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A General Equilibrium Appraisal of Energy Policy in Mexico

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Abstract: This paper develops a static neoclassical general equilibrium model of the Mexican economy that focuses on production, consumption, and exports of energy goods. The specification of the 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. The analysis presented in this paper serves as a case study of how to design and use an applied general equilibrium model to do policy analysis. An interesting feature is that the model itself is used to determine one of the key parameters, the elasticity of substitution of non-energy imports for domestic goods.

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1 Introduction

Applied general equilibrium analysis traces its roots to the work of Harberger (1962) and Johansen (1960). It is now a large and growing field. In this paper we use a general equilibrium model to analyze the situation faced by the Mexican government in 1983. Faced by a severe economic crisis, the government chose to substantially increase indirect taxation and domestic energy prices in order to reduce the government and trade deficits. Our analysis indicates that higher in-

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creases in energy prices not accompanied by increases in taxed would have been a preferable policy in terms of its impact on consumer welfare. An important caveat is in order, however: although our analysis takes into account the subtantial fall in international petroleum prices that precipitated the crisis in Mexico, it does not account for the even more substantial decreases that occurred subsequently.

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 two decades. In Mexico, in particular, earnings from oil exports helped promote its economic growth during the late seventies and early eighties. 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 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. The model is not able to address such macroeconomic issues as growth and inflation. Certain key variables in the model, such as the real exchange rate, are exogenous. Although the model is not able to explain how these variables are determined, it does explain how changes in them affect income distribution and resource allocation. We are therefore able to incorporate exogenous changes in the real exchange rate in our simulations even though our simplistic treatment of international capital flows and lack of monetary phenomena prevent us from determining it endogenously.

Any approach that assumes standard market equilibrium throughout the economy would not 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.

Table 1. List of sectors

Nonenergy production			
1.	Agriculture	8.	Machinery and automobiles
2.	Mining	9.	Commerce
3.	Food products	10.	Transportation
4.	Textiles	11.	Services
5.	Wood products	12.	Construction
6.	Chemical products	13.	Government services
7.	Nonmetal manufacturing		
Energy production			
14.	Petrochemicals	17.	Refined poducts
15.	Goal	18.	Electricity
16.	Crude petroleum and natural gas		
Nonconsumption demand			
19.	Imports – exports		
20.	Fixed investment and inventory accumulation		
Consumption demand			
21.	Bread and cereals	29.	Furniture
22.	Milk and eggs	30.	Electronic products
23.	Other groceries	31.	Medical products
24.	Fresh fruits and vegetables	32.	Transportation
25.	Meat	33.	Educational articles
26.	Fish	34.	Articles for personal care
27.	Beverages	35.	Services
28.	Clothing		
Factors of production			
36.	Capital and other factors	38.	Rural labor
37.	Urban labor		

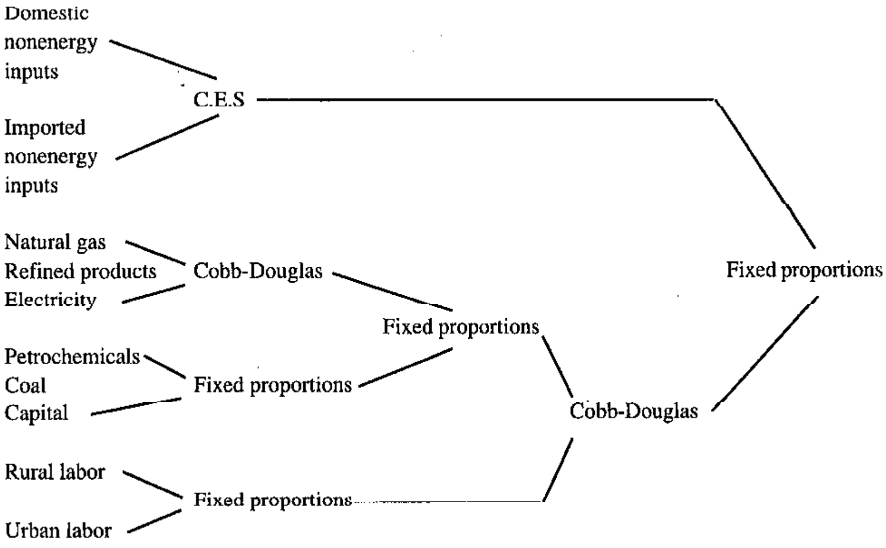
The analysis presented in this paper serves as a case study of how to design and use an applied general equilibrium model to do policy analysis. The structure of the model is very similar to that used by Kehoe, Manresa, Noyola, Polo and Sancho (1988) to analyze the impact of the 1986 indirect tax reform on the Spanish economy. In the next section, we describe the model, placing emphasis on its novel features. In the third section, we describe the concept of equilibrium and the calibration of the parameters of the model. An interesting feature of our analysis is that we use the model itself to determine one of the key parameters, the elasticity of substitution of nonenergy imports for domestic inputs in production. In the fourth section, we analyze the results of three policy simulations. Finally, in the fifth section, we discuss the lessons learned from these simulations and point out directions for future research.

