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A General Equilibrium Appraisal of Energy Policy in Mexico

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Abstract

We develop a model of the Mexican economy to analyze the impact of government energy policies on relative prices and income distribution and on such macroeconomic variables as government and trade deficits. It is a static neoclassical general equilibrium model that focuses on production, consumption, and exports of energy goods. The specification allows the government to set prices and production levels of energy goods exogenously. Domestic prices differ from international prices and net exports of these goods are determined residually. The level of energy exports plays a major role in determining the government and trade deficits. The model is used to analyze the impact of government policies on the economy from 1977 to 1981 and also to analyze four alternative policies to restore economic stability following the 1982 financial crisis.

A General Equilibrium Appraisal of Energy Policy in Mexico

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1. Introduction

Recent history indicates that volatility in energy prices has a major impact on income distribution and resource allocation in the economy. Changes in the relative price of energy, considered as an input into the production process, alters the choice of techniques and, therefore, demand for other factors of production. When energy is considered as a final consumption good, these changes affect consumer welfare unevenly, since expenditure shares on energy goods vary widely across income groups.

Besides the obvious importance of energy markets in the determination of relative prices and incomes, they play a major role in the design of macroeconomic policy. The share of energy in international trade has increased substantially over the past decade. In Mexico, in particular, earnings from oil exports have helped promote its recent economic growth. Since the energy sector in Mexico is owned by the government, changes in energy prices and production levels have a significant impact on the government deficit. Energy pricing and production policies, consequently, play a crucial role in the current effort of the government to restore economic stability following the 1982 fiscal crisis.

Our goal is to develop a framework to analyze the impact of energy policies on income distribution and resource allocation and on such macroeconomic

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variables as government and trade deficits. As a first step we construct a static neoclassical general equilibrium model of the Mexican economy that focuses on production, consumption, and exports of energy goods. The degree of integration of the energy sector with the rest of the economy makes anything but a general equilibrium approach unattractive for analyzing energy policy.

Any approach that assumes perfect competition throughout the economy would not, however, be appropriate for such an analysis: The prices and production levels of energy goods in Mexico are determined by the government rather than by market forces. The specification of our model allows the government to set prices and production levels of energy goods exogenously. Domestic prices differ from international prices and net exports of these goods are determined residually. The level of energy exports is a major factor in the determination of the government and trade deficits.

2. The Model

The structure of this model is similar to that of Serra-Puche (1981) and Kehoe and Serra-Puche (1982). In the subsequent description we concentrate on the differences between the models. The model used in this paper includes 38 sectors: 12 non-energy production sectors, 5 energy sectors, 3 non-consumption demand sectors (government, foreign sector, and investment), 15 final consumption

Table 1

goods, and 3 factors of production. Notice that petrochemicals are classified as an energy good. We have done this because it is convenient to model the supply of petrochemicals in the same as way the supply of other energy goods.

The outputs of the first 12 non-energy sectors are produced by a series of nested constant elasticities of substitution production functions. This nesting is described diagramatically in Table 2. The intermediate inputs of the

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Table 2

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non-energy production sectors are aggregated with non-energy imports, which are a single homogeneous good, under the category of non-energy inputs. This aggregation uses a C.E.S. production function with elasticity equal to 2.6674. (The value of the substitution parameter has been obtained using a calibration procedure that we describe later.) Petroleum and natural gas, refined products, and electricity are aggregated using a Cobb-Douglas production function under the category of fuels. (The Cobb-Douglas production function is the limiting case of a C.E.S. production function with elasticity of substitution equal to 1.) Except in the energy sectors inputs of petroleum and natural gas are natural gas only. We have left this good as an aggregate, however, since petroleum and natural gas are joint products. Petrochemicals, coal, fuels, and capital are aggregated in fixed proportions. (The fixed coefficients production function is the limiting case of a C.E.S. production function with elasticity of substitution equal to 0.) Urban labor and rural labor are also aggregated in fixed proportions. The energy and capital composite input is combined with labor using a Cobb-Douglas production function. The final step of the aggregation is to combine the composite input of energy goods and factors of production with non-energy inputs in fixed proportions. The production functions at each level of this aggregation procedure differ from sector to sector.

The production functions for petrochemicals, crude petroleum and natural gas, and refined products differ from those described above in that all of the energy inputs enter the production function in fixed coefficients form. The production functions for coal and electricity, however, have the same structure as those of the non-energy production sectors.

This specification captures several stylized facts: Capital and fuels are complements. Labor, however, tends to be substitutable for both fuels and capital. The ratio between intermediate inputs and value added tends to remain fixed. The nesting of domestic non-energy inputs with non-energy imports is meant to capture the stylized fact that domestic goods and imported goods are close, but not perfect, substitutes. This specification is in the spirit of that of Armington (1969), who constructs a composite input of each non-energy good using a C.E.S. aggregation of the corresponding domestic good and imported good. Our specification differs from Armington's in two respects: First, because of lack of information, we treat non-energy imports as an aggregate. Second, the production function that aggregates domestic inputs and imported inputs differs from sector to sector: The fixed proportions production function for domestic inputs differs from sector to sector, as do the relative weights put on domestic inputs and on imported inputs in the C.E.S. production function. In principle, we could also vary the elasticity of substitution across sectors. We do not do so here, however, again because of lack of information. Notice that imports of energy goods are treated differently from those of the non-energy aggregate. Domestic energy goods and imported energy goods are, in fact, perfect substitutes.

The three non-consumption demand sectors and 15 consumption demand sectors have production functions that allow a similar structure of substitutability among inputs. The government services sector is, however, the only one of these sectors that utilizes factors of production. The production functions for the 15 consumption demand sectors serve only to transform the aggregation of outputs from the 17 production sectors into a different aggregation of consumer goods.

