An Assessment of the Economic Impacts of the Energy Price Increase in Mexico[*]

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The focus of this study is the impacts of the recent increase in the prices of gasoline and electricity on the Mexican economy. The analytical approach used consists of a general equilibrium model composed of thirteen producing sectors, fourteen consuming sectors, four household categories classified by income and a government. The effects of the recently implemented increase in the price of gasoline and electricity of 26.2 percent on prices and quantities are examined. The results suggest, for example, that the consequences of an increase in the prices of gasoline and electricity would be a decrease in output by all producing sectors of about 0.31 percent, a fall in the consumption of goods and services by about 0.56 percent, a reduction in total utility by 1.29 percent and higher revenue for the government of 0.31 percent. When subjected to a sensitivity analysis, the results are reasonably robust with regard to the assumption of the values of the substitution elasticities.

I. Introduction

In December 1995, Mexico began a process of increasing the prices of gasoline and electricity, both produced by state monopolies. The objective of the price increases, which are to take place over the course of the next year, is to raise revenue as well as reduce consumption of fossil fuels (New York Times News Service (1995)). The Mexican economy is currently in dire straights for a variety of reasons including stagnating production, relatively high real interest

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rates, inflation, an insolvent banking system, and previous extensive offshore borrowing and relatively large government expenditures to finance various economic policies.[1] One factor in particular that led to the current economic problems began in 1994 when wealthy Mexicans shifted much of their wealth out of the country, while middle-class Mexicans spent record amounts of money, much of it on American-made consumer goods. To accommodate this capital outflow, the peso normally would have dropped in value. Instead, the Mexican central bank depleted its foreign currency reserve in an effort to prop up the currency. When this failed, the government had to devalue the peso,[2] contributing to the crisis. Investors began massive conversions of peso holdings to dollars, also contributing to the relatively sharp depreciation of the peso.[3]

As a consequence of the government's policy actions, foreign sector debt that must be serviced in 1996 will be at least $25 billion (Whalen (1996)). The gasoline and electricity price increases are designed to partially meet this obligation.

A second reason for the increase in the prices of gasoline and electricity is to reduce fossil fuel consumption. The pollution problems associated with the combustion of fossil fuels in Mexico are legendary (Pezzoli (1991), Energy Information Administration (1994), and Los Alamos National Laboratory (1995)). Between 1970 and 1995, carbon emissions in Mexico increased by 221 percent. In 1994, energy-related carbon emissions in Mexico were 91.9 million metric tons. This is 1.5 percent of the total world carbon emissions and makes Mexico the fourteenth most carbon emitting country in the world (Energy Information Administration (1996)). Carbon emissions per thousand dollars of gross domestic product in 1994 was 0.44 metric tons for

1. It is not the purpose here to fully explore the plight of the Mexican economy. That is done adequately elsewhere including Energy Information Administration (1995a) and Whalen (1995, 1996).
2. Technically, on December 20, 1994, the Mexican government decided to allow the peso to float freely.
3. The peso was devalued from one U.S dollar equal to 3.5 pesos in December 1994 to one U.S. dollar equal to 5.7 pesos in January 1995 (The World Almanac and Book of Facts (1996)). This is nearly a 63 percent fall in value in a single month. It is currently fluctuating around one U.S. dollar equal to 7.3 pesos.

Mexico versus 0.29 metric tons for the United States.[4]

Combustion of refined petroleum products is the primary source for carbon emissions in Mexico. Refined petroleum products accounted for approximately 72 percent of Mexico's 1994 energy consumption of 5.1 quadrillion Btu. Petroleum consumption in Mexico emitted 74 million metric tons of carbon in 1994, about 81 percent of the country's total carbon emission in that year (Energy Information Administration (1995a, 1995b)). About 75 percent of Mexico's electricity is generated by plants which burn primarily refined petroleum.[5] Residual fuel oil is used to fire base load plants located near ports or Pemex[6] refineries. Diesel generators are used for peak power and in isolated areas (Energy Information Administration (1995a)).

One unknown with regard to the price increases for gasoline and electricity is what will be the expected impact as the Mexican economy struggles to rebound. This is of more than spurious concern since many Mexican industries rely both intensively and extensively on gasoline and electricity to produce their goods and services. For example, the petrochemical and steel manufacturing industries are major consumers in Mexico's industrial sector which accounts for 55 percent of total energy consumption. Mexico's steel industry is one of the most electricity intensive in the world, with heavy reliance on electric arc furnace technology. Mexico's transportation sector accounts for about thirty percent of total energy consumption (Energy Information Administration (1995a)). Higher energy prices are expected to affect

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4. An alternative to increasing the price of gasoline and electricity to control air pollution is to implement more stringent air quality standards. Such a program was established in October 1990 for Mexico City under the auspices of Programma Integral Contra Lan Contaminacion Atmosferica (PICCA). The strategies include requiring vehicular emission control (the average car in Mexico City emits three times the carbon as one in the United States (Los Alamos National Laboratory (1995)), developing cleaner fuels and requiring emission controls on industrial processes using fossil fuels and electricity generation. The costs of such actions, however, are prohibitive under the current economic situation (Baker (1995)).

