us argue the plausibility of the existence of equilibrium by verifying that our system has the same number of equilibrium conditions as endogenous variables.

There are 37 prices p^* to be determined and 37 equations requiring demand to equal supply (15). There are 34 activity levels y^* and 34 zero profit conditions (11). There are eight subisidy rates and eight exogenously fixed prices (14). There is an equilibrium level of government deficit GD^* and a fixed level of government expenditure (17). There is an equilibrium level of the trade deficit TD^* and a fixed level of domestic investment (17). There is an equilibrium level of net tax revenue R^* and a government budget constraint (16). Finally, of course, although Walras's law (12) allows us to disregard one of the demand equals supply conditions, homogeneity allows us to add the price normalization (14).

5. Data and calibration

The parameters of the model have been derived from observations of the Mexican economy in 1977 and have been carefully calibrated to replicate the values of major economic variables observed that year. The year 1977 is used because it is the latest for which a complete data set could be assembled. The procedure used to calibrate this type of model is similar to procedures used to construct social accounting matrices and involves many of the same difficulties. Published sources of data are listed in the appendix.

The production side of the economy has been specified using the input–output matrix for 1970 published by the Secretaría de Programación and Presupuesto. The matrix has been updated to 1977 by the RAS method using production and price information obtained from the national accounts published by the Banco de México. An exercise comparing the values of coefficients from this matrix with those derived from a similar updating of the 1975 matrix reveals remarkably little difference. Rather than indicating a lack of structural change in Mexico between 1970 and 1977, however, this seems to indicate a scarcity of fresh information in the 1975 matrix. Unfortunately, this is the only source of such data available, and the reader is warned that this is a potential weakness of this model. The value-added parameters have been computed under the assumption of cost minimization and have been adjusted to be consistent with the national accounts.

The demand side of the economy has been specified using the household survey for 1977. The demand parameters α_i^h are the shares of expenditure on good i by consumer group h observed in the survey, adjusted so as to have the market demands equal to the final consumption column in the input–output matrix. The initial endowments of the consumer groups have also been adjusted to equal the value-added figures in the national accounts.

To obtain tax and subsidy information we have carefully aggregated the actual tax and subsidy rates so as to match our aggregation. We have calculated the indirect taxes to match those actually in place in 1983. There are two types of taxes. First, there are special taxes on the sale of the alcoholic beverages, soft drinks, tobacco, automobiles and gasoline. We have calculated these tax rates using information on revenues from the Secretaría de Hacienda for 1981. The tax rates are the effective tax rate. Second, there is a consumption value-added tax, which was revised extensively in January 1983. The previous value-added tax rate of 10% on most goods was increased to 15%, except in regions near the border where it remained 6%. Many processed food products that were previously exempt subjected to a tax rate of 6%. A few goods classified as luxuries, and of very minor importance as a percentage of total consumption, were subjected to a 20% tax. Some services that had been exempt were subjected to the 15% rate. Patent medicines, which were previously taxed at the 10% rate, were subjected to a 6% rate. Since there is no information on tax revenues for this system, we have imposed the official rather than the effective tax rates. The reader is warned that we may, therefore, overestimate tax revenues because we ignore evasion of the value-added tax. The income tax rates are effective rates derived while keeping the whole income tax structure unchanged; we assume that tax evasion is neutral across consumer groups and independent of the income source. Information on tariffs, export taxes, and the trade deficit has been obtained from the national accounts.

6. Simulation results

In this section we report the results of five comparative statics exercises. We first compute a benchmark equilibrium meant to characterize the Mexican economy following the 1982 financial crisis. Then we calculate five alternative government policy scenarios designed to reduce the government deficit as a percentage of GDP. Finally, the results are compared with each other and with those of the benchmark in terms of differences in major macroeconomic variables, relative prices, activity levels, and utility indices.

