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# Econometric modeling and decision support systems: An applied exercise for a Mexican firm

by

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# CHAPTER 1. INTRODUCTION

The increasing complexity of society, particularly as it is manifested in social, political, and economic organizations, has served to further complicate the business firm decision-making process. As this occurs, it becomes more and more difficult for decision makers to define their course of action in the manner deemed most effective and optimal for the organization as a whole. On the other hand, since the problems of each functional area in the firm should be solved according to objectives of the overall organization, decision makers must attempt the following when proceeding to evaluate a decision: a) consideration of all outside events, b) consideration of all alternatives, and c) definition of the objective function of the entire organization. Furthermore, as Keeney and Raiffa (1975) suggest, another reason why one might do a formal analysis to break down the overall problem of the firm into component parts, is to strengthen the decision process through a reconciliation approach weighing the possible results that any decision could bring.

If well-defined, a system to analyze the firm's problems will permit its bounding. Again, Keeney and Raiffa state that even though suboptimization is dangerous, if a problem is not bounded in some way it remains hopelessly intractable. Thus, to have the problem identified and bounded, the generation of alternative decision choices and the analysis of their impact on the firm's situation must be considered. An interactive process has, therefore, to be established as an adaptive process-oriented system of alternatives which recognize the possibility that future actions could depend on information learned along the way. Hence, in addition to developing reports and methods for historical record keeping to satisfy accounting and government requirements, a firm must implement an optimal decision support system including logico-mathematical submodels that, providing alternative predictive and control information, will enable managers to take optimal, or at least near optimal, decisions in the allocation of the business resources.

In order to perform this task adequately, the firm needs a methodology to acquire and process the data required by the decision-making process in an efficient and optimum fashion. The systems approach methodology, through which management views the interrelationships of the subsystems in the organization as an integrated assemblage of components, provides what in managerial economics is called the decision support system (DDS) of the firm. This decision support system is formed by extra and intrafirm submodels which are employed to analyze the general business conditions that influence and shift the firm's environment, and to forecast sales, input utilization, and financial results under alternative environments.

## Decision Support Systems

Although much has been written on this subject, a formal definition of DSS has not emerged thus far. Alter (1977) reports that despite the growing number of corporations using data processing systems, there exists relatively little organized knowledge about DSSs. He distinguishes between electronic data processing (EDP) systems which are merely designed to automate or expedite transaction processing, record keeping and business reporting and DSS which are designed to aid in decision-making and decision implementation. His study convinced him that what people thought of as being DSS did not fall into a homogeneous category. As he aptly stated:

> This led me to wonder why people who talk about DSSs often seemed to talk about DSSs in general. It appeared that this was much like talking about pets in general, without distinguishing between dogs and cats and piranha fish and turtles (Alter, 1977).

Although Alter's work is provocative, his taxonomy does not provide a useful definition or specification of DSSs. In fact the definition is hard to grasp because DSSs are not a single model, but rather a conjunction of several planning and simulation models consisting of EDPs, forecasting models and decision-simulation models for various corporation areas. Synthesizing what Naylor (1979) presented in his book, a good DSS for a firm must contain the following elements:

1) A management information system which consists of a database management process, a security system, a report generator, and a graphic processor.
2) A forecasting system for any external activity of the firm such as market, industry or national environment.
3) A production planning model which, given a sales forecast, will permit the definition of a minimum cost output to satisfy demand.
4) A financial model to simulate the effects on net profits of alternative business strategies.
5) A corporate simulation model that joins the previous models into one integrated model, along with the subjective feeling that top management might have on the future corporate policies to define a maximization process for the firm.

In summary, to have a true DSS the firm must have the ability to integrate national, marketing, production and financial submodels into a consolidated system that allows "top down" analysis of alternative corporate policies in search of maximization of an established objective function of the firm.

## Econometric Models and the Firm Decision Support System

The starting point of any DSS is the forecasting of the firm's environment. Such a forecast will permit the firm to make an assessment of its future sales volume and market share under alternative macroeconomic conditions and different pricing, advertising, and competitive strategies that could be undertaken.

Good forecasts are vital to the success of the decision support system of the firm. Consequently, over the past 30 years there has occurred a growing utilization of quantitative approaches to assist managers in their decision-making process. One such quantitative technique (econometric simulation models) can be successfully used to forecast both the general business climate and the firm's product sales. It represents, therefore, an essential tool for a complete corporate decision support system.