5. Electricity is controlled by the state electricity monopoly – Comision Federal de Electricidad (CFE). It has responsibility for the generation, transmission and distribution of electricity.

6. Petroleos Mexicanos or Pemex has a complete monopoly, by law, over the exploration and extraction of all hydrocarbons in Mexico: pipelines, refining of crude oil, and the production of basic petrochemicals.

significantly the price and quantity of the goods and services produced (Baker (1995)). The nature and extent of this effect is the subject of what follows. Before turning to an examination of this issue, however, the modelling approach to be used will be discussed.

II. Overview of the Model

Given the interrelationships between the sectors directly involved in producing gasoline and electricity and the rest of the Mexican economy, to properly analyze the effect of higher gasoline and electricity prices, a comprehensive analysis must be employed, one where the linkages between sectors of the economy are explicitly taken into account and one where the price responsiveness of producers and consumers both to absolute and relative changes in the prices of the various goods and services is considered (Hoffman and Cano (1995) and Energy Information Administration (1995a)). The analytical approach used will be a computable general equilibrium model that has been disaggregated into 13 producing sectors, 14 consuming sectors, four household (income) categories and the government. This level of disaggregation allows for an assessment of the direct effects as well as the indirect effects of the price increases for gasoline and electricity. By measuring these effects, it will be possible to identify the extent to which the producing and consuming sectors and household groups will gain or lose due to the energy price increases. Hence, equity considerations as well as efficiency considerations can be addressed.

III. A General Equilibrium Model

The use of a general equilibrium approach to analyze the effects of increasing the prices of gasoline and electricity is reasonable given the interactions between participants within the energy markets as well as other interrelated markets (Ballard, et al. (1985), Harberger (1962, 1974), and Shoven and Whalley (1972, 1992)). Note that the adoption of a general equilibrium model approach to assess the effects of increasing the prices of gasoline and electricity on the Mexican economy is unique to this study. There are no previous efforts using this methodology for

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an analysis of energy issues in Mexico.[7]

The model used follows in the tradition of the Shoven and Whalley (1972) tax analysis research and incorporate some of the methodological enhancements of the general equilibrium work of Hudson and Jorgenson (1974a, 1974b). For example, it recognizes the differences in preferences of consumers as a function of their incomes and specifies a distinct demand system for each group of households. Additionally, a neoclassical microeconomic model of producer behavior is employed. The model of consumer behavior is integrated with the model of producer behavior (which contains a price-responsive input-output component) to provide a comprehensive framework for policy simulations.

(a) The Producing Sectors

The production sector of the model consists of an input-output matrix with some flexibility with regard to the substitution of the factor inputs (capital, labor, and land). Technologies are represented by production functions that exhibit constant elasticities of substitution. Technological progress (both embodied and disembodied (Uri (1984)) is assumed not to occur over the period of investigation. Each sector as defined in Table 1 is assumed to have a constant elasticity of substitution (CES) production function (Arrow, et al. (1961)) where the value added by the specific sector is a function of labor and capital.[8] Note that there is a transformation matrix whereby raw inputs in the producing sectors are transformed into consumption goods and services. Thus, the fact that refined petroleum products are combined with various intermediate goods and services to produce, say, manufactured goods is reflected via this transformation matrix.

For the agriculture and the forestry sector, a third factor of production - land - is included. This is done because of the special importance of this input to these sectors (Heady and Dillon (1961)).

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7. Serra-Puche (1979, 1984) developed a computable general equilibrium model (now somewhat dated) for the Mexican economy. The model, however, was designed to analyze tax incidence.

8. This functional specification makes the model tractable. Other potential specifications focusing on factor substitution (an important ingredient in the general equilibrium model design) make the empirical parameterization too suspect.

The incorporation into the production function of this factor is accomplished by nesting the CES production function. In particular, an input is defined which is solely a function (in CES form) of land and capital which, in turn, takes the place of capital in the original production function specification. Note that while it would be possible to simply add land as an explicit input in the production function, this would implicitly assume that the elasticity of substitution between all pairs of inputs are the same. By nesting, however, the substitution elasticities are permitted to be different between different inputs.

(b) The consuming Sectors

On the demand side, the model reflects the behavior of consumers (who can also serve as investors), the government, and foreigners. Consumers are grouped according to income (indicated in Table 2) and a demand system is specified for each group. Each income group has an endowment of labor and capital and, given the vector of prices, decides the amount to save and invest, and the amount of each good and service to consume (purchase). Investment, consequently, is determined by savings.

The output of the 13 producing sectors accrues to the owners of the factors of production (i.e., land, labor and capital) which they sell. With the receipts from sales, these individuals either consume domestic or foreign goods and services, save, or pay taxes to the government. The savings are used for investment and the taxes are ultimately returned to these individuals.

The demand for final goods and services comes from three primary sources: (1) final goods and services which are directly consumed by individuals, (2) investment (which is equal to savings), and (3) foreign demand.