The matrix representing these fixed proportions production functions acts as a black box, with production goods going in and consumption goods coming out.

Producers demand inputs in proportions that minimize costs given the production functions described above. Let B(p) be the 38 x 35 activity analysis matrix:

$$(1) \qquad B(p) = \begin{bmatrix} A(p) \\ F(p) \end{bmatrix} .$$

Here p is a 38 x 1 vector of prices; A(p) is a 35 x 35 input-output matrix whose elements vary with prices; and F(p) is a 3 x 35 matrix of factor demands that also vary with prices. B(p) is continuous and homogeneous of degree zero in p; that is, input demands do not vary if all prices are multiplied by a positive constant.

There are 12 consumer groups in the model. The first 10 represent aggregates of households in the Mexican economy and are divided into 5 income groups in both urban and 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 definition of capital is a weak point of this model: It is the residual of value added after labor costs and indirect taxes are substracted.

Table 3

The demand function of each of these groups is derived by solving a problem of maximizing a Cobb-Douglas utility function subject to a budget constraint. The income of the groups is the value of its initial endowment net of income tax.

$$(2) \quad Y^h = (p_{36}w_{36}^h + p_{37}w_{37}^h + p_{38}w_{38}^h)(1-i^h).$$

Here p_{36}, p_{37}, and p_{38} are the prices and w_{36}^h, w_{37}^h, and w_{38}^h, the initial endowments of capital, urban labor, and rural labor, 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 21 through 35. In addition, the consumer saves a constant fraction of income, which becomes a purchase of the investment good (20). The demand for good i by consumer h is

$$(3) \quad x_i^h = \frac{\alpha_i^h Y^h}{p_i(1 + cf_i)} .$$

Here α_i^h is the proportion of income spent on good i by consumer group h, p_i is the producer price of good i, cf_i is the *ad valorem* tax rate on purchase of good i.

The 11th consumer is the government, which taxes production, imports, consumer income, and sales. It also earns a return on the capital that it owns. The energy industry in Mexico is owned by the government. The two biggest firms are Pemex (Petroleos Mexicanos), which controls supply of petrochemicals, crude petroleum and natural gas, and refined products, and CFE (Comisión Federal de Electricidad), which controls supply of electricity. Most of the supply of coal is controlled by another government firm, Altos Hornos de México. Although a small fraction of demand for coal is supplied privately, we have chosen to model the entire coal sector as controlled by the government. The government in this model is an aggregate of the federal government and these firms. The government sets the prices of the five energy goods. It also sets production levels in the first four energy sectors and exports or imports the difference between supply and domestic demand; the production level of electricity varies, however, so that supply equals domestic demand. The profits or losses of these activities are absorbed into the government budget.

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 13th column of the input-output matrix. These services are purchased 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 in the economy. The government also invests in public works and in the energy sectors.

The income tax revenue collected by the government is

$$(4) \qquad I = \sum_{h=1}^{10} i^h Y^h .$$

Let ci_i be the *ad valorem* tax rate paid by the producer of good i, i=1,...,20, on sales. Similarly, let cf_i be the sales tax rates defined previously. Each tax rate is computed as the weighted sum of taxes on all goods aggregated into good i in the model. The total revenue collected from these taxes is

$$(5) \qquad C = \sum_{i=1}^{20} p_i ci_i a_{ii} y_i + \sum_{i=21}^{35} p_i cf_i \sum_{h=1}^{10} x_i^h .$$

Here a_{ii} is a diagonal element of the input-output matrix, y_i is the associated activity level, and x_i^h is the expenditure on good i by consumer h.

Imports of non-energy goods are assumed to be a single homogeneous good. The model has an aggregate tariff that applies to this good when used as an input. The revenue from taxing imports is

$$(6) \qquad T = p_M t_M \sum_{j=1}^{20} |a_{Mj}| y_j \quad ,$$

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. The government's total tax revenue is the sum

$$(7) \qquad R = I + C + T.$$

The composition and level of government expenditures are viewed as independent policy decisions. In the absence of simulated changes, our behavioral assumption is that they are fixed in physical terms. The government can be thought of as maximizing a fixed proportion utility function subject to the budget constraint.

$$(8) \qquad Y^G = p_{20} w_{20}^G + p_{36} w_{36}^G + R + E,$$

where p_{20} and w_{20}^G are the price and endowment of bonds in the hands of the government, w_{36}^G is the government's endowment of physical capital, and E is the net energy profits. Consumers regard government bonds as perfect substitutes for physical investment when making saving decisions. The government's utility function has only two non-zero coefficients, that for government services and that for investment.

An important feature of this model is that 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 level of government revenue varies, we allow the deficit to adjust so that the level of government expenditures remains fixed.

The final consumer in the model represents the rest of the world. The specification of the foreign sector is very simplistic. Nevertheless, it captures the structure of the balance of trade and the corresponding capital flow. Exports generate foreign exchange that the economy uses to finance imports. Non-energy goods are exported in fixed proportions, which are given by the elements of the 19th column in the input-output matrix. The diagonal element of this column indicates the amount of imports that are "produced" by the export activity. By changing this element we are able to simulate changes in the terms of trade between Mexico and the rest of the world. We assume that the level of these exports remains fixed. Net export levels of petrochemicals, coal, crude petroleum and natural gas, and refined products are determined residually: The government determines production levels, the residual is either exported or imported. The international prices of these goods are determined exogenously. They may differ from the domestic prices, which are also exogenous but are set by the government. The level of non-energy imports is determined endogenously by final and intermediate demands. Any trade deficit appears endogenously as a net endowment of non-energy imports in hands of the 12th consumer, who demands the domestic investment good. This demand may be positive or negative depending on whether there is a trade deficit or surplus. Thus, any deficit on the trade account has a corresponding surplus on the capital account.