In general it is difficult, if not impossible, to ensure that this type of model has a unique equilibrium [see Kehoe (1985)]. Using a technique described by Kehoe and Whalley (1985), however, we have carried out an exhaustive search to verify that the equilibrium of this model is indeed unique. We can therefore carry out comparative statics exercises without worrying about non-uniqueness of equilibria.

Although the model is based on a 1977 data set, we have made an effort to compare the results of our simulations with a benchmark equilibrium that incorporates the most important structural changes that have occurred in Mexico between 1977 and 1983. There are five changes in exogenous variables that cause equilibrium to differ from one that could be computed using the original 1977 data set. First, the prices of controlled goods are uniformly lower by 1.6% relative to the price index (20). As we have explained, these prices first fell from 1977 to 1981, then rose sharply from

1981 to 1983. Second, agricultural output is lower by 13.4% in physical terms. This is the actual change scaled down by the increase in real GDP. Third, government expenditures, both consumption and investment, are increased significantly as a percentage of GDP. Fourth, total physical investment, which had risen sharply compared to real GDP between 1977 and 1981, then fallen sharply during 1982 and early 1983, is set at its 1977 level. Fifth, the indirect tax structure is changed to simulate the 1983 fiscal reform. In this and the subsequent simulations we assume that the real exchange rate, given by the diagonal element of the export column in the input–output matrix, remains at its 1977 level. Compared to this level the peso became overvalued between 1977 and 1981; between 1981 and 1983 it has become undervalued. The 1977 exchange rate is used because it can be argued that it is the long-run equilibrium exchange rate attained after a financial crisis similar to, though less severe than, the one in 1982.

The five policy simulations reported below have all been conceived to achieve the same goal: to reduce the government deficit to 90 billion 1977 pesos, roughly 2% of GDP. They all involve various combinations of indirect tax increases and subsidy reductions. The first four simulations all assume that agricultural production levels remain constant. The fifth simulation allows agricultural production to change in response to changes in demand. While the first four simulations are intended to analyze alternatives for reducing the government deficit, the fifth is intended to illustrate the sensitivity of the model to assumptions about the responsiveness of agricultural supply to changes in support prices.

(1) This simulation differs from the benchmark in that indirect tax rates are increased proportionally by 53.3%. All subsidies are retained.
(2) In this simulation indirect tax rates are increased by 23.2%. All subsidies on agricultural production and food consumption are abolished.
(3) In this simulation indirect taxes are increased by 43.0%. The controlled prices on agriculture, tortillas, and bread remain the same. The subsidies on other goods (sugar, milk, eggs, and non-alcoholic beverages) are abolished.
(4) In this simulation indirect tax rates are increased by 45.6%. The controlled price on agriculture remains the same. Those on bread and tortillas are lowered by 5%. The subsidies on other goods are abolished.
(5) This simulation is the same as the previous one except we now allow the production of agriculture to increase to meet domestic demand. The tax rate increase needed to meet the desired level of the government deficit is now 46.3%.

As the results in table 3 indicate all five policies have the desired effects on the major macroeconomic variables. Net government revenues rise and the

Table 3
Major macroeconomic variables (percentage of GDP).

	Base case	Subsidies retained	Subsidies abolished	Selected subsidies retained	Selected subsidies increased (1)	Selected subsidies increased (2)
1. Tax revenues	11.77	14.73	14.83	14.76	14.76	14.87
2. Government capital income	0.85	0.82	0.82	0.82	0.82	0.83
3. Government consumption	10.70	10.40	10.41	10.40	10.40	10.46
4. Government investment	7.39	7.20	7.27	7.22	7.22	7.33
5. Government deficit (=3+4−1−2)	5.62	2.04	2.04	2.04	2.04	2.07
6. Private consumption	66.94	64.42	64.39	64.41	64.41	63.99
7. Private investment	15.98	15.57	15.73	15.62	15.62	15.85
8. Trade deficit	1.01	−2.41	−2.19	−2.34	−2.34	−2.38
9. Gross domestic investment (=3+4+6+7−8)	100.00	100.00	100.00	100.00	100.00	100.00

government and trade deficits fall. Notice that the level of the trade deficit is approximately the same as in the other four simulations even though we allow the production of agriculture to increase, which lowers imports. This is explained by our macroeconomic closure rules, which fix government expenditures and total investment but allow the level of exports to vary. In particular, notice that in table 5 this level (18) is lower for the fifth simulation than for the other four.