A review of Table 1 will show that the composition of the consumer goods and services sectors does not match that of the producing sectors because the final goods and services produced by the producing sectors must go through various channels (i.e., transportation and distribution) before they can be consumed. To address this problem, a transformation matrix is introduced that defines the

contribution of each producing sector to the composition of each of the final (consumer) goods and services.

For each category of households (Table 2), utility is assumed to be a weighted constant elasticity of substitution (CES) function of the 14 consumer goods and services. The weights on these goods and services (which are household category specific) are computed as the share of total purchases going to a specific consumer good or service. The nature of the CES utility function implies that the elasticity of substitution is the same between any pair of goods and/or services. Because reliable estimates of the respective substitution elasticities across pairs of goods and/or services is difficult to obtain, they are assumed to equal one for all of the combinations.[9]

Finally, consumers obtain utility from the consumption of all goods and services including leisure. Hence, it is necessary to determine a weight for this factor in the utility function. For the purpose of the current analysis, this value is assumed to be 0.5 times labor income. The net effect of adding leisure is to incorporate explicitly the fact that consumers not only derive utility from the act of consuming goods and services (which comes through owning the factors of production) but that they also derive utility from leisure. Thus, an increase in leisure can lead to an enhancement of individual well-being in the model. Because Mexico is a developing country, however, and it has been suggested that leisure has a relatively low value (Pezzoli (1991)), a sensitivity analysis is conducted where this value is lowered to 0.1 times labor income.

A household's budget constraint is defined such that expenditures on goods and services must be less than or equal to its income, which is defined to equal its portion of the returns to labor plus the returns to capital plus the returns to land. That is, expenditure by a household must be less than or equal to the total factor payments it receives. Maximizing utility subject to this expenditure constraint gives the demand for the various goods and services by household categories (see, e.g., Mixon and Uri (1985) for a discussion of this). Observe that since

9. This effectively simplifies the specification, making it a Cobb-Douglas function. This specification makes the model tractable. Other potential specifications make the empirical parameterization too suspect.

savings are considered as one of the items in an individual's utility function, the choice between consumption and savings is made explicit. That is, intertemporal tradeoffs are an integral part of the model.

The second component of the demand for goods and services is investment. Like the final demand by individuals, total investment is disaggregated (though a transformation matrix) by the sector of the economy that produces it. For the purpose of constructing the general equilibrium model and calibrating it, investment is taken directly from the national income and product accounts (as compiled by the Instituto National de Estatistica, Geographia e Informatia) and, since savings are assumed to exactly equal investment, personal savings are scaled to equal the measured gross investment for each of the 13 producing sectors.

The final component of demand for goods and services is the demand by foreign consumers. The foreign sector produces imports and consumes exports. Trade balance is assumed. Consequently, foreigners can be regarded as consumers who purchase Mexican exports with income from the sale of imports to Mexico. Moreover, as specified, foreign demand is separate and distinct from domestic demand.

In the model exports are delineated by producing sector. That is, a transformation matrix analogous to that used for the consumption of final goods and services is employed. A similar delineation is utilized for imports (i.e., foreign supply). The exports and imports are then scaled so that the total foreign account is balanced. By employing elasticity estimates (both demand and supply) found in the literature, export and import demand relationships are constructed for each producing sector.

(c) The Government Sector

The government levies taxes on both production and consumption. That is, there are taxes on factors of production, on output, on income and on consumption. Revenues are used to distribute income back to consumers and to purchase goods and services, as well as capital and labor.

First, there is a question of how to treat the government in a

general equilibrium model. For the purpose at hand, it is treated as a separate sector with a constant elasticity of substitution utility function. The elasticity of substitution is assumed to be one. This means that the CES production function collapses to a Cobb-Douglas-type production function. The government collects tax revenue in various forms. The explicitly considered taxes include personal income tax, labor taxes (e.g., a social security tax), capital taxes (e.g., a corporate income tax), property taxes, and sales and excise taxes. All these are treated as *ad valorem* taxes and a marginal rate is used for each household category, consumer good and service sector, producing sector and factor input. In this respect, the model is a distinct improvement over earlier general equilibrium models (e.g., Shoven and Whalley (1972)) which simply employed lump sum transfer schemes or used average tax rates.

(d) A Mathematical Statement of the Model

Given these foregoing considerations, it is useful to state precisely the conditions that the model being used here must satisfy for a general equilibrium to exist. First, there cannot be positive excess quantities demanded. That is,

$$\sum_{j=1}^{m} a_{ij} \ M_j \ - \ E_i(\mathbf{p}, \ \mathbf{Y}) \ \geq \ 0 \ \text{for} \ p_i \ \geq \ 0 \qquad (1)$$

and where i $(i=1, 2, \cdots, n)$ denotes the consumer goods and services, M_j $(j=1, 2, \cdots, m)$ denotes the activity levels, a_{ij} denotes the ij-th element in the activity analysis matrix, $\mathbf{Y}$ denotes a vector of incomes for the k consumers, $\mathbf{p}$ denotes a vector of prices for the n consumer goods and services and E_i denotes the excess demand for good or service i.