Historically, the best exercises have been carried out in the field of macroeconometric modeling of developed economies. There is a world of difference between Tinbergen's initial 1930s work for the League of Nations and the macroeconometric models realized at present. Starting with the Brookings model (1965) macroeconometric modeling has been performed for almost all western industrial nations. Thus, Klein (1977) reports a world economic forecasting service which includes 25 developed nations, several developing nations, and even forecasts for centrally planned economies including in a specific way forecasts for the U.S.S.R.

Shapiro and Halabuk (1976) examine the building of macroeconometric models in socialist and nonsocialist countries and allow one to realize that despite a later start, macroeconometric modeling is well established in the Soviet Union and Eastern Europe.

In contrast, econometric modeling has not yet fully blossomed at the individual firm level. What may be described as sophisticated information systems for the firm are built around the principle of budgetary control. It is this that represents the link between the several departmental operations of the firm rather than a true decision support system which simultaneously collects information from the revenue and cost sides. The forecasting nature of econometric modeling has reached the industrial and commodity level, but has not been accurately linked to the decision system by the firms. Industrial and commodity econometric studies have only in the past 10 years been given a stronger emphasis. Nevertheless, econometric modeling at the firm level is performed mainly by firms that represent a large share of the industry or market for a commodity.[1]

In the developing areas of the world, macroeconometric models began to appear in the latter part of the 1950's, and since the second half of the 1960's they have appeared for Latin American economies. Pure academic interest aside, use of these models should be to define policy actions at the government and firm levels. To do so, it is necessary to define not only sectorial models of the economy but to develop a natural linkage framework which might be used to incorporate macroeconomic information into the firm's decision support system, thereby permitting the firm to program its activities with a minimum of capital and natural resources.

The need for the construction of industrial econometric models and its inclusion as a prerequisite for a sound DSS in any nation is therefore stronger in developing nations. It is the objective of this work to define such a forecasting system for a particular firm in Mexico, in order to construct a bridge between an existing macroeconomic model of

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[1]For example, a large amount of work has been produced in the field of industrial economics and in commodity markets. Good examples of this are the books edited by Labys (1975), Klein (1969, 1970) and Masera et al. (1975). Still most of the work done was made as an econometric exercise and was not made as part of any firm's decision support system. Today much of the work being done by the Naylor group at SSI is directed toward the integration of the several modules of a DSS.

the Mexican economy--the Wharton-Diemex model of the University of Pennsylvania--and a DSS for the firm which will provide the basic element to forecast sales, for these represent the key functions to define production, inventory procurement, employment and profit results of the firm.

## Problem Description

The industry chosen for this exercise is the glass industry of Mexico. Manufacturing activities have for the past several years accounted for 23 percent of Mexico's Gross Domestic Product (GDP). The rate of growth of this sector had followed GDP's rate of growth remaining at high levels up to 1975-77, when abnormal political and economic events buffeted the Mexican economy reducing the GDP rate of growth from a 7.5 percent annual average to a mere 2 percent for the period 1975-1977.

By the end of 1978, the major structural upheavals which occurred in the last years of the Echeverría administration, such as the breaking of communication between private and public administrators, high levels of public expenditures, labor unions' aggressive positions, and devaluation of the Mexican peso, had subsided. This was the result of the López Portillo administration's policy of encouraging the participation of all sectors in the restructuring of the Mexican economy using oil as the pivotal tool of upsurge.

Once again, manufacturing activities became an important factor in total GDP's rate of growth, and 1978 became the first year since 1971 that private expenditures outpaced public outlays in the overall composition of the country's investment and production activities.

Industry description

The glass industry in Mexico represented only 2 percent of the total manufacturing production in 1976. However, during the 1965-1975 period it grew at an average annual rate of 9 percent. Further, its link to other manufacturing activities such as soft-drinks, beer, food and automobile industries enhances its relative significance in the Mexican economy.

Approximately 90 percent of all the industry's raw materials are produced in Mexico, and by the end of 1978 industry investment was estimated at 3.5 billion pesos, with more than 20,000 persons working full time. Thus, in terms of production, export possibilities, employment, and strategic industrial situation this industry ranks among the most important in Mexico.

The main activities of this industry are centered in the production of sheet glass and glass containers, as can be appreciated in Table 3.