Since this model is not intended to forecast macroeconomic fluctuations or economic growth, the values of the major macroeconomic variables are reported as percentages of GDP rather than in absolute terms. Since the first four policies have been designed to achieve similar levels of the government deficit and trade deficit, the specification of how these deficits are determined becomes relatively unimportant: if we had specified these deficits exogenously and let the levels of government expenditures and total investment be determined endogenously, we would have obtained very similar results. The case with the fifth policy is, of course, different. As we have mentioned, however, the results of this simulation have been included mostly to illustrate the importance of assumptions about the supply of agricultural produce.

One unrealistic aspect of the macroeconomic specification of this model is that it does not account for the impact of these policies on unemployment.

One story that goes with this specification is that we want to concentrate on how the economic pie is divided, on how policy changes affect relative prices, resource allocation, and income distribution, and not on what the size of the economic pie is. The reporting of major macroeconomic variables as percentages of GNP facilitates this interpretation. The reader is warned, however, that this interpretation depends crucially on unemployment rates for all factors being equal.

Table 4
Market prices (Base case = 1.0).

Sector	Subsidies retained	Subsidies abolished	Selected subsidies retained	Selected subsidies increased (1)	Selected subsidies increased (2)
1	1.0000	1.1360	1.0000	1.0000	1.0000
2	1.0014	1.0334	1.0017	1.0019	1.0063
3	1.0025	1.0016	1.0022	1.0024	1.0084
4	1.0047	1.0048	1.0046	1.0048	1.0112
5	1.0004	1.0341	1.0126	1.0127	1.0123
6	1.0006	1.0800	1.0677	1.0677	1.0664
7	1.0003	1.0557	1.0017	1.0016	0.9992
8	1.0000	1.4448	1.3975	1.3976	1.3986
9	1.0009	1.0343	1.0046	1.0047	1.0069
10	1.0069	1.0061	1.0068	1.0072	1.0105
11	1.0011	1.0115	1.0046	1.0046	1.0036
12	1.0003	0.9996	1.0001	1.0003	1.0023
13	1.0019	1.0056	1.0034	1.0034	1.0017
14	1.0001	1.0020	1.0008	1.0008	1.0000
15	1.0013	1.0064	1.0031	1.0031	1.0020
16	1.0186	1.0117	1.0163	1.0171	1.0124
17	0.9996	1.0034	1.0007	1.0004	0.9912
18	1.0022	1.0418	1.0186	1.0187	1.0195
19	1.0013	1.0152	1.0057	1.0057	1.0055
20	1.0000	1.1753	1.0000	0.9500	0.9500
21	1.0000	1.2550	1.0000	0.9500	0.9500
22	1.0059	1.0412	1.0068	1.0072	1.0091
23	1.0000	1.0365	1.0170	1.0171	1.0202
24	1.0000	1.1440	1.1225	1.1226	1.1260
25	1.0225	1.0407	1.0235	1.0247	1.0273
26	1.0275	1.1011	1.0220	1.0234	1.0245
27	1.0170	1.0294	1.0161	1.0169	1.0195
28	1.0183	1.0207	1.0164	1.0173	1.0212
29	1.0000	1.1381	1.1323	1.1324	1.2661
30	1.1592	1.0754	1.1294	1.1378	1.1417
31	1.4670	1.1998	1.3475	1.3754	1.3830
32	1.0783	1.0387	1.0645	1.0685	1.0700
33	1.1549	1.0674	1.1236	1.1317	1.1325
34	1.0865	1.0380	1.0696	1.0739	1.0742
35	1.0107	1.0081	1.0098	1.0100	1.0315
36	0.9967	1.0021	0.9982	0.9976	0.9792
37	0.9999	0.9975	0.9993	0.9996	1.0055

The effects of these alternative policies on relative prices and resource allocation can be seen in tables 4 and 5. These effects are fairly straightforward. Except in the final simulation, there are no significant changes in the factor prices (35–37). Consequently, the changes in the prices of produced goods (1–16) are, for the most part, directly attributable to changes in controlled prices. In the first simulation, where the controlled prices do not change, the prices of produced goods do not change. Since the price controls on agriculture and food have little effect on transportation, services, or construction, their prices do not change significantly in any of the simulations.