The second requirement for general equilibrium is that the profits associated with a given activity are not positive. That is,

$$- \sum_{i=1}^{n} a_{ij} \ p_i \ \geq \ 0 \ \text{for} \ M_j \ \geq \ 0. \qquad (2)$$

Finally, all prices and activity levels must be non-negative. That is,

$$p_i \geq 0, \ i = 1, 2, \cdots, n \tag{3a}$$

and $$M_j \geq 0, \ j = 1, 2, \cdots, m. \tag{3b}$$

The model is solved for a general equilibrium using the iterative algorithm nominally referred to as the Sequence of Linear Complementary Problems (SLCP) developed by Mathiesen (1985a, 1985b). This algorithm is based on the fixed point theorem proved by Scarf (1967).

A complete listing of the equilibrium conditions together with relevant definitions is found in the Appendix.

(e) Data for the 1988 Base Year

The general equilibrium model is calibrated for 1988. This year was selected because it is the most recent year for which the requisite input-output matrix (compiled by the Instituto National de Estatistica, Geographia e Informatia (I.N.E.G.I.)) connecting the various producing sectors is available. For the producing sectors, data on capital receipts and taxes are computed from data obtained directly from I.N.E.G.I. and from *The Mexican Economy 1993* (published by the Banco de Mexico). The various elasticities of substitution employed in the analysis were obtained from the empirical literature on production functions including Berndt and Samaniego (1984), Dahl and Fields (1985), Dunkerly and Hoch (1985), Koshal, et al. (1990) and Siddayao, et al. (1987).

Capital income (earnings) and labor income were obtained from the *Anuario Estadistico de Los Estado Unidos Mexicanos* published by I.N.E.G.I. Land income was estimated using factor shares obtained from the *Anuario Estadistico de Los Estado Unidos Mexicanos* and applied to the capital income component.

Data on expenditures on each of the 14 goods and services consumed by each of the 4 household categories were obtained from

Encuestra National y Gastros de Los Hogares 1988 published by I.N.E.G.I. By combining this information with the number of households in each household (income) category, the aggregate expenditures on each category of consumer goods and services by each household category were computed.

The various marginal tax rates used were obtained from numerous Mexican government agencies. The value of exports and imports for 1988 were taken from *International Financial Statistics* published by the International Monetary Fund. Data on government expenditures and transfer payment data come from *El Ingreso y Gasto Publico en Mexico 1988* from I.N.E.G.I.

IV. A Methodological Caveat

Before proceeding to assess the results from implementing the general equilibrium model, a short digression is in order. In particular, a discussion concerning the advantages and shortcomings of using the modelling approach adopted is needed.

The primary advantage of the general equilibrium modelling approach is that, with all economic entities maximizing their behavior subject to the relevant constraints, all markets are required to clear. No transactions are conducted at prices other than equilibrium prices and for every factor of production and every good and service consumed, the quantity supplied must exactly match the quantity demanded. All interactions among markets are taken into account and, consequently, all interrelationships between both consuming and producing sectors are explicitly considered.

Another advantage of this modelling approach is that it performs the analysis at a disaggregated level and hence can identify sector specific impacts of the policy question being addressed. Frequently, small aggregate effects obfuscate the larger impacts at the sectoral level. Thus, for example, at the aggregate level a change might have little effect on income, but at the household level, the distributional impacts on income might be fairly substantial.

The general equilibrium model also includes a treatment of all taxes. These taxes can introduce a considerable differential between

prices paid by consumers and prices received by producers. This may result in distortions in market signals that lead to market failure (e.g., inefficient use of factors of production)(Friedman (1984)).

The model is solved numerically and, after any change in the exogenous (e.g., policy) variable(s), a new, independent equilibrium is computed. As a result, the conclusions do not depend on first-order or second-order approximations or the assumption of an infinitesimally small change in one or more of the variables.

The general equilibrium modelling approach is not devoid of deficiencies. The values of the various parameters used in the model are not estimated directly by econometric means. Rather, as noted, they are taken from the literature and represent a consensus among researchers with regard to appropriate values. This does not mean that a complete set of econometric results cannot be generated at some future date. The complexities of such an undertaking, however, are enormous (see, e.g., Jorgenson (1984) and MacKinnon (1984) for a discussion of these) and so it is not attempted here.

Another assumption that does not emulate reality completely is that consumer and producer behavior is modelled with full and complete adjustment between perturbations. This means that the distributed lags associated with the adjustments of the various factors are not overtly modelled although the magnitude of the full adjustment by each producing and consuming sector is captured. Additionally, there is the implicit assumption that all economic agents know the vector of final equilibrium prices, thus allowing for full adjustment on their part.

Next, with the requirement that profits are not positive (relationship (2)), the implicit assumption is that all producer and consumer goods and services markets are perfectly competitive. While this is not totally realistic, modelling imperfectly competitive behavior has too many vagaries to permit a tractable analysis (Shoven and Whalley (1992)).