2 The Model

The structure of this model is similar to that of Serra-Puche (1983) and Kehoe and Serra-Puche (1983a). It follows in the tradition of Shoven and Whalley (see Shoven and Whalley (1984)). It differs from standard models of this type in the treatment that it gives to energy prices, to the foreign sector, and to the government and trade deficits, aspects of the Mexican economy that are of vital concern in the context of energy policy. In the description of the model that follows we concentrate on the special features of the model; a more detailed description is given by Kehoe and Serra-Puche (1983b).

The goods in the model are listed in Table 1. Each production sector utilizes a nested, constant-returns production function. This nesting is described diagrammatically in Table 2. The intermediate inputs of the nonenergy production sectors are aggregated with nonenergy imports, which are a single homogeneous good, under the category of nonenergy 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. Except in the energy sectors, inputs of the petroleum and natural gas aggregate are natural gas only. We have left this good as an aggregate, however, since petroleum and natural gas are joint products. Petrochemicals, coal, fuel, and capital are aggregated in fixed proportions. 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 way as the supply of the other energy goods. 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 nonenergy inputs in fixed proportions. The production function at each level of this aggregation procedure differs from sector to sector. Producers demand inputs in proportions that minimize costs given these production functions.

Table 2. Nesting of production functions



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 nonenergy production sectors.

The specification captures several stylized facts: Capital and fuels are complements. Labor, however, tends to be substitutable for both fuels and capital. The ratio between nonenergy intermediate inputs and the aggregate of energy inputs and value added tends to remain fixed. The nesting of domestic nonenergy inputs with nonenergy 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). The fixed proportions production function for domestic inputs differs from sector to sector, as does the relative weight put on domestic inputs and on imported goods 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, because of lack of information. Notice that imports of energy goods are treated differently from those of the nonenergy aggregate. Domestic energy goods and imported energy goods are, in fact, perfect substitutes.

The nonconsumption demand sectors and consumption demand sectors have production functions that allow a similar structure of substitutability among inputs. They do not, however, utilize factors of production. The inputs into the imports-exports production function are nonenergy exports; the output is foreign exchange, which is used to purchase imports at fixed foreign prices. (Exports of energy goods also produce foreign exchange but are modeled differently). The reciprocal of the price of output of this sector is the real exchange rate, the rate at which imports exchange for exports. The production functions for the consumption demand sectors serve only to transform the aggregation of outputs from the 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.

Table 3. List of consumers' net household income in pesos per month ($23 1977 Mex. = $1 1977 U.S.)

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

Each consumer group in the model is distinguished by its base period income and its location. Here *urban* means resident in a city or town of more than 10,000 inhabitants. Each group is endowed with stocks of capital and labor. Urban labor and rural labor are considered to be separate factors of production. We assume full employment of both types of labor and flexible real wages. Kehoe and Serra-Puche (1983a) analyze an alternative version of this model in which there is unemployment of urban labor and downwardly rigid real wages. Their results suggest that the treatment of deficits is a more crucial determinant of the results of this model than is the treatment of unemployment. Recent history in Mexico has shown that, while there may be significant unemployment in Mexico, real wages are certainly not rigid. 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 subtracted.

The demand function of each of these group is derived by solving a problem of maximizing a Cobb-Douglas utility function subject to a budget constraint. The income of a group is the value of its initial endowment net of income tax. This income is used to finance the purchase of a consumption bundle made up of the consumption goods. In addition, the consumer saves a constant fraction of income, which becomes a purchase of the investment good or of government or foreign bonds, which consumers consider perfect substitutes.