The leader in the industry is the Grupo FIC which has

Table 1. Mexico's gross domestic product[a] (proportional share)

| Activity | 1973 | 1974 | 1975 | 1976 | 1977 | 1978[b] |
|---|---|---|---|---|---|---|
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Primary Sector | 10.2 | 9.9 | 9.5 | 8.9 | 9.1 | 9.1 |
| Industrial Sector | 38.1 | 38.7 | 39.0 | 39.8 | 40.8 | 42.8 |
| Mining | 3.6 | 3.9 | 4.0 | 4.4 | 5.0 | 4.7 |
| Petroleum | 3.6 | 3.9 | 4.0 | 4.4 | 5.0 | 7.0 |
| Petrochemical | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 1.2 |
| Manufacturing | 23.2 | 23.2 | 23.1 | 23.2 | 23.2 | 23.2 |
| Construction | 5.1 | 5.1 | 5.2 | 5.0 | 4.7 | 4.4 |
| Electricity | 2.0 | 2.0 | 2.1 | 2.2 | 2.3 | 2.3 |
| Tertiary Sector | 51.7 | 51.4 | 51.5 | 51.3 | 50.1 | 48.1 |

[a]Source: Banco de Mexico (1974-1978).

[b]Unofficial estimate.

Table 2. Mexico's gross domestic product[a] (millions of 1960 pesos

| Activity | 1974 | 1974 | 1975 | 1976 | 1977 | 1978[b] |
|---|---|---|---|---|---|---|
| Primary Sector | | 37175 | 37511 | 36080 | 37307 | 38725 |
| Industrial Sector | | 134134 | 139936 | 144493 | 150231 | 164503 |
| Manufacturing | | 82941 | 90060 | 92430 | 95203 | 103105 |
| Tertiary Sector | | 208118 | 217537 | 222697 | 227139 | 234862 |
| TOTAL | | 375000 | 390000 | 398600 | 409760 | 432297 |

[a]Source: Banco de Mexico (1974-1978).

[b]Unofficial estimate.

Table 3. Production of Mexico's glass industry[a]

| Product | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|
| Sheet Glass (tons) | 51537 | 56475 | 61977 | 70537 |
| Cut Glass (tons) | 14388 | 15697 | 17949 | 22162 |
| Float Glass (tons) | 37342 | 64075 | 64455 | 63320 |
| Automotive Glass (000 $M^2$) | 783 | 685 | 664 | 701 |
| Fiber Glass (tons) | 4102 | 4234 | 4711 | 5350 |
| Bottles (mill units) | 2129 | 2426 | 2550 | 2915 |
| Jars (mill units | 154 | 172 | 169 | 155 |
| Tubes (mill units) | 40 | 44 | 49 | 46 |
| Ampules (mill units) | 241 | 214 | 270 | 273 |
| Crystalware (mill units) | 230 | 216 | 279 | 296 |

[a]Source: General Statistics Bureau (1974-1978).

just started a $5 billion pesos expansion program. FIC spent $1 billion pesos in 1978 to expand its container operations, and expects to spend another $1.2 billion during 1979.

The star performer of the FIC group from a sales standpoint is its glass container division, which is the particular firm for which this study will define a microeconometric model useful as a link between the macroeconometric model of Wharton and the firm's decision support system.

The glass container industry

The glass container industry comprises eight plants, four of them belonging to the FIC group thus integrating the firm of our study. Of the other four, Fabrica Nacional de Vidrio, S.A. (FANAL) which is the second largest firm in the market, and Vidrio Moctezuma, S.A. are totally under the control and management of two of the largest beer companies in Mexico, Cerecería Modelo, S.A. and Cervecería Moctezuma, S.A. and therefore have all of their production committed to these firms. This is why they represent no threat to the FIC group. Another one, Vidriera Occidental, S.A., started production in 1978, has only 200 employees and very low levels of production.

The eight principal markets for the production of glass containers are in descending order of importance: food, beer, soft-drinks, wine, medicines, perfume, and commercial and industrial articles.

In general, one would have to build an industry econometric model and from it, the company's sales and market share would follow. In this case, however, the FIC firm dominates the market to such extent that this, combined with the fact that the next two firms are captive producers for two beer companies, means that any industry microeconometric model is in fact equivalent to a firm's demand model.

To strengthen this idea, let us look at Table 4, which presents total industry and our firm sales along with the market share of the FIC firm and FANAL for the 1964-1975 period.