Although the model is static, we must account for the investment that takes place during the period of analysis. An aggregated investment good is produced by the 20th activity in the input-output matrix. We are assuming that the composition of investment remains fixed in physical terms. Total investment in the economy is given by

$$(9) \quad V = S + GI + TD - GD,$$

where S is total savings by consumers, GI is government investment, TD is the trade deficit, and GD is the government deficit.

3. Definition and Computation of Equilibrium

We tie together the components of the model described in the previous section by defining the concept of equilibrium. The utility maximizing consumption bundles chosen by consumers vary with prices and incomes, which in turn vary with prices. In the case of the government, income also varies with tax receipts R and the deficit GD. The income of the rest of the world is determined by the trade deficit TD. Consumers' demands are aggregated into a vector of excess demand functions $\xi_i(p, R, GD, TD)$, i=1,...,38. These functions are continuous, at least for strictly positive price vectors, and homogeneous of degree zero. Let t(p, R, GD, TD) denote total taxes paid by consumers, including taxes on final consumption and income. t is continuous and homogeneous of degree one. Moreover, ξ_i and t obey the following version of Walras's law:

$$(10) \quad \sum_{i=1}^{38} p_i\xi_i(p, R, GD, TD) + t(p, R, GD, TD) \equiv R,$$

which can be derived by adding up the consumers' budget constraints.

Define the matrix $\bar{B}(p)$ by the rule

$$(11) \quad \bar{b}_{ij} = b_{ij} - s_{ij}|b_{ij}|$$

Here s_{ij} denotes the tax on the sales or purchases of good i by sector j; the tax rates s_{ij} include the rates ci_i and t_M discussed previously. In this notation $p\bar{B}(p)y$ represents the after-tax profitability of the production plan $B(p)y$, where y is a 35 x 1 vector of non-negative activity levels. The total tax revenue is $p(B(p) - \bar{B}(p))y$.

An equilibrium is a vector of prices p^*, a tax receipts level R^*, a government deficit GD^*, a trade deficit TD^*, and a vector of activity levels y^* that satisfy the following conditions: First, all activities, except those for energy goods, must make zero profits after the payment of taxes:

$$(12) \qquad \sum_{i=1}^{38} p_i^* \bar{b}_{ij}(p^*) = 0, \; j=1,\ldots,12,18,\ldots,35.$$

This, of course, is the profit maximization condition for a competitive, constant-returns industry. Second, demand equals supply for all goods:

$$(13) \qquad \xi(p^*, R^*, GD^*, TD^*) = B(p^*)y^*.$$

Third, the tax receipts that enter the government budget constraint are equal to what it actually collects:

$$(14) \qquad R^* = t(p^*, R^*, GD^*, TD^*) + p^*(B(p^*) - \bar{B}(p^*))y^*.$$

Fourth, and finally, we require that prices satisfy

$$(15) \qquad \sum_{i=36}^{38} \gamma_i p^*_i = 1.$$

Here $\gamma_i > 0$, $\sum_{i=36}^{38} \gamma_i = 1$, are fixed weights based on the shares of the three factors in national income. This is just a price normalization that we are permitted by the homogeneity of ξ, t, and B.

The equilibrium conditions can be viewed as a non-linear system with the same number of equations as unknowns: There are 38 prices p_i^* and 38 requirements that demand equal supply (13). Although Walras's law (10) implies that one of these requirements is superfluous, homogeneity allows us to impose the price normalization (15) to replace it. There are also 35 activity levels y_j^* and 35 zero profit conditions (12). Dropping the 5 zero profit conditions for the energy goods allows us to set their prices $p_{13}^*,\ldots,p_{17}^*$ exogenously in terms of a weighted average of factor prices. Letting net exports of the first 4 energy goods vary, thus letting the demands for them vary, allows us to set their activity levels $y_{13}^*,\ldots,y_{16}^*$. There are three additional unknowns in our system, the tax receipts level R^*, the government deficit GD^*, and the trade deficit TD^*. Corresponding to them are the government budget constraint (14) and conditions that fix the levels of exports of non-energy goods and of government expenditures y_{18}^* and y_{20}^*. These can either be fixed in physical terms,

$$(15) \qquad y_j^* = \bar{y}_j \; ,$$

or fixed so that value is constant in real terms using the price index,

$$(16) \qquad y_j^* = (\Sigma_{i=36}^{38} \gamma_i p_i^* \; / \; p_j^*)\bar{y}_j .$$

Other combinations of equilibrium conditions and endogenous variables are certainly possible: We could fix the government deficit, for example, and allow the level of government expenditure to adjust.

The parameters of the model have been derived from observations of the Mexican economy in 1977 and have been carefully calibrated to replicate the economy in that year. The year 1977 is used because it is the latest for which a complete data set could be assembled. 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 y Presupuesto. We have adjusted the elements in the columns corresponding to government services, non-energy exports, and investment using the input-output matrix for 1975. We have also adjusted the elements in the rows and columns corresponding to the energy sector using information obtained from the Secretaría de Programación y Presupuesto and the Instituto Mexicano del Petróleo. Finally, the entire 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. 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.

Specification of profit rates and pricing policies in the energy sector is difficult because of the reticence of Pemex to disclose information. Profit rates have been estimated by comparing the net incomes of different industries in

1977 with those in 1970, assuming that the technological structure of inputs remained constant over this period and that industries earned zero net profits in 1970. Although these assumptions are drastic, the profit rates derived are consistent with the other limited information we have: The crude petroleum and natural gas and refined products sectors make large profits; the electricity sector makes a loss. The international prices of crude petroleum and natural gas and refined products are 180% higher than the domestic prices; the domestic prices of petrochemicals and coal are the same.