The government 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 the supply of petrochemicals, crude petroleum and natural gas, and refined products, and CFE (Comision Federal de Electricidad), which controls the supply of electricity. Most of the supply of coal is controlled by another government firm, Altos Hornos de Mexico. 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 demands; 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 acts as a producer in producing a public good, government services. 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 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. An important feature of this model is that government may spend more than it receives in revenues. Any deficit becomes a supply of bonds. As the level of government revenue varies we allow the deficit to adjust so that the level of government expenditures remains fixed.

The specification of the foreign sector is very simplistic. Nevertheless, it captures the structure of the balance of trade and the corresponding capital flows. Exports generate foreign exchange that the economy uses to finance imports. Nonenergy goods are exported in fixed proportions which are given by the elements of the imports-exports 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 and composition of these exports are exogenous: they are determined more by forces outside the model, such as economic conditions in Mexico's trading partners, than by forces within the model. 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 exogenous. They may differ from the domestic prices, which are also exogenous but are set by the government. The level of nonenergy imports is determined endogenously by final and intermediate demands. Any trade deficit appears endogenously as a net supply of nonenergy imports by the rest of the world, which demands the domestic investment good. This demand may be positive or negative depending on whether there is a trade deficit or surplus. A negative demand is to be interpreted as a supply of foreign bonds. 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 aggregate investment good is produced by the investment activity in the input-output matrix. We assume that the composition of investment remains fixed in physical terms. Total investment in the economy is given by

$$V = S + GI + TD - GD,$$

where S is total savings by consumers, GI is government investment, TD is the trade deficit, and GD is the government deficit. Although this equation mixes physical and financial flows, there is nothing controversial in it: it is a standard accounting identity. What is controversial is our modeling of consumers' savings decisions, that they regard government bonds as net wealth. We discuss this point in the final section.

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 maximixing consumption bundles chosen by consumers vary with prices and incomes, which in turn vary with prices. Prices form a 38×1 vector, p. 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. The demands of consumers, the government, and the rest of the world are aggregated into a vector of excess demand function $\xi(p, R, GD, TD)$, $i = 1, \ldots, 38$. 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 and t obey the following version of Walras's law:

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

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

Let $B(p)$ be the cost minimizing matrix of net outputs on the production side of the model. $B(p)$ is a 38×35 matrix. Its elements are homogeneous of degree zero and vary continuously with prices. Define the matrix $B(p)$ by the rule

$$\bar{b}_{ij} = b_{ij} - s_{ij} \mid b_{ij} \mid .$$

Here s_{ij} denotes the tax on the sales or purchases of good i by sector j; the tax rates s_{ij} include the tariff. In this notation $p\bar{B}(p)y$ represents the after-tax profitability of the production plan $B(p)y$ where y is a 35×1 vector of nonnegative 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:

$$\sum_{i=1}^{38} p_i^* \bar{b}_{ij}(p^*) = 0, \; j = 1, \ldots, 13, 19, \ldots, 35 .$$

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

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

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

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

Fourth, and finally, we require that prices satisfy

$$\sum_{i=36}^{38} \gamma_i p_i^* = 1$$

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 nonlinear system with the same number of equations as unknowns: There are 38 prices p_i^* and 38 requirements that demand equal supply. Although Walras's law implies that one of these requirements is superfluous, homogeneity allows us to impose the price normalization to replace it. There are also 35 activity levels y_j^* and 35 zero profit conditions. Dropping the 5 zero profit conditions for the energy goods allows us to set their prices $p_{14}^*, \ldots, p_{18}^*$ 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 $y_{14}^*, \ldots, y_{17}^*$.. 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 and conditions that fix the levels of exports of nonenergy goods and of government expenditures y_{13}^* and y_{20}^*. These can either be fixed in physical terms,

$$y_j^* = \bar{y}_j,$$

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

$$y_j^* = \left(\sum_{i=36}^{38} \gamma_i p_i^* / p_j^* \right) \bar{y}_j \,.$$

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. In the next section we explain how the model is updated to analyze the choices faced by the Mexican government in 1983. 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, nonenergy 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 Petroleo. 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 Mexico. 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 crucial demand parameters are the shares of expenditure on each good by consumer group 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 in the base period; the domestic prices of petrochemicals and coal are the same.

The elasticity of substitution between domestic nonenergy 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. 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 constructive proof of the existence of 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 exogenously set by the government in terms of factor prices, the zero profit conditions can be used to compute commodity prices. The supply equals demand condition 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 those that 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 in the base case. 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.