Finally, the model does not, as noted, make any provision for technological innovation and, hence, is not suitable for addressing policy issues that will take a long time to have their full (cumulative) impact.

These model limitations imply that the results of the subsequent modelling effort should not be unequivocally accepted but rather

interpreted in the context of offering an improved, but not perfect, analysis of the impact of the increase in the prices of gasoline and electricity.

V. General Equilibrium Results

Before discussing the results of the general equilibrium model, a couple of items need to be mentioned. First, as observed in a preceding section, the model is solved by the SLCP algorithm of Mathiesen. This algorithm is based on the fixed point theorem proved by Scarf (1967).

Second, the magnitude of the effect of price increases for gasoline and electricity on the substitution between the various goods and services consumed is an important consideration. Because of the potential overall importance of these elasticity of substitution values to the results of the analysis, however, a sensitivity analysis will be performed whereby the values will be assumed to vary around their point estimates.

(a) Reference Case

The Reference Case results (both quantities and normalized prices) are presented in Table 3, Table 4 and Table 5 for the producing sectors, the consuming sectors, and households (income categories), respectively. Note that the nominal values of the quantities are in tens of billions of 1988 Mexican new pesos. The sector numbers and category numbers correspond to those used in Table 1 and Table 2. The Reference Case is carried out to make sure the computable general equilibrium model adequately and accurately simulates the Mexican economy in 1988.

By themselves, the values found in Table 3 through Table 5 provide little useful information beyond showing how the model is calibrated. Rather, the significance of the general equilibrium model and of the equilibrium values is in how these values change in response to a policy initiative that perturbs the general equilibrium.

(b) An Increase in the Prices of Gasoline and Electricity

To raise revenue and mitigate pollution associated with fossil fuel combustion, the Mexican government increased the prices on gasoline and electricity by 7 percent in December 1995 and 1.2 percent each month through 1996 except for April, when the prices rise by 6 percent. This is a cumulative increase of 26.2 percent and is the value that will be used in assessing the impact of an increase in gasoline and electricity prices.[10]

Table 3, Table 4 and Table 5 present the general equilibrium values for prices and quantities for the producing sectors, consuming sectors households, respectively, as a result of an increase in the prices of gasoline and electricity. The tables also indicate the percentage changes in the equilibrium quantities in the producing sectors, consuming sectors and households in response to an increase in the prices of gasoline and electricity.

An increase in the prices of gasoline and electricity will have several effects. Consider the producing sectors first. In response to an increase in the prices of gasoline and electricity, total output in the producing sectors will fall by 0.31 percent or by about 22.43 billion Mexican new pesos.[11] This decline, however, is not uniformly spread across producing sectors. For example, the output of electricity will fall by 3.2 percent (2.24 billion new pesos) while the output in the crude oil production/petroleum refining sector will decline by 5.65 percent (17.82 billion pesos).[12] This is primarily result of the direct effects of higher prices of these types of energy. Output in the manufacturing sector will increase slightly by 0.19 percent (4.63 billion new pesos). This reflects the diversion of resources coincident with changing relative

10. In mid-1995, the price of regular unleaded gasoline in Mexico averaged 1.37 new pesos per liter. For the same period, the industrial price of electricity averaged 0.1849 pesos per kilowatt-hour and the residential price averaged 0.3055 per kilowatt-hour (International Energy Agency (1995)).

11. Note that these and other effects are in terms of the annual impacts. That is, they indicate what will occur each year.

12. In order to limit the number of tables, some of the equilibrium prices and quantities will not be presented although selected values will be discussed. The omitted tables are available upon request.

factor prices from the electricity and crude oil production/petroleum refining sectors. Output in the coal mining sector will increase by 1.27 percent (0.12 billion new pesos) as coal is substituted for gasoline and electricity, to the extent possible in response to the changing relative prices. Output in the forestry sector will expand by 0.19 percent (0.037 billion new pesos) as households move away from using electricity and towards wood for space conditioning.[13] The agricultural sector will witness a slight reduction in output of 0.17 percent (0.394 billion new pesos) as the price an of important factor input used in field operations – gasoline – increases. In the aggregate, the price of land will fall as the reduction in agriculture sector output is quantitatively greater than the rise in forestry sector output. For the same reason as with the agriculture sector, the other services sector which includes the provision of transportation related services such as taxis and buses, experiences a modest decline of 0.27 percent (8.14 billion new pesos).

With regard to the consuming sectors, an increase in the prices of gasoline and electricity yields a reduction in the consumption of goods and services of 0.56 percent (18.42 billion new pesos). The most significantly impacted sectors are, not surprisingly, the utility which experiences an 8.58 percent (4.16 billion new pesos) fall in consumption and the gasoline sector which realizes a 10.80 percent (10.96 billion new pesos) fall. The transportation sector, which utilizes gasoline as an input, observes a decline in consumption of 3.97 percent (5.59 billion new pesos). Most other sectors realize slight increases – on the order of 0.05 to 0.08 percent – increase in consumption. This is attributable to the direct and indirect effects of an increase in the prices of gasoline and electricity. The direct effects include a lower real income due to an increase in the prices of gasoline and electricity. Indirect effects include higher absolute prices for relatively energy intensive goods and services brought about by higher costs of production resulting from an increase in the prices of gasoline and electricity.