Since most of the rest of the firms' market share can be attributed to Cervecería Moctezuma, S.A. installation of its own bottle plant, one can see why by defining the firm's econometric demand model, one ends up with the industry's econometric model, and market share projections.

Table 4. Total industry sales, FIC firm sales and percentage market share of FIC and FANAL for the 1964-1975 period (sales in millions of pesos)[a]

| Year | Industry Sales | FIC firm Sales | FIC % Mkt/Share | FANAL % Mkt/Share | Rest of Firms % Mkt/Share |
|---|---|---|---|---|---|
| 1964 | 897.64 | 732.31 | 81.5 | 15.0 | 3.5 |
| 1965 | 1108.18 | 865.76 | 78.1 | 15.0 | 6.9 |
| 1966 | 1079.26 | 848.62 | 78.6 | 15.0 | 6.4 |
| 1967 | 1211.46 | 932.71 | 76.9 | 15.0 | 8.1 |
| 1968 | 1389.77 | 1042.41 | 75.0 | 15.0 | 10.0 |
| 1969 | 160795 | 1192.58 | 74.1 | 15.0 | 10.9 |
| 1970 | 1659.72 | 1263.04 | 76.1 | 15.0 | 8.9 |
| 1971 | 1727.74 | 1327.14 | 76.8 | 15.0 | 8.2 |
| 1972 | 2018.12 | 1473.40 | 73.0 | 15.0 | 12.0 |
| 1973 | 2299.13 | 1655.10 | 71.9 | 15.0 | 13.1 |
| 1974 | 2627.88 | 1914.40 | 72.8 | 15.0 | 12.2 |
| 1975 | 2689.65 | 1812.30 | 67.4 | 15.0 | 17.6 |

[a]Source: Estimated by the marketing department of FIC firm (see pages 9, 12).

## Scope of This Study

It is not intended here to develop an econometric model for the Mexican economy, nor to produce the complete decision support system for the firm.

This study will only look at the Wharton-Diemex model of the Mexican economy to examine its validity as a forecasting tool for the firm's DSS. It will then follow that if one accepts the usefulness of that forecasting tool for the firm, this study will provide the next forecasting tool required by the DSS by constructing the demand forecast model and simulating it to observe the impact of alternative pricing policies the firm might like to follow.

In order to maintain an adequate framework to work with, limitations as to the type of computer software were accepted and decision was taken to work with the equipment available in Monterrey, Mexico in terms of EDP. Thus, all of the estimation and simulation processes remain within the realm of possibilities open to any firm in a developing country to show that although fine statistical problems are accepted, the econometric model to be defined is a working tool usable anywhere.

## Organization of the Study

Chapter 2 presents an analysis of the important features of macroeconometric models and a review of the three main conceptual frameworks which explain the functioning of the economic system. It ends with a presentation of the needs of developing nations for industrial and marketing models.

Chapter 3 is used to lay down the foundations of an adequate DSS for firms in developing nations.

Chapter 4 undertakes the task of studying the Mexican macroeconometric model. Its structure is examined and discussed, and its results are then judged in terms of their predictive abilities to determine confidence levels one can have in their forecasts for macroeconomic variables to be used by the industry model of the firm.

Chapter 5 is devoted to the presentation and discussion of the equations, the estimation results, and the simulation results of the glass container model. The results of several simulations of the firm's alternative pricing strategies are then compared in terms of sales and market share for the firm in the period 1977-1981.

Chapter 6 summarizes the results of this study and suggests further work to be done in the development of industrial microeconometric models and corporate decision support systems in developing nations.

The purpose of this study is, therefore, to develop a microeconomic demand model for a particular industry in Mexico and show how the usefulness of mcaroeconometric models can be enhanced by such linkage. By doing so, the first bridge will be built between the macro aspects of a developing economy and the decision support system needed in a firm to optimize the use of its scarce resources.

# CHAPTER 2. MACROECONOMETRIC MODELING: A SUGGESTION FOR DEVELOPING COUNTRIES

Since Tinbergen's early work in the 1930's, the construction of large and sophisticated macroeconometric models has been going on in the economics profession. Given that so many versions exist to explain any particular economy, especially that of the United States, one would be led to believe that they are based upon fundamental differences. Therefore, it is necessary to ask what if anything makes them different, and to verify how these differences improve the forecasting accuracy of the macroeconomic variable they attempt to explain.