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 (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.

In all of our simulations there are a number of key exogenous variables. These variables fall into two categories: those, like production levels and prices of energy goods, taxes, and the level and composition of government spending, that are directly controlled by the government and those, like the real exchange rate, the international prices of energy goods, and the level and composition of nonenergy exports, that are determined by forces outside the model. The spirit of the first simulation is to mimic the principal changes in exogenous variables 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 GNP that occurred between 1977 and 1981. Production of petrochemicals, for example, actually increased by 68.09% between 1977 and 1981: 1.2146 = 1.6809/1.3839.

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

value-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.

Table 4. Indirect tax rates

Sector	1977	1981	1983
Agriculture	.0012	–.0766	–.0095
Mining	.0431	.0088	.0088
Food products	.0383	–.0173	.0021
Textiles	.0286	.0	.0
Wood products	.0384	.0	.0
Chemical products	.0529	.0	.0
Nonmetal manufacturing	.0342	.0	.0
Machinery	.0564	.0	.0
Commerce	.0	.0	.0
Transportation	.0144	.0	.0
Services	.0718	.0	.0
Construction	.0155	.0	.0
Government services	.0	.0	.0
Petrochemicals	.1015	.0	.0
Coal	.1154	.0521	.0521
Petroleum and gas	.0795	.0	.0
Refined products	.0002	.0	.0
Electricity	.0413	.0	.0
Exports	.1508	.0	.0
Investment	.0	.0	.0
Bread and cereals	.0068	–.0797	–.0107
Milk and eggs	.0030	–.0547	–.0071
Other groceries	.0723	.1786	.2236
Fruit and vegetables	.0	.0	.0600
Meat	.0080	.0	.0300
Fish	.0045	.0	.0300
Beverages	.1322	.1860	.2563
Clothing	.0211	.0902	.1352
Furniture	.0387	.0902	.1352
Electronic products	.0644	.0902	.1352
Medical products	.0445	.0902	.0502
Transportation	.1568	.0902	.1452
Educational articles	.0142	.0	.0
Personal articles	.0339	.0902	.1352
Services	.0340	.0473	.1473
Tariff	.0843	.0843	.0843

Table 5. Major macroeconomic variables (millions of 1977 pesos)

		1977 Base case	1981 Update	52% Price increase	39% Price increase/ tax cut	149% Price increase/ tax cut
1.	Tax receipts	216,816	166,327	225,203	152,753	155,964
2.	Government capital income	37,562	37,178	37,124	37,710	36,570
3.	Energy revenues	15,438	47,285	164,703	147,611	241,065
4.	Government consumption	195,552	211,794	181,729	178,519	185,064
5.	Government investment	137,750	253,061	223,976	224,230	226,940
6.	Government deficit (= 4 + 5 – 1 – 2 – 3)	63,486	214,065	–21,352	64,674	–21,325
7.	Private consumption	1,101,127	1,100,796	1,101,327	1,101,310	1,101,347
8.	Private investment	241,801	248,704	234,959	449,068	154,651
9.	Trade deficit	1,529	159,004	–90,000	–90,000	–170,204
10.	Gross domestic product (= 4 + 5 + 7 + 8 – 9)	1,674,700	1,655,351	1,831,991	1,743,126	1,838,206

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 the 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 2.6%. 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 nonenergy goods fall by 12.84% in physical terms.

Table 6. Market prices ($.5793p_{36} + .3213p_{37} + .1048p_{38} = 1$)