It is interesting to note that in the aggregate the consumption of consumer goods and services falls slightly more in relative terms than does output in the producing sectors (0.55 percent versus 0.31 percent).

13. Energy Information Administration (1995a) discusses such a possibility.

This is a reflection of the greater response in the aggregate of consumers to energy price changes than producers.

Utility decreases for all four of the household categories. The aggregate reduction utility is 1.29 percent (60.88 billion new pesos) for all household categories. The increase however, does not fall fairly evenly across households. For example, Category IV households (i.e., those households where consumer income exceeds 5000 new pesos) experience an decrease in utility of 1.42 percent while Category III households (i.e., those households where consumer income is between 2500 and 3999 new pesos) realize a decrease in utility of just 1.13 percent. The other income categories incur progressively smaller reduction in utility. Thus, when all of the effects of an increase in the prices of gasoline and electricity (that is, both the direct and the indirect effects) are considered, the energy price increase are clearly progressive. That is, the costs in terms of reduced utility of an increase in the prices of gasoline and electricity are incurred by the highest household (income) category and progressively less by households with smaller incomes.

The government is a large gainer in this process. As a result of an increase in the prices of gasoline and electricity, government receipts increase by 0.31 percent (2.938 billion new pesos).

VI. Sensitivity Analysis

No analysis is complete without an examination of the sensitivity of the results to key assumptions. In the foregoing discussion, many assumptions were made with regard to model structure and parameter estimates. A full examination and discussion of these assumptions would be virtually impossible. Consequently, only the results from the sensitivity analysis of two crucial assumptions will be analyzed. First will be the effects on the vector of equilibrium prices and quantities of the elasticities of substitution – the explicit behavioral parameters in the model. Second will be the impact of leisure on the utility function.

For an assessment of the sensitivity of the results to the elasticities of substitution, the original point estimates of these elasticities are allowed to vary by 50 percent. That is, they were first increased by

150 percent of their assumed value and subsequently decreased by 50 percent. In general, the effect of raising the elasticity of substitution is to make the impact of an increase in the prices of gasoline and electricity somewhat larger. The quantitative magnitude of the effect, however, on the results is minimal. Neither output nor consumption is affected by more than 150 million new pesos and there are no changes in the qualitative results discussed above. In the case of lower elasticities of substitution, the effects are even smaller such that changes in output and consumption never exceed 75 million new pesos for any good or service.

For an assessment of the assumption of the impact of leisure on the utility function, its value was lowered to 0.1 times labor income in the utility function for each income category. The utility levels for both the Reference Case and the Energy Price Increase Case witness a fairly uniform reduction across income levels by about 15 percent. There is, however, no change in the order of magnitude of the percentage change in the utility levels either across income categories or in the aggregate.

These sensitivity analyses results suggest that the values of the substitution elasticities, while important in the determination of the vectors of general equilibrium prices and quantities are significant in determining the implications of a policy initiative, are not so pivotal to the model that errors in their values lead to misleading and/or nonsensical results.

VII. Conclusion

The foregoing analysis has examined the impact of an increase in the prices of gasoline and electricity on the Mexican economy. The analytical approach used in the analysis consisted of a general equilibrium model composed of thirteen producing sectors, fourteen consuming sectors, four household categories classified by income and a government. The effects of the recently implemented increase in the price of gasoline and electricity of 26.2 percent on prices and quantities are examined. The results are revealing. For example, the consequences of an increase in the prices of gasoline and electricity would be a decrease in output by all producing sectors of about 0.31

percent or about 22.43 billion new pesos, a fall in the consumption of goods and services by about 0.56 percent or 18.42 billion new pesos, a reduction in total utility by 1.29 percent or 60.88 billion new pesos and higher revenue for the government of 0.31 percent or 2.938 billion new pesos.

It is this increase in government revenue that can be used in partially servicing its foreign sector debt which, as noted previously, is one of the justifications for increasing the prices of gasoline and electricity.

Next, from the perspective of reducing carbon emissions, the price increases will have a beneficial effect. For each one percent increase in the price of gasoline, the consumption of gasoline falls by 0.41 percent. This translates into a corresponding proportionate reduction in carbon emissions from gasoline (Energy Information Administration (1994)). Analogously, a one percent rise in the price of electricity yields a 0.33 percent reduction in electricity consumption giving a coincident decline in carbon emission from the generation of electricity.[14,15]

When subjected to a sensitivity analysis, the results are reasonably robust with regard to the assumption of the values of the substitution elasticities. That is, while the model's equilibrium values do vary in response to different assumptions of the values of these elasticities, the fluctuations are not so enormous to suggest that the model is unrealistically sensitive to these parameters.