The elasticity of substitution between domestic non-energy inputs and imports has been calibrated by finding the value consistent with the correct level of investment when the major exogenous variables are updated from 1977 to 1981: This elasticity of substitution is crucial for determining the level of imports, which, in turn, determines the trade deficit since exports are fixed, which, in turn, is related to the level of investment by the macroeconomic accounting identity (19). The results of the update from 1977 to 1981 are presented in the next section.

To obtain tax information we have carefully aggregated the actual tax rates so as to match our aggregation. The tax that each good faces is a weighted average of effective rates obtained from the Secretaría de Hacienda. We assume neutrality of tax evasion within the sector or aggregate good. The income tax rates are effective rates derived while keeping the whole income tax structure unchanged; again 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.

An equilibrium is computed using a Quasi-Newton method. Alternatively, it would be possible to use a version of Scarf's fixed point algorithm. In fact, the applicability of this algorithm to this model can be viewed as a constructive proof of the existence of an equilibrium (see Scarf (1973)).

The computation is greatly simplified by reducing the problem to a search over the factor prices, tax receipts level, government deficit, and trade deficit: Given a vector of factor prices and energy prices, which are exogeneously set by the government in terms of factor prices (15), the zero profit conditions (12) can be used to compute commodity prices. The supply equal demand condition (13) can then be used to compute activity levels. As we have mentioned, there are enough degrees of freedom in the model to fix the activity levels of the first four energy industries. The activity levels are then used to compute factor demands. The conditions that excess demands for factors equal zero and that the tax receipts level, government deficit, and trade deficit used to compute demands are the same as result from computation of activity levels are then the equilibrium conditions.

Units have been normalized so that all prices and activity levels should be one. The results of computation are indeed equal to one to six significant digits. The values of all major macroeconomic variables coincide exactly with those actually observed in 1977. Computation of an equilibrium usually takes less than three minutes of CPU time on an IBM 370/168.

4. Simulations

To illustrate uses of the model we have conducted several comparative statics exercises. First, a benchmark equilibrium is computed; then changes are made in the parameters of the model; finally, a new equilibrium is computed and the results compared with those of the benchmark. In general, it is difficult, if not impossible, to ensure that this type of model has a unique equilibrium (Kehoe (1982)). Using a technique described by Kehoe and Whalley (1982), however, we have carried out an exhaustive search to verify that the equilibrium of this model is indeed unique.

The spirit of the first simulation is to mimic the principal changes in government energy policy and spending levels that occurred from 1977 to 1981. There are seven changes in exogenous variables:

1. Production levels of energy goods change: Production of petrochemicals increases by 21.46%; that of coal decreases by 20.83%; that of crude petroleum and natural gas increases by 79.17%; and that of refined products increases by 10.87%. These changes are the actual changes in physical production indices for these goods deflated by the 38.39% increase in real GDP that occurred between 1977 and 1981.

2. Domestic prices of energy goods change: The price of petrochemicals falls by 24.00%; that of coal falls by 22.60%; that of crude petroleum and natural gas and that of refined goods fall by 11.50%; and that of electricity falls by 23.90%. These changes are the actual changes in price indices deflated by the 128.95% increase in the GDP deflator that occurred between 1977 and 1981.

3. The system of indirect taxes has been altered to reflect the 1980 fiscal reform, which replaced a complex system of sales taxes and production taxes with a valued added tax system. In addition, subsidies to agricultural production and food consumption increase substantially. The net tax and subsidy rates are given in Table 4.

4. The terms of trade between Mexican exports and foreign imports, given by the relative size of the diagonal element of the export activity, increases by 60.63%. Between 1977 and 1981 the GNP deflator in the U.S., by far Mexico's

biggest trading partner, rose by 31.25%, 97.70% less than the increase in Mexico, yet the exchange rate of pesos per dollar rose by only 8.56%.

5. The international prices of energy goods change: Crude petroleum and natural gas rises by 14.40%; petrochemicals, coal, and refined products falls by 2.60%. These changes are the actual changes in price indices in the U.S. deflated by the increases in the terms of trade and in the U.S. GNP deflator.

6. Exports of non-energy goods fall by 12.84% in physical terms.

7. Government consumption increases by 8.31% and government investment increases by 83.71%, both in value terms.

As we have explained the elasticity of substitution between domestic non-energy inputs and imports has been chosen so as to allow a 32.20% increase in total investment in value terms. This change, as well as the final two above, is again deflated by the 38.30% growth of the economy as a whole.

Table 4

As would be expected, these changes have a major impact on the economy. Table 5 describes the impact in terms of changes in the major macroeconomic variables. The differences in the absolute size of GDP have little meaning since we have not accounted for economic growth, technological changes, or changes in unemployment and capacity utilization. Nonetheless, the sizes of these variables

Table 5

in relation to GDP are encouragingly close to those actually observed: The 1980 fiscal reform and subsidy increases cause net tax receipts (not including energy revenues) to drop. The increase in energy revenues is not substantial enough to compensate for this drop in tax receipts and the increases in government expenditure. Consequently, the government deficit rises sharply. The only way this increase in the deficit can be accommodated without crowding out private investment is for foreign borrowing to increase dramatically. In our simple model the level of foreign borrowing necessary to finance the high levels of the government deficit and private investment can only be reflected in a large trade deficit.

Table 6

The impact of these changes on relative prices and resource allocation is reflected in Tables 6 and 7. The largest price change is that of imports, which falls because of the changes in the real exchange rate. Another very large price change is that of investment goods, which increases sharply. (Notice that much of the large increase in total investment in Table 5 is accounted for by this change in relative prices: The increase in physical terms given in Table 7 is much smaller.) The prices of energy goods and food products, both heavily subsidized by the government, drop significantly. These changes in relative prices are close to those that did, in fact, occur between 1977 and 1981.