This analysis, along with a definition of the special characteristics that most developing nations have, such as strong dependence on foreign trade, very few products as the principal source of foreign currencies, its nondiversified economic structure, the strong role played by the public sector, and the limitations of capital goods which create an output constraint, will allow the suggestion of a basic framework to construct macroeconometric models for developing nations, instead of the commonly practiced "transference of technology" of econometric models which reflect accurately developed economies, but are inadequate to a great extent in explaining developing economies.

Still, the starting point in this chapter will be to look at the principal theoretical macroframeworks established in the economic literature, prior to an examination of results obtained from certain models being utilized for the U.S. economy.

## Basic Macroeconomic Frameworks

The simple models advanced by Klein and Goldberger (1955), Suits (1962), as well as the large structured ones such as the Brookings-SSRC (Dusenberry et al., 1965; Fromm and Taubman, 1968), MIT-FRB (De Leeuw and Gramlich, 1968) and Wharton (Preston, 1973), all have in common the classic textbook macroeconomic model of the System (A) below:

$$\begin{aligned} Y &= C + I + G + X - M \\ C &= f(Y) \\ I &= f(Y,r) \\ M &= f(Y,P) \end{aligned} \qquad \text{(System (A))}$$

where,

$Y$ = Gross National Product,

$I$ = Investment Expenditures,

$C$ = Consumption Expenditures,

$X$ = Exports,

$M$ = Imports,

$G$ = Government Expenditures,

$r$ = Interest Rate,

$P$ = Price Level

In principle, all models defined follow a demand oriented approach, and it seems as if no fundamental difference exists to explain the economy with the national account identities providing the cornerstone for any macroeconometric model to be constructed. However, after a better examination of the structure of each model, one finds that three theoretical frameworks of operation can be defined, each yielding a different model representation in order to explain how the economy works.

In fact, three main theoretical currents can be defined: The neo-Keynesian explanation, the neoclassical-monetarist interpretation, and the neo-Marxian viewpoint.

<u>The neo-Keynesian model</u>[1]

The simplest version of this model is presented below in Equations 1-7.

$$O = C + I + G \qquad (1)$$

$$C = f_c \ (Y_d) \qquad (2)$$

$$I = f_i \ (R, \ O_1) \qquad (3)$$

$$M/P = fn \ (R, \ O) \qquad (4)$$

$$O = f_o \ (N) \qquad (5)$$

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[1]To observe the development of this basic neo-Keynesian framework one has to start with Keynes himself, and work all the way through with Hicks (1937), Brownlee (1950), Bailey (1962) and Christ (1966) among many others.

$$do/dN = fn\ (W/P) \quad (6)$$

$$N = f_w\ (W_o) \quad (7)$$

where,

O = Total output,

C = Total private consumption,

I = Total private investment,

M/P = Real money balances,

N = Total labor force

W/P = Real wage rate,

R = Interest rate,

G = Government expenditures,

Yd = Personal disposable income,

Wo = Nominal wage rate,

do/dN = Relation to determine demand for labor,

P = Price level

In this model the endogenous variables are, C, I, M, R, N, P, and it has three main sectors defined. Equations 1-3 represent the demand sector of the economy. Consumption and investment are explained in the traditional IS-LM framework, with investment and savings reaching equilibrium levels through interest rate and disposable income adjustments after results have been achieved in the production and employment equations of the model. As in all post-Keynesian models, aggregate demand determines the level of income, but its amount and composition are conditioned by the potential output of the economy through the degree of idle capacity and by labor unemployment rates.

Equations 5-7 represent the production and employment sector of the model. These equations define the real levels of output reached by the economy, and are the equations where disequilibrium factors are introduced into the model. Its definition stresses the fundamental disagreement between the supply and demand for labor in the economy. Equation 6 defines producers' demand for labor, where labor input demand reaches the point where equilibrium is attained between the real cost of hiring an extra unit (W/P) and its marginal productivity (do/dN). On the other hand, Equation 7 represents labor supply as a function not of the real wage level, but rather as a function of the money wage prevalent in the market. Hence, it is quite possible that a disequilibrium between both might occur, even though the system taken as a whole could be in equilibrium.

Finally, Equation 4 defines the monetary aspects of the economy. Real balance stocks are defined in this model by the interest rate and production levels as determined in the demand and production sectors of the economy.

The structure thus defined stresses real relationships as the principal forces operating in the economy, and emphasizes fiscal policies and interest rate adjustments as the relevant variables conducting the economy towards an equilibrium situation with the monetary relation playing an essentially passive role.