Table 5
Activity levels (Base case = 1.0).

Sector	Subsidies retained	Subsidies abolished	Selected subsidies retained	Selected subsidies increased (1)	Selected subsidies increased (2)
1	1.0000	1.0000	1.0000	1.0000	1.2707
2	1.0904	1.0413	1.0722	1.0762	1.0172
3	1.0557	1.0612	1.0583	1.0576	1.0012
4	1.0159	0.9863	1.0125	1.0166	0.9965
5	0.8804	0.9415	0.9011	0.8951	0.8884
6	1.0001	0.8801	0.8847	0.8846	0.7932
7	0.7781	0.9006	0.8274	0.8151	0.7844
8	1.2058	1.1495	1.1729	1.1754	1.0304
9	1.0399	0.9902	1.0326	1.0403	1.0090
10	1.2368	1.2097	1.2284	1.2302	1.0854
11	1.0214	1.0302	1.0244	1.0234	0.9913
12	0.9841	0.9779	0.9817	0.9822	0.9639
13	0.9546	0.9927	0.9675	0.9640	0.9400
14	0.9443	0.9742	0.9543	0.9517	0.9455
15	1.0000	1.0000	1.0000	1.0000	1.0000
16	1.0121	1.0226	1.0157	1.0147	0.9889
17	1.0000	1.0000	1.0000	1.0000	1.0000
18	1.3699	1.3226	1.3552	1.3585	1.1412
19	1.0000	1.0000	1.0000	1.0000	1.0000
20	1.0000	0.8510	1.0000	1.0527	1.0522
21	0.9999	0.7970	1.0000	1.0526	1.0518
22	0.9959	0.9611	0.9947	0.9945	0.9982
23	0.9999	0.9648	0.9832	0.9831	0.9794
24	1.0001	0.8742	0.8910	0.8908	0.8880
25	0.9784	0.9611	0.9774	0.9763	0.9749
26	0.9736	0.9084	0.9787	0.9774	0.9771
27	0.9833	0.9716	0.9842	0.9833	0.9805
28	0.9819	0.9797	0.9838	0.9829	0.9786
29	1.0001	0.8789	0.8836	0.8835	0.7912
30	0.8629	0.9301	0.8857	0.8791	0.8767
31	0.6820	0.8337	0.7424	0.7274	0.7242
32	0.9274	0.9628	0.9394	0.9359	0.9345
33	0.8656	0.9368	0.8897	0.8834	0.8819
34	0.9200	0.9633	0.9347	0.9309	0.9296

The significance of our assumption about the supply of agricultural produce is clearly seen in the differences between the fourth and fifth simulations. In the fifth, since agricultural production is allowed to expand, the rural wage increases significantly. This change in factor prices leads to changes in relative prices throughout the system. The price of fishing (4), for example, increases in the fifth simulation due to the increase in wage costs, but remains relatively constant in the other four simulations.

Abolishing food subsidies leads to higher food prices (20–29). In contrast, raising indirect tax rates proportionally leads to higher prices for alcoholic beverages (30), tobacco (31), manufactured goods (32), and services (33–34) since these goods face relatively high indirect tax rates. Simulations like the first, which are associated with low levels of food prices and high levels of indirect tax rates, are therefore also associated with high levels of food consumption compared to consumption of services and manufactured goods. The reverse is, of course, true of simulations like the second, which are associated with high levels of food prices and low levels of indirect tax rates. The large increases in the activity levels of sugar (8) and mining (10) in the first simulation are due to the increase in exports (18).