Table 7

The impact of these changes on income distribution are reflected in the changes in factor prices given in Table 6. Notice, in particular, the large increase in the urban wage rate relative to the rural wage rate and, to a lesser extent, to the return to capital. This is due largely to the increases in the activity levels of the government sector and the investment sector, which, directly and indirectly, demand large amounts of urban labor. The fall in the return to capital relative to the urban wage comes in spite of the fall in the prices of energy inputs that are complements to capital and substitutes to labor.

Another way to analyze the impact of these changes on income distribution is to calculate changes in utility indices. Percentage changes in values of these indices can be interpreted as percentage changes in real incomes: The Cobb-Douglas utility functions are weighted geometric means of consumption levels of different goods. A 1% increase in utility, for example, corresponds to a 1% increase in income if prices are constant. The present specification of the utility indices ignores changes in the provision of public goods due to changes in government spending; it ignores changes in future utility levels due to changes in investment; and it assumes that consumers perceive government bonds as net wealth. See Kehoe and Serra-Puche (1982) for a discussion of these issues.

Table 8

The results in Table 8 indicate that these changes result in a shift of real income from the rural to the urban sector. It is the relative changes in the utility indices that are significant. To make sense of the absolute level of the 1981 utility levels, we must remember that real per capita GDP grew by roughly 15% between 1977 and 1981: The numbers in the first column of Table 8 could be scaled up by a factor of 1.15. Except for favoring urban groups at the expense of rural groups, there is no clear tendency to the pattern of change. Notice, however, the relatively large drop in the utility levels of the two rural middle income groups and the relatively small drop in those of the two urban middle income groups.

In 1982 Mexico found itself faced with a severe financial crisis. The immediate causes of this crisis were the fall in international petroleum prices in June of 1981 and the high interest rates in international financial markets throughout 1980 and 1981, caused to a large extent by restrictive U.S. monetary policy. The deeper causes were the high, and growing, levels of the government and trade deficits and the overvaluation of the peso. The crisis was accompanied by a massive outflow of capital and devaluation of the peso: The terms of trade between Mexican exports and foreign imports fell by almost 70% from 1.6063 to 0.4906, where 1977 equals 1.0. See Garcia-Alba and Serra-Puche (1983) for a thorough analysis of this crisis and its historical precedents.

The spirit of the other four simulations is to examine the impact on relative prices, resource allocation, and income distribution of alternative policies to restore economic stability. In each of these simulations there are six changes in exogenous variables from the previous simulation:

1. Prices of all energy goods are increased by 20%.

2. The indirect tax system is altered to reflect the increases in the value added tax and cuts in subsidies enacted in early 1983.

3. The terms of trade are allowed to return to their 1977 levels, which, it can be argued, were the long run equilibrium levels attained after a similar, but

less severe, financial crisis in 1976. This change would most likely be accomplished by allowing domestic prices to rise.

4. The international price of petroleum and natural gas increases by 24.65% and those of the other energy goods increase by 38.40%. These changes correspond to the actual fall in the international price of petroleum and a roughly stable level of other energy prices that occurred between 1981 and 1983, offset by a significant improvement in the real exchange rate.

5. Non-energy exports return to their 1977 level.

6. The levels of government consumption and investment are both reduced and remain constant in physical terms.

The goal of the policies enacted in the first three of these simulations is to bring about a trade surplus that is roughly 5% of GDP in order to finance service and eventual reduction of the foreign debt. In the first scenario the production level of petroleum and natural gas is increased by 17.22%; in the second energy prices are increased by 26.73%; and in the third energy prices are increased by 16.12% while the indirect tax and subsidy rates return to their 1981 levels. Notice in Table 4 that the third policy results in a much larger government deficit than the other two. Consequently, since reducing the government deficit is also a major policy goal, we simulate a fourth policy in which energy prices are increased by 107.49%, while tax rates return to their 1981 levels. This results in a government surplus as large as any of the other policies and a trade surplus that is even larger, more than 9% of GDP.

All four of these policies are able to reduce the trade deficit by increasing revenues from energy exports: Increasing the prices of domestic energy goods increases domestic revenues, and, because it causes domestic consumption to fall, it also causes the residual exports to rise. The substantial increase in the price of imports caused by the change in the terms of trade also causes imports to drop. All four of these policies result in a substantial drop in the price of investment goods. Although total investment spending falls in all of our scenarios, physical investment actually increases in the first two. The return to capital is lower, relative to that of urban and rural labor, in the second and fourth scenarios than in the first and third. This, of course, is the result of the large increases in the prices of energy inputs, which are complements to capital and substitutes to labor.

Examining the utility indices, we observe that the third and fourth policies, those that cut indirect taxes, increase food subsidies, and increase energy prices, pareto dominate the first two. All four of the policies result in changes in real incomes that are moderately progressive. The third policy results in the most progressive changes; it also favors the rural consumer groups the most. Notice, however, that it is accompanied by the largest government deficit and the lowest level of physical investment.

That the third and fourth policies pareto dominates the first and second is a striking result. It clearly suggests that a policy of lowering indirect taxes and increasing energy prices would improve the welfare of most consumers in Mexico. It should not be taken to indicate, however, that all consumers would be better off as the result of such a policy. The consumer groups and factors of production in our model are too aggregated to warrant such a conclusion. The owners of firms in some narrowly defined industries, for example, would undoubtedly suffer a decline in real income if such a policy were enacted.

Nevertheless, our results indicate that no broadly defined consumer group would suffer such a decline.