The neoclassical-monetarist interpretation

The neo-Keynesian model presented above stresses real relations and fiscal policy as the key elements in producing an equilibrium relation in the economy. Recently, this assumption has been challenged by the so-called "new monetarists". For example, Branson and Klevorick (1969) challenged the idea that the money illusion was not a determinant of consumption. Friedman (1956), Ando and Modigliani (1969), De Leeuw and Gramlich (1968) and several others have challenged, in turn, the idea that monetary policy and money relations were irrelevant in reaching an equilibrium level for the economic system. In general, monetarists concentrate their efforts not in denying the relevance of fiscal policy, but rather in stressing the treatment of financial markets and the linkages with the goods and services markets.

When money matters, the simplest version of a macroeconometric model is,

$$O = C + I + G \tag{8}$$

$$C = f_c\ (Y_d,\ P) \tag{9}$$

$$I = f_i\ (R) \tag{10}$$

$$M = kPO \tag{11}$$

$$O = f_o (N) \tag{12}$$

$$\frac{dO}{dN} = \frac{W}{P} \tag{13}$$

$$N = f_w (W, P) \tag{14}$$

In this model the endogenous variables are O, C, I, R, W, P, and N. Equations 8-10 again represent the demand side of the economy. Although they continue to operate in a fashion similar to the neoclassical neo-Keynesian model, one finds O as a new factor determining the levels of consumption. This makes the IS-LM framework inoperative in reaching an equilibrium situation. Furthermore, the equations defining output and employment are additionally affected by prices. Therefore, the equilibrium levels of employment depend on the price level. Since Equation 11 makes P a function of M, the result is that money does matter in any short run economic solution, and this, in fact, changes the whole equilibrium determination found in the simple Keynesian model. Now money also becomes a determining variable as it plays an active role in the economic results to be obtained. The monetary sector is therefore highly relevant in these models, which tend to have strong monetary and financial sectors to explain the influence that money has over credit, interest rates, prices, and real variables. Of course, in contrast with the neoclassical neo-Keynesian models, monetarists tend to stress free equilibrium relations and to give fiscal policy a reduced role in the attainment of equilibrium levels.

<u>The neo-Marxian viewpoint</u>

The final theoretical difference is found in the Marxist view of the economy, as reflected by the writings of Kalecki (1964), Morishima (1970), and others. The foundation stone of this position lies with the idea that economic behavior varies according to the income distribution prevailing in the economy. Thus, what defines the equilibrium levels is the relation between marginal propensities to consume and to invest of different economic groups. Any model built upon this viewpoint must therefore have a well-defined income distribution sector coupled with consumption and investment relations through which the income distribution factor plays a significant role. The Marxist theoretical consideration to be empirically proved is the price formation mechanism, for the Marxist value theory argues that prices are a function of the goods' socially needed labor time as measured in hours. The problem is that these values will seldom if ever be recorded in the national accounts.

The definition of this model is given in Equations 15-22 below:

$$C = f_c\ (Y_c,\ Yw) \tag{15}$$

$$I = f_i\ (Y_e,\ O_{-1}) \tag{16}$$

$$P = fn\ (N) \tag{17}$$

$$O = fo\ (Y_c) \tag{18}$$

$$Yc = f_{yc}\ (W/P,\ O) \tag{19}$$

$$Yw = fyw\ (W/P) \tag{20}$$

$$\frac{dO}{dN} = f\ (\frac{W}{P}) \tag{21}$$

$$\frac{W}{P} = fw\ (N) \tag{22}$$

where,

Yc = Capital income,

Yw = Labor income, and all the other variables remain as defined before.

The endogenous variables are O, C, I, Ye, Yw, P, W, and N. It is interesting to note that this model does not have an O = C + I + G identity, for it is not required in the system since all output relations are supply oriented with the whole system envisioned at a continuous nonequilibrium situation.

A second difference with the other models lies in the emphasis put on income distribution as the relevant factor, if a final equilibrium is to be reached in the economy.

Finally, Equation 17 presents the role of the financial sector. Since there does not exist a clear interpretation of Marx's labor theory, this is the hardest sector to define in the model. Thus, investment is represented as a function of past output and capital income in Equation 16, with the equation defining employment (Equation 22) based upon Marx's idea of the industrial proletarian army of unemployed and its depressing effects over the real wage.