There is no easy solution to the dilemma faced by the Mexican government. It is difficult to define a middle ground between an increase in the prices of gasoline and electricity targeted at servicing the foreign sector debt and reduction carbon emissions and no increase. Inherently, some sectors will be adversely affected while some will benefit and some income categories will be more severely impacted than others. It appears, however, that such a price increase is justified. A number of alternatives have been suggested to deal with the inequities

14. The absence of the requisite disaggregated data by energy type (e.g., gasoline, diesel fuel, and residual fuel) precludes computing the quantitative magnitude of the carbon emissions expected from gasoline and electricity price increases.

15. There is no attempt to quantify the environmental improvements associated with the reduction in carbon emissions. This is beyond the capability of the computable general equilibrium model.

including providing direct cash grants to the groups most adversely impacted by the increase in the prices of gasoline and electricity (Munasinghe (1987)). These groups include energy intensive industries. Such an approach would mitigate but not eliminate the impact that the energy price increases have on the Mexican economy. This is one possibility that might be examined in terms of its administrative feasibility (Jha (1987)).

Table 1   Classification of Producing Sectors
and Consumer Goods and Services

Industries	Consumer Goods
1. Manufacturing	1. Food
2. Coal Mining	2. Alcohol and Tobacco
3. Other Mining	3. Utilities
4. Services	4. Furnishings and Appliances
5. Chemicals and Plastics	5. Housing
6. Food Processing	6. Clothing and Jewelry
7. Electricity	7. Transportation
8. Financial	8. Financial Services
9. Forestry	9. Other Services
10. Agriculture	10. Motor Vehicles
11. Livestock	11. Gasoline
12. Fisheries	12. Reading and Entertainment
13. Crude Oil Production/	13. Nondurable Household Items
Petroleum Refining	14. Savings

Table 2   Household Categories Based on Income

Category	Income Range (new pesos)
I	0 - 999
II	1000 - 2499
III	2500 - 4999
IV	5000 and over

Table 3 Equilibrium Prices (normalized) and Quantities (in tens of billions of new pesos) for the Producing Sectors

Sector	Reference Case		Energy Price Increase		Percent Change[1]
	Price	Quantity	Price	Quantity	
1. Manufacturing	1.00000	24.3532	1.00000	24.3995	0.1901
2. Coal Mining	1.00000	0.09772	1.00000	0.09896	1.2696
3. Other Mining	1.00000	0.96045	1.00001	0.96069	0.0246
4. Services	1.00000	29.9505	1.00001	29.8691	-0.2718
5. Chemicals	1.00000	1.47675	1.00001	1.46960	-0.4841
6. Food Processing	1.00000	6.09141	0.99993	6.10710	0.2575
7. Electricity	1.00000	0.70135	1.24510	0.65891	-3.2008
8. Financial	1.00000	0.99595	1.00001	0.99564	-0.0312
9. Forestry	1.00000	0.19418	0.99996	0.19455	0.1905
10. Agriculture	1.00000	2.32426	0.99995	2.32032	-0.1695
11. Livestock	1.00000	1.86053	0.99996	1.86546	0.2649
12. Fisheries	1.00000	0.15887	1.00001	0.15924	0.2341
13. Crude Oil Production	1.00000	3.15624	1.25613	2.97804	-5.6459
Total	1.00000	72.3214	1.00621	72.0971	-0.3101

Note: The percent change represents the percentage change in the equilibrium quantities between a 26.2 percent increase in the price of gasoline and electricity and the reference case.

Table 4 Equilibrium Prices (normalized) and Quantities (in tens of billions of new pesos) for the Consuming Sectors

Sector	Reference Case		Energy Price Increase		Percent Change[1]
	Price	Quantity	Price	Quantity	
1. Food[2]	1.00000	1.21409	1.00000	1.21476	0.0551
2. Alcohol and Tobacco	1.00000	0.47433	0.99995	0.47567	0.0699
3. Utilities	1.00000	0.48474	1.23970	0.44313	-8.5827
4. Furnishings	1.00000	1.25109	1.00000	1.25184	0.0599
5. Housing	1.00000	10.3351	1.00000	10.3406	0.0534
6. Clothing	1.00000	2.49132	1.00000	2.49291	0.0638
7. Transportation	1.00000	1.40984	1.12531	1.35386	-3.9706
8. Financial Services	1.00000	0.13317	1.00001	0.13326	0.0683
9. Other Services	1.00000	5.10817	1.00001	5.11221	0.0791
10. Motor Vehicles	1.00000	2.31605	1.00017	2.28510	-1.3363
11. Gasoline	1.00000	1.01550	1.25911	0.90586	-10.796
12. R and E	1.00000	0.45191	1.00001	0.45223	0.0709
13. Nondurable Goods	1.00000	1.06419	1.00000	1.06472	0.0501
14. Savings	1.00000	5.21452	0.99999	5.25459	0.7684
Total	1.00000	32.9640	1.01381	32.7798	-0.5589

Notes: 1. The percent change represents the percentage change in the equilibrium quantities between a 26.2 percent increase in the price of gasoline and electricity and the reference case.