5. Concluding Remarks

In spite of the large increase in energy production levels between 1977 and 1981 and the large increase in the international prices of energy goods, the government and trade deficits in Mexico rose rapidly. One major reason was the increases in government expenditures. Another reason was the increase in the terms of trade, which encouraged imports, discourged exports, and lessened the effect of rising international energy prices. Yet another reason was the fall in the relative price of energy goods domestically, which resulted in a substantial increase in domestic energy consumption at the expense of exports. A final reason was the fall in indirect taxes net of subsidies brought about by the 1980 fiscal reform and the large increase in agricultural and food subsidies.

Faced with a major financial crisis, the Mexican government is now forced to choose among policies that reduce the government deficit and produce a trade surplus. We have simulated four possible policy scenarios. In all four we have assumed that the government is able to reduce expenditures, particularly government consumption, as a percentage of GDP. We have also assumed that it, along with market forces, is able to restore the real exchange rate and the level of non-energy exports as a percentage of GDP to their 1977 levels, which, we feel, are close to their long run equilibrium levels. The first policy scenario increases the production level of crude petroleum and natural gas. The second increases the prices of all energy goods. The third and fourth increase energy prices at the same time as they restore indirect tax and subsidy rates to their 1981 levels.

The final two policy scenarios result in changes in real incomes that pareto dominate those of the first two. Unfortunately, the first two policy scenarios result in higher levels of physical investment. It seems clear, however, that policies that increase energy prices while decreasing taxes have a more favorable impact on consumer welfare and income distribution than policies that retain the high tax rates that were instituted in 1983.

The model undoubtedly has shortcomings: First, the model ignores monetary issues. For example, much of the government deficit over the years 1977 to 1981 was financed by inflation. Our model, which deals only with real variables, neglects this important phenomenon. Second, the model specifies the determination of the levels of non-energy exports and private investment in simplistic ways. Third, the model ignores migration from the rural to the urban sector. Such migration probably mitigated the shift in demand from rural labor toward urban labor that occurred from 1977 to 1981. Fourth, the model ignores short run disequilibrium phenomena, particularly speculative capital movements, unemployment, and underutilization of capacity, which are obviously very important in the adjustments that Mexico now has to make following the major shocks it has been subjected to.

In spite of such shortcomings, our simulations provide valuable insights into recent history and current alternatives in Mexico. One obvious conclusion to be drawn with regard to recent history is that increases in energy exports were too small to justify the massive increases in government spending, investment, and imports that occurred from 1977 to 1981. An obvious conclusion to be drawn with regard to current alternatives is that domestic energy prices are low compared with indirect tax rates and that there is room to shift from one policy tool to another. In particular, lowering taxes and increasing energy prices can increase consumer welfare and improve income distribution. This is obviously a desirable goal since inequality in income distribution is a major problem in Mexico. The results of the simulations indicate, however, that care should be taken in designing a policy to accomplish this goal. Policies that increase the government deficit or increase the trade surplus while transfering income to consumers with low propensities to save may also retard investment and economic growth.

One way to circumvent this problem of analyzing the impact of government policy on investment would have been to fix the level of investment in all four scenarios rather than the level of non-energy exports. The same qualitative results emerge under this specification: Increasing energy prices and lowering indirect taxes pareto dominates alternative policies. Such a specification merely shifts the problem, however. Now it is the impact on the level of exports that we have problems in analyzing. We have chosen the alternative that we have used because we think it is the more realistic. The ultimate answer to the problem is, of course, to develop a model that can handle these issues adequately. Major improvements, for example, could be made by incorporating dynamic factors. This would obviously help in specifying investment behavior and foreign borrowing. It would also help us to better understand the tradeoffs between short run improvements in consumer welfare and more rapid eocnomic growth. The construction of such a dynamic general equilibrium model remains an important challenge.

Appendix

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Table 1

List of Sectors

Non-Energy Production

1. Agriculture
2. Mining
3. Food products
4. Textiles
5. Wood products
6. Chemical products
7. Non-metal manufacturing
8. Machinery and automobiles
9. Commerce
10. Transportation
11. Services
12. Construction

Energy Production

13. Petrochemicals
14. Coal
15. Crude petroleum and natural gas
16. Refined products
17. Electricity

Non-Consumption Demand

18. Government services
19. Imports-exports
20. Fixed investment and inventory accumulation

Consumption Demand

21. Bread and cereals
22. Milk and eggs
23. Other groceries
24. Fresh fruits and vegetables
25. Meat
26. Fish
27. Beverages
28. Clothing
29. Furniture
30. Electronic products
31. Medical products
32. Transportation
33. Educational articles
34. Articles for personal care
35. Services