We can analyze the effects of these alternative policies on income distribution by calculating the percentage changes in utility indices for the different consumer groups. This is done in table 6. Since the Cobb–Douglas utility indices that we use are homogeneous of degree one, these changes can be interpreted as percentage changes in real income: a 1% increase in income would result in a 1% increase in the utility index if the prices of

Table 6
Percentage changes in utility indices from base case.

Consumer group	Subsidies retained	Subsidies abolished	Selected subsidies retained	Selected subsidies increased (1)	Selected subsidies increased (2)
1	−3.47	−5.36	−3.88	−3.73	−4.28
2	−3.65	−4.86	−3.74	−3.76	−3.27
3	−4.18	−5.31	−4.33	−4.24	−5.20
4	−4.10	−5.23	−4.34	−4.33	−3.89
5	−5.08	−5.41	−5.00	−4.97	−6.20
6	−4.61	−5.15	−4.70	−4.72	−4.19
7	−5.57	−4.75	−5.19	−5.30	−6.28
8	−3.95	−4.02	−3.93	−4.01	−3.35
9	−5.27	−3.92	−4.74	−4.93	−5.37
10	−7.19	−4.64	−6.34	−6.60	−6.01
Urban	−5.28	−4.49	−4.90	−5.02	−5.78
Rural	−4.55	−4.67	−4.48	−4.55	−3.99

consumption goods remained fixed. The changes in utility indices should be interpreted with care. The specification ignores changes in per capita GDP; it ignores changes in future utility levels that result from changes in investment; and it assumes that consumers perceive government bonds as net wealth.

Notice that all of the simulations result in declines in utility indices compared with the base case. This is because they are all associated with an increase in the tax burden and a decrease in the government deficit: since consumers perceive government bonds as net wealth, a decrease in their supply results in a welfare loss. The interesting comparison is across different policy scenarios.

No policy Pareto-dominates any other. The poorer consumer groups in both the urban and the rural sectors prefer the policies that retain all subsidies or, if some are to be abolished, increase those on bread and tortillas. The richer consumer groups, on the other hand, especially those in the urban sector, prefer the policy that abolishes all subsidies. This is because this policy is associated with lower indirect tax rates, and commodities subjected to these taxes, as opposed to subsidized food, form a bigger part of these consumers' consumption bundles than they do of the consumption bundles of the poorer consumers.

Reducing food subsidies clearly has an adverse effect on the poorer consumer groups. Yet maintaining food subsidies has a high opportunity cost. To achieve the same reduction in the government deficit, a policy that retains food subsidies has to increase indirect taxes by a significantly larger factor than does a policy that abolishes subsidies. This clearly has an adverse effect on the upper income groups. If the government is concerned with improving income distribution, however, it should consider carefully what policies to employ to lower the government deficit. Policies that retain some subsidies, particularly those on bread and tortillas, seem preferable to ones that abolish all subsidies.

7. Concluding remarks

The results of our simulations are both believable and interesting. As is usual with this type of analysis, however, as many questions are raised by these results as are answered. Our results indicate that the impact of agricultural support prices on the welfare of rural consumer groups depends heavily on the responsiveness of supply to price changes. One obvious direction in which the model could be improved is a better specification of agricultural supply, possibly including considerations of the uncertainty that producers face. Another direction in which the model could be improved is in specification of consumer demand. To gain the generality of heterogeneous demand functions, we have sacrificed generality in their functional forms. Given our emphasis on welfare analysis and the scarcity of data, this trade-off is, perhaps, excusable. More effort, however, must be put into constructing demand functions that allow different income elasticities. Linear expenditure functions, for example, would allow income elasticities to differ from the unitary elasticities of the Cobb–Douglas functions. Obviously, such generality may be important in analyzing the demand for different food products. Given our system of classification of consumer groups by base period income and the fact that all of our expenditure data comes from a single household survey, it is not clear that estimating the parameters of such a system, while possible, would make much sense. There is certainly room, however, for experimenting with such a formulation and with alternative specifications of both demand functions and consumer groups.