Sector	1981 Update	52% Price increase	39% Price increase/ tax cut	149% Price increase/ tax cut
Agriculture	0.1980	0.9582	0.9313	0.9175
Mining	1.0235	0.9763	0.9820	0.9842
Food products	0.9607	0.9600	0.9275	0.9184
Textiles	1.0170	0.9761	0.9716	0.9772
Wood products	1.0684	0.9781	0.9762	0.9790
Chemical products	0.9597	0.9640	0.9568	1.0241
Nonmetal manufacturing	1.0791	0.9795	0.9845	0.9861
Machinery	0.9116	0.9495	0.9378	0.9591
Commerce	0.9956	0.9938	1.0003	0.0991
Transportation	1.0525	0.9967	0.9974	1.0090
Services	1.0109	0.9829	0.9836	0.9856
Construction	1.0421	0.9831	0.9823	0.9933
Government services	1.0281	1.0996	0.9918	1.0281
Petrochemicals	0.7600	1.1588	1.0590	1.8923
Coal	0.7740	1.1771	1.0785	1.9272
Petroleum and gas	0.8850	1.3459	1.2332	2.2035
Refined products	0.8850	1.3459	1.2332	2.2035
Electricity	0.7610	1.1573	1.0604	1.8948
Imports	0.5130	0.8228	0.8084	0.8103
Investment	1.2698	1.0181	1.0192	1.0316
Bread and cereals	0.8822	0.9583	0.8700	0.8601
Milk and eggs	0.9010	0.9729	0.9007	0.8893
Other groceries	1.0617	1.1117	1.0454	1.0336
Fruits and vegetables	0.9441	1.0474	0.9545	0.9413
Meat	0.9633	0.9943	0.9457	0.9357
Fish	0.9516	1.0041	0.9467	0.9350
Beverages	1.0279	1.0874	1.0166	1.0051
Clothing	1.0762	1.0936	1.0504	1.0486
Furniture	1.0454	1.0683	1.0270	1.0368
Electronic products	0.9843	1.0332	0.9936	1.0013
Medical products	1.0182	0.9827	1.0192	1.0507
Transportation	0.9440	0.9782	0.9329	0.9388
Educational articles	1.0227	0.9710	0.9727	0.9691
Personal articles	1.0401	1.0751	1.0320	1.0556
Services	1.0185	1.0937	0.9989	0.9995
Capital	0.9483	0.9884	1.0040	0.9736
Urban labor	1.0351	1.0143	0.9840	1.0429
Rural labor	0.9483	1.0199	1.0275	1.0132

Table 7. Activity levels (1977 = 1.0)

Sector	1981 Update	52% Price increase	39% Price increase tax cut	149% Price increase/ tax cut
Agriculture	1.0178	0.9916	1.0387	1.0481
Mining	0.8690	1.0744	0.9728	0.9733
Food products	1.0057	0.9807	1.0376	1.0464
Textiles	0.9275	0.9321	0.9604	0.9614
Wood products	0.9218	1.0086	0.9733	0.9688
Chemical products	0.9521	0.9978	0.9869	0.9811
Nonmetal manufacturing	0.9836	1.1106	0.9706	0.9752
Machinery	1.0227	1.0966	1.0082	1.0055
Commerce	0.9628	0.9867	0.9960	0.9981
Transportation	1.0264	1.0504	1.0423	1.0407
Services	0.9899	0.9400	0.9940	0.9924
Construction	1.0240	1.1864	0.9622	0.9717
Government services	1.0535	0.9205	0.9205	0.9205
Petrochemicals	1.2146	1.2146	1.2146	1.2146
Coal	0.7917	0.7917	0.7917	0.7917
Petroleum and gas	1.7313	1.7313	1.7313	1.7317
Refined products	1.1087	1.1087	1.1087	1.1087
Electricity	1.2434	0.8788	0.9689	0.5436
Exports	0.8716	1.0000	1.0000	1.0000
Investment	1.0411	1.1877	0.9650	0.9746
Bread and cereals	1.1269	1.0438	1.1528	1.1601
Milk and eggs	1.1108	1.0285	1.1099	1.1261
Other groceries	0.9393	0.8998	0.9579	0.9968
Fruits and vegetables	1.0573	0.9551	1.0487	1.0623
Meat	1.0388	1.0061	1.0571	1.0703
Fish	1.0520	0.9962	1.0559	1.0707
Beverages	0.9705	0.9200	0.9849	0.9946
Clothing	0.9293	0.9146	0.9521	0.9540
Furniture	0.9557	0.9363	0.9742	0.9645
Electronic products	1.0178	0.9679	1.0058	0.9996
Medical products	0.9807	1.0178	0.9819	0.9513
Transportation	1.0614	1.0220	1.0709	1.0657
Educational articles	0.9786	1.0301	1.0277	1.0327
Personal articles	0.9628	0.9305	0.9683	0.9487
Services	0.9842	0.9142	0.9999	1.0015

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 38.39% growth of the economy as a whole.

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 change, or changes in unemployment and capacity utilization. Nonetheless, the sizes of these variables 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.

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, whose fall corresponds to an increase in the real exchange rate. Another large price change is that of investment goods, which increases sharply. (Notice that much of the 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.