Factors of Production

36. Capital and other factors
37. Urban labor
38. Rural labor

Table 2

Nesting of Production Functions

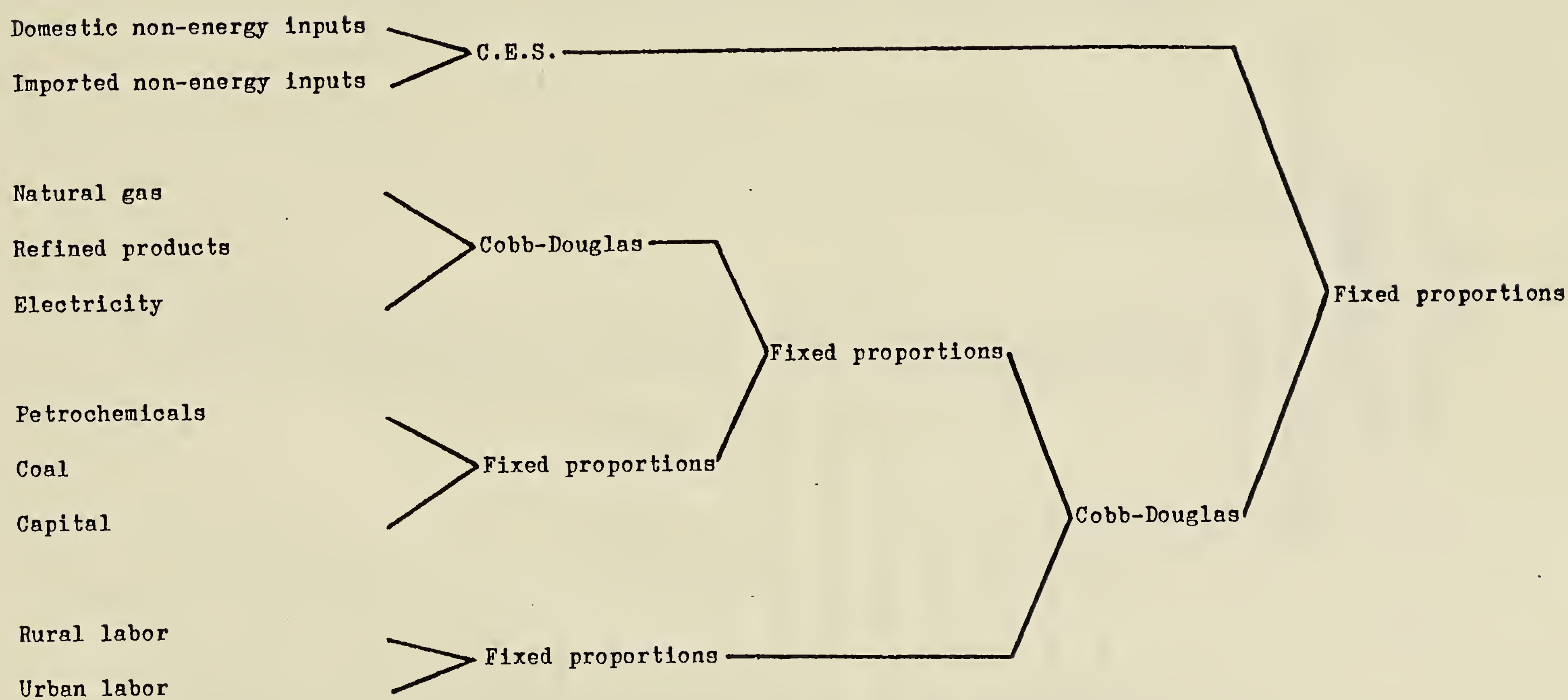

Table 3

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-)
11. Government
12. Foreign sector

Energy Simulations

Indirect Tax Rates

	1977	1981	1983
1.	.0012	-.0766	-.0095
2.	.0431	.0088	.0088
3.	.0383	-.0173	-.0021
4.	.0286	.0000	.0000
5.	.0384	.0000	.0000
6.	.0529	.0000	.0000
7.	.0342	.0000	.0000
8.	.0564	.0000	.0000
9.	.0000	.0000	.0000
10.	.0144	.0000	.0000
11.	.0178	.0000	.0000
12.	.0155	.0000	.0000
13.	.0000	.0000	.0000
14.	.1508	.0000	.0000
15.	.0000	.0000	.0000
16.	.0068	-.0797	-.0107
17.	.0030	-.0547	-.0071
18.	.0723	.1786	.2236
19.	.0000	.0000	.0600
20.	.0080	.0000	.0300
21.	.0045	.0000	.0300
22.	.1322	.1860	.2563
23.	.0211	.0902	.1352
24.	.0387	.0902	.1352
25.	.0644	.0902	.1352
26.	.0445	.0902	.0502
27.	.1568	.0902	.1452
28.	.0142	.0000	.0000
29.	.0339	.0902	.1352
30.	.0340	.0473	.1473
31.	.1015	.0000	.0000
32.	.1154	.0521	.0521
33.	.0795	.0000	.0000
34.	.0002	.0000	.0000
35.	.0413	.0000	.0000
t_M	.0843	.0843	.0843

Table 5

Major Macroeconomic Variables

(millions of 1977 pesos)

		1977 Base Case	1981 Update	Production Increase	Price Increase	Price Increase/ Tax Cut (1)	Price Increase/ Tax Cut (2)
1.	Tax receipts	216,816	166,327	224,345	225,203	152,753	155,964
2.	Government Capital Income	37,562	37,178	37,460	37,124	37,710	36,570
3.	Energy Revenues	15,438	47,285	145,386	164,703	147,611	241,065
4.	Government Consumption	195,552	211,794	180,316	181,729	178,519	185,064
5.	Government Investment	137,750	253,061	222,783	223,976	224,230	226,940
6.	Government Deficit (=4+5-1-2-3)	63,486	214,065	-4,091	-21,325	64,674	-21,325
7.	Private Consumption	1,101,127	1,100,796	1,101,055	1,101,327	1,101,310	1,101,347
8.	Private Investment	241,801	248,704	217,847	234,959	149,068	154,651
9.	Trade Deficit	1,529	159,004	-90,000	-90,000	-90,000	-170,204
10.	Gross Domestic Product (=4+5+7+8-9)	1,674,700	1,655,351	1,812,001	1,831,991	1,743,126	1,838,206