Yet another obvious direction in which to improve the model is in the specification of investment and borrowing and lending decisions. A realistic specification would be forced to explicitly confront intertemporal issues that we have avoided in this model. Using an intertemporal general equilibrium model, we could more easily integrate microeconomic and macroeconomic issues. Questions about the macroeconomic closure of this sort of model can be more adequately addressed if we are able to develop a realistic intertemporal model that takes into account expectations, technological change, and demographic factors. There are, to be sure, formidable obstacles, in terms of both lack of theory and lack of data, that stand in the way. Nevertheless, construction of a realistic intertemporal equilibrium model is a major goal for future research.

Appendix: Sources of published data

Análisis de la Reforma Fiscal para 1983, Mexico City, Editorial Diana, S.A., 1983.

Encuesta Nacional de Ingresos y Gastos Familiares en 1977, Mexico City, Secretaría de Programación y Presupuesto, 1980.

Estadística de Ingresos Federales, Mexico City, Secretaría de Hacienda y Crédito Publico, 1983.

Indicadores Tributarios, Mexico City, Secretaría de Hacienda y Crédito Público, 1978.

Información Económica, Producto Interno Bruto y Gastos, 1970–1979, Mexico City, Banco de México, S.A., 1980.

Matriz de Insumo-Producto de México, Año 1970, Mexico City, Secretaría de Programación y Presupuesto, 1976.

Sistema de Cuentas Nacionales de México, 1970–1978, Mexico City, Secretaría de Programación y Presupuesto, 1981.

Sistema de Cuentas Nacionales de México, 1979–1981. Mexico City, Secretaría de Programación y Presupuesto, 1983.

Submatriz de Consumo Privado por Objeto del Gasto y Rama de Actividad de Origen, Año 1970, Mexico City, Secretaría de Progamación y Presupuesto and Banco de México, S.A., 1980.

References

Garcia-Alba, P. and J. Serra-Puche, 1983, Financial aspects of macroeconomic management in Mexico, Joint Research Program Series, no. 36 (Institute of Developing Economies, Tokyo).

Gibson, B., N. Lustig and L. Taylor, 1982, Terms of trade and class conflict in a Marxian computable general equilibrium model for Mexico, Paper presented at the Latin American Meetings of the Econometric Society, Mexico City.

Kehoe, T.J., 1985, The comparative statics properties of tax models, Canadian Journal of Economics 18, 314–339.

Kehoe, T.J. and J. Serra-Puche, 1983a, A computational general equilibrium model with endogenous unemployment: An analysis of the 1980 fiscal reform in Mexico, Journal of Public Economics 22, 1–26.

Kehoe, T.J. and J. Serra-Puche, 1983b, A general equilibrium appraisal of energy policies in Mexico, Working paper no. 321 (MIT, Cambridge, MA).

Kehoe, T.J. and J. Whalley, 1985, Uniqueness of equilibrium in large scale numerical general equilibrium models, Journal of Public Economics 28, 247–254.

Kehoe, T.J., J. Serra-Puche and L. Solis 1984, A general equilibrium model of domestic commerce in Mexico, Journal of Policy Modeling 6, 1–28.

Norton, R. and L. Solis, 1983, The book of CHAC: Agricultural planning in Mexico (Johns Hopkins University Press, Baltimore, MD).

Sen, A., 1963, Neo-classical and neo-Keynesian theories of distribution, Economic Record 39, 53–64.

Serra-Puche, J., 1984, A general equilibrium model of the Mexican economy, in: H.E. Scarf and J.B. Shoven, eds., Applied general equilibrium (Cambridge University Press, Cambridge) 447–481.

Taylor, L. and F. Lysy, 1979, Vanishing income redistributions: Keynesian clues about model surprises in the short run, Journal of Development Economics 6, 11–29.