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 for 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 (1983a) for a discussion of these issues.

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 magnitudes 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.

Table 8. Utility indices (1977 = 1.0)

Consumer group	1981 Update	52% Price increase	39% Price increase/ tax cut	149% Price increase/ tax cut
1	0.9495	0.9631	1.0159	1.0079
2	0.9624	0.9653	1.0096	1.0201
3	0.9868	0.9617	1.0055	1.0274
4	0.9670	0.9568	0.9983	1.0137
5	0.9302	0.9566	0.9957	0.9941
Total urban	0.9534	0.9580	0.9991	1.0075
6	0.9548	0.9638	1.0312	1.0079
7	0.9479	0.9622	1.0295	1.0080
8	0.9431	0.9587	1.0238	1.0019
9	0.8986	0.9649	1.0146	0.9875
10	0.9631	0.9352	1.0147	0.9889
Total rural	0.9340	0.9587	1.0221	0.9979

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 three 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 five changes in exogenous variables from the previous simulation:

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

2. 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 accompanied by allowing domestic prices to rise.

3. 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 fall in the real exchange rate.

4. Nonenergy exports return to their 1977 level.

5. 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 two of these simulations is to bring about a trade surplus of 90 billion 1977 pesos, which is roughly 5% of GDP, to finance the service and eventual reduction of the foreign debt. In the first scenario energy prices are increased by 52.08% and in the second energy prices are increased by 39.34% while the indirect tax and subsidy rates return to their 1981 levels. Notice a smaller increase in energy prices is needed to achieve the same trade deficit with lower taxes. This is because lower taxes and higher subsidies stimulate sectors like agriculture with low import content and cause producers to substitute away from imports. Notice in Table 4, however, that the second policy results in a much larger government deficit than does the first policy. Consequently, since reducing the government deficit is also a major policy goal, we simulate a third policy in which energy prices are increased by 149.00% 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 three 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 three 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 one. The return to capital is lower, relative to that of urban and rural labor, in the first and third scenarios than in the second. 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 second and third policies, those that cut indirect taxes, increase food subsidies, and increase energy prices, Pareto dominate the first policy. All three of the policies result in changes in real incomes that are moderately progressive. The second 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 second and third policies Pareto dominate the first 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 Discussion of Results

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 increase in government expenditures. Another reason was the increase in the terms of trade, which encouraged imports, discouraged 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 was forced in 1983 to choose among policies to reduce the government deficit and produce a trade surplus. We have simulated three possible policy scenarios. In all three we have assumed that the government was able to reduce expenditures, particularly government consumption, as a percentage of GDP. We have also assumed that it, along with market forces, was able to restore the real exchange rate and the level of nonenergy 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 prices of all energy goods. The second and third increase energy prices at the same time as they restore indirect tax and subsidy rates to their 1981 levels. In reality, although the government was able to restore the real exchange rate and to increase nonenergy exports, it faced two major problems in its stabilization scheme: the international price of petroleum continued to fall from 1983 to 1986, and the government was unable to reduce expenditures as much as had been planned.

In spite of these limitations, our simulations help us to understand the choices faced by the Mexican government. The final two policy scenarios result in changes in real incomes that Pareto dominate those of the first. The first policy scenario, however, results in a higher level of physical investment. Nevertheless, it seems clear 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 nonenergy 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 has had to make following the major shocks it has been subject to.

Nevertheless, 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 alternatives faced in 1983 is that domestic energy prices were low compared with indirect tax rates and that there was room to shift from one policy tool to another. In particular, lowering taxes and increasing energy prices could have increased consumer welfare and improved 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 transferring 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 three scenarios rather than the level of nonenergy 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 also help us to better understand the trade-offs between short-run improvements in consumer welfare and more rapid economic growth. Consumers in the model save a constant proportion of their after-tax income. This specification is very similar to that in traditional Keynesian models. Consumers regard bonds, like physical capital, as net wealth. In a fully dynamic model, the impact of government deficits on savings decisions could be determined exogenously.

Even given the limits imposed by our static framework, it would be interesting to see how well our model tracks changes in relative prices and resource allocation over time. Changes in key exogenous variables, such as government spending and the real exchange rate, could be made on a yearly basis from 1978 onwards. The results of the model could then be compared with the actual changes in the economy. This type of procedure could also be used to calibrate more parameters, just as we have calibrated the elasticity of substitution for imports.

Appendix

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