Table 6

Market Prices

$(.5739p_{36} + .3213p_{37} + .1048p_{38} = 1)$

	1981 Update	Production Increase	Price Increase	Tax Cut/ Price Increase (1)	Tax Cut/ Price Increase (2)
1.	0.9180	0.9823	0.9852	0.9313	0.9175
2.	1.0235	0.9711	0.9763	0.9820	0.9842
3.	0.9607	0.9592	0.9600	0.9275	0.9184
4.	1.0170	0.9748	0.9761	0.9716	0.9772
5.	1.0684	0.9763	0.9781	0.9762	0.9790
6.	0.9597	0.9435	0.9640	0.9568	1.0241
7.	1.0791	0.9753	0.9795	0.9845	0.9861
8.	0.9116	0.9342	0.9405	0.9378	0.9591
9.	0.9956	0.9967	0.9938	1.0003	0.0991
10.	1.0525	0.9915	0.9967	0.9974	1.0090
11.	1.0109	0.9828	0.9829	0.9836	0.9856
12.	1.0421	0.9776	0.9831	0.9823	0.9933
13.	0.7600	0.9120	1.1558	1.0590	1.8923
14.	0.7740	0.9288	1.1771	1.0785	1.9272
15.	0.8850	1.0620	1.3459	1.2332	2.2035
16.	0.8850	1.0620	1.3459	1.2332	2.2035
17.	0.7610	0.9132	1.5732	1.0604	1.8948
18.	1.0281	1.0018	1.0096	0.9918	1.0281
19.	0.5130	0.8201	0.8228	0.8084	0.8103
20.	1.2698	1.0127	1.0181	1.0192	1.0316
21.	0.8822	0.9584	0.9583	0.8700	0.8601
22.	0.9010	0.9727	0.9729	0.9007	0.8893
23.	1.0617	1.1118	1.1117	1.0454	1.0336
24.	0.9441	1.0464	1.0474	0.9545	0.9413
25.	0.9633	0.9948	0.9943	0.9457	0.9357
26.	0.9516	1.0037	1.0041	0.9467	0.9350
27.	1.0279	1.0890	1.0874	1.0166	1.0051
28.	1.0762	1.0940	1.0936	1.0504	1.0486
29.	1.0454	1.0646	1.0683	1.0270	1.0368
30.	0.9843	1.0304	1.0332	0.9936	1.0013
31.	1.0182	0.9731	0.9827	1.0192	1.0507
32.	0.9440	0.9708	0.9782	0.9329	0.9388
33.	1.0227	0.9713	0.9710	0.9727	0.9691
34.	1.0401	1.0676	1.0751	1.0320	1.0556
35.	1.0185	1.0912	1.0937	0.9989	0.9995
36.	0.9898	0.9973	0.9884	1.0040	0.9736
37.	1.0351	1.0086	1.0143	0.9840	1.0429
38.	0.9483	0.9885	1.0199	1.0275	1.0132

Table 7

Activity Levels

(1977 = 1.0)

	1981 Update	Production Increase	Price Increase	Tax Cut/ Price Increase (1)	Tax Cut/ Price Increase (2)
1.	1.0178	0.9881	0.9916	1.0387	1.0481
2.	0.8690	1.0679	1.0744	0.9728	0.9733
3.	1.0057	0.9789	0.9807	1.0376	1.0464
4.	0.9275	0.9312	0.9321	0.9604	0.9614
5.	0.9218	1.0028	1.0086	0.9733	0.9688
6.	0.9521	0.9970	0.9978	0.9869	0.9811
7.	0.9836	1.0852	1.1106	0.9706	0.9752
8.	1.0227	1.0902	1.0966	1.0082	1.0055
9.	0.9628	0.9833	0.9867	0.9960	0.9981
10.	1.0264	1.0529	1.0504	1.0423	1.0407
11.	0.9899	0.9446	0.9400	0.9940	0.9924
12.	1.0240	1.1434	1.1846	0.9622	0.9717
13.	1.2146	1.2146	1.2146	1.2146	1.2146
14.	0.7917	0.7917	0.7917	0.7917	0.7917
15.	1.7313	2.0294	1.7313	1.7313	1.7317
16.	1.1087	1.1087	1.1087	1.1087	1.1087
17.	1.2434	1.0753	0.8778	0.9689	0.5436
18.	1.0535	0.9205	0.9205	0.9205	0.9205
19.	0.8716	1.0000	1.0000	1.0000	1.0000
20.	1.0411	1.1464	1.1877	0.9650	0.9746
21.	1.1269	1.0420	1.0438	1.1528	1.1601
22.	1.1108	1.0284	1.0285	1.1099	1.1261
23.	0.9393	0.8989	0.8998	0.9579	0.9968
24.	1.0573	0.9553	0.9551	1.0487	1.0623
25.	1.0388	1.0054	1.0061	1.0571	1.0703
26.	1.0520	0.9966	0.9962	1.0559	1.0707
27.	0.9705	0.9178	0.9200	0.9849	0.9946
28.	0.9293	0.9141	0.9146	0.9521	0.9540
29.	0.9557	0.9392	0.9363	0.9742	0.9645
30.	1.0178	0.9709	0.9679	1.0058	0.9996
31.	0.9807	1.0273	1.0178	0.9819	0.9513
32.	1.0614	1.0306	1.0220	1.0709	1.0657
33.	0.9786	1.0297	1.0301	1.0277	1.0327
34.	0.9628	0.9370	0.9305	0.9683	0.9487
35.	0.9842	0.9170	0.9142	0.9999	1.0015

Table 8

Utility Indices

(1977 = 1.0)

Consumer Group	1981 Update	Production Increase	Price Increase	Tax Cut/ Price Increase (1)	Tax Cut/ Price Increase (2)
1	0.9495	0.9705	0.9631	1.0159	1.0079
2	0.9458	0.9627	0.9638	1.0312	1.0079
3	0.9624	0.9697	0.9653	1.0096	1.0201
4	0.9479	0.9568	0.9622	1.0295	1.0080
5	0.9868	0.9640	0.9617	1.0055	1.0274
6	0.9431	0.9524	0.9587	1.0238	1.0019
7	0.9670	0.9603	0.9568	0.9983	1.0137
8	0.8986	0.9624	0.9649	1.0146	0.9875
9	0.9302	0.9630	0.9566	0.9957	0.9941
10	0.9631	0.9349	0.9352	1.0147	0.9889
Urban	0.9534	0.9627	0.9580	0.9991	1.0075
Rural	0.9340	0.9557	0.9587	1.0221	0.9979