2. Note that some of the sector titles in the table have been abbreviated. The complete designations are given in Table 1.

Table 5 Equilibrium Utility Levels (in tens of billions of new pesos) by Household Categories

Category	Reference Case Utility Level	Energy Price Increase Utility Level	Percent Change[1]
I[2]	1.05913	1.05040	-0.8242
II	2.49730	2.47131	-1.0407
III	16.08660	15.90440	-1.1326
IV	27.57700	27.18511	-1.4211
Total	47.22003	46.61121	-1.2893
Government	9.36853	9.39791	0.3136

Notes: 1. The percent change represents the percentage change in the equilibrium quantities between a 26.2 percent increase in the price of gasoline and electricity and the reference case.

2. Note that the household categories correspond to those defined in Table 2.

Appendix

Empirical Model

I. Overall Equilibrium by Sector

(1) $Y_j + GE_j + UM_j = \sum_L RAS_{jL} + GD_j + CD_j + UX_j + INV_j$

(2) $\sum_c SL_c = \sum_j DL_j + GDL$

(3) $\sum_c SK_c = \sum_j DK_j + GDK$

(4) $\sum_c SD_c = \sum_j DD_j + GDD$

where

(5) $GDL = \sum_j TL_j$

(6) $GDK = \sum_j TK_j$

(7) $GDD = \sum_j TD_j$

II. Consumer Goods and Services

(8) $CD_j = \sum_i Z_{ji} [GCE_j - TC_j]$

(9) $\sum_c RCS_{ic} = GCE_i$

(10) $\sum_i RCS_{ic} = SL_c + SK_c + SD_c + TRN_c - PIT_c$

(11) $GC_c = \sum_i RCS_{ic} - SAV_c + (1 - TAU_c)(ZTA_c - 1) SL_c$

(12) $GC_c = SL_c + SK_c + SD_c + TRN_c - PIT_c$

$\qquad + (1 - TAU_c)(ZTA_c - 1) SL_c.$

(13) $TE = \sum_c (SL_c \, ZTA_c \, TAU_c + SK_c \, TAU_c + SD_c \, TAU_c$

$\qquad - (\Phi_c + TRN))$

where $\Phi_c = SL_c \, TAU_c + SK_c \, TAU_c + SD_c \, TAU_c - PIT_c$

III. Foreign Sector Balance

(14) $\sum_j (UM_j (EM_j /(1+ EM_j)) + UM_j / (1+ EM_j))$

$= \sum_j (UX_j + FE_j)$

IV. Consistency

(15) $\sum_c (SL_c + SK_c + SD_c + TRN_c - PIT_c - TC_c) = \sum_c CG_c$

(Net household income equals household expenditures.)

(16) $\sum_j (GSK_j + GE_j + TL_j + TK_j + TD_j + TXO_j) + GTL$

$= \sum_c TRN + \sum_j (GDK_j + GD_j) + GD_c)$

(Government income plus endowments equals government outlays.)

(17) $\sum_j (UM_j - UX_j) = 0$

(Net exports equal zero.)

(18) $\sum_j (CD_j + GD_j + UX_j - GE_j - UM_j)$

$= \sum_j (DL_j + DK_j + TL_j + TK_j + TXO_j)$

(The value of demand equals value added plus taxes.)

Y_j - Total production in sector j (j = 1, 2, $\cdots$, 13)

CD_j - Consumer demand for product j

GE_j - Government endowment of product j

UM_j - Imports of product j

$\Sigma_L RAS_{jL}$ - RAS balanced input - output intermediate demands

GD_j - Government demand for product j

INV_j - Investment in sector j

UX_j - Exports of product j

SL_c - Supply of labor by household c (c = 1, 2, $\cdots$, 6)

SK_c - Supply of capital by household c

SD_c - Supply of land by household c

DL_j - Demand for labor in the industry j

DK_j - Demand for capital in the industry j

DD_j - Demand for land in industry j

GDL - Government demand for labor

GDD - Government demand for land

TL_j - Tax on labor in industry j

TK_j - Tax on capital in industry j

TD_j - Tax on land in industry j

GCE_i - Consumer demand for consumer product i (i = 1, 2, $\cdots$, 14)

Z_{ji} - A 13 by 14 transformation matrix

RCS_{ic} - RAS balanced matrix of each household's demand for each consumer good

TC_j - Excise tax on consumer good j

TRN_c - Transfer payment to household c

PIT_c - Personal income tax payment for household c

TAU_c - Marginal income tax rate for household c

SAV_c – Savings in household c

GC_c – Gross consumption of household c

ZTA – Consumption plus leisure coefficient

TE – Total government endowments

EM_j – Demand elasticity of export demand

FE_j – Endowment/Demand sector of adjusted elasticity of export demand

GSK_j – Government endowment of capital in industry j

GDK_j – Government demand for capital in industry j

GTL – Government wage taxes on its own employees

TXO_j – Government output tax on industry j

TC_c – Consumption taxes on household c

CG_c – Total government consumption by household c

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