## Macroeconomic Models and Policy Analysis

A second reason to have different models' structures is derived from the economic need to perform policy evaluation in a country: For instance, the first models for the United States economy had few equations since they were built with forecasting purposes in mind. As more and more public intervention appeared in the economy, fiscal and monetary policies had to be evaluated in terms of their impact upon the different sectors and activities of the economy. Thus, today's models are extensive and have policy evaluations as their goal. As a rule, Keynesian models are more disaggregated than those based upon monetarist or Marxian foundations, e.g., the Fair or Federal Reserve of St. Louis Models, and the Planned Economies models discussed by Shapiro and Halabuk (1976). Yet, some of the latter, such as the FRB-MIT model, are reasonably large and are intended to be used not only with forecasting purposes in mind, but also to obtain estimates of the economy's basic structural relations and the effects of alternative monetary policies upon them.

In short, to construct a macroeconometric model may appear deceptively simple, for as Klein suggests, once we know the demand relations we know how much has to be supplied to the market. Hence, the supply side must be developed in accordance with the basic demand relationships stated by the Keynesian text book model. However, things are not that simple. Policy evaluation rather than simple forecasting forces a decision on which behavioral and institutional relations have to be specified. Thus, a thorough knowledge of the economy and of economic theories is necessary before a model is even attempted. The final complexity of the model will depend on theoretical and policy considerations, as much as on availability of data and computing resources.

## Macroeconometric Models' Predictive Ability

Since the usefulness of any macroeconometric model used by a firm for its DSS depends on its predictive ability, it is good forecasting rather than structural explanations which emerges as the basic reason to choose one model over another. Thus, to resolve which theoretical framework one should pick, it looks as if one should look to each model's proven record of success.

Several studies comparing well-known econometric models have been made for the United States' macroeconometric models. A whole issue of the International Economic Review in 1975 was devoted to this task. In what follows, a comparative evaluation performed by Fromm and Klein (1973) for nine macroeconometric models of the U.S. economy is employed. The models compared are basically built upon the Keynesian and Monetarist theories, and have different sector specifications. The comparisons were made for GNP forecasts in real and nominal dollars. They are reproduced in Tables 5 and 6 and comprise within and outside-the-sample-period results.

A careful examination of the results appears to yield three main conclusions. First, those models with a smaller structure predict better. Second, quarterly forecasts are superior to annual forecasts. Third, the farther one predicts, the worse off the prediction will be.

The first conclusion is a generally accepted dogma in economics. It has been repeated many times over to forecast GNP; all one has to do is to utilize a model as simple as the one defined by the System (A) at the beginning of this chapter.

The second and third conclusions have an interesting implication for macroeconometric modeling in developing nations. Since quarterly predictions are better than annual forecasts, having information on the variables required by the model is the relevant constraint. In general, this

Table 5. A comparison of GNP forecasting accuracy from several macro-econometric models of the U.S. economy (in current dollars)[a]

| Model[b] | Period of Simulation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | % Forecast Error for Sampling Periods[c] | | | | | |
| BEA | 61.1-67.4 | 2.39 | 4.68 | 6.57 | 7.81 | 8.95 | 9.99 | x | x |
| BROOK | 59.1-65.4 | 4.08 | 5.38 | 5.83 | 5.85 | 5.78 | 5.72 | 5.66 | x |
| DHLIII | 61.1-67.4 | 3.09 | 4.90 | 7.31 | 8.44 | x | x | x | x |
| FAIR | 62.1-67.4 | 2.80 | 4.12 | 4.49 | 4.56 | 4.00 | x | x | x |
| FRB-S.L. | 61.1-67.4 | 3.16 | 4.51 | 5.52 | 6.34 | 6.93 | 7.55 | 8.51 | x |
| MPS | 61.1-67.4 | 2.53 | 3.57 | 4.97 | 5.50 | 6.61 | 6.58 | 6.64 | 6.59 |
| WHAR-III | 61.1-67.4 | 3.14 | 4.70 | 6.05 | 6.62 | 6.98 | 7.04 | 7.02 | 6.82 |
| STANF | 55-66 | 7.30 | 8.94 | 8.01 | 7.85 | 7.80 | 7.66 | x | x |
| WHAR-AN | 61-67 | 4.97 | 5.74 | 10.34 | 14.32 | 23.57 | x | x | x |
| | | | | % Forecast Error Outside the Sampling Periods | | | | | |
| BEA | 69.1-71.2 | 4.30 | 12.47 | 18.21 | 20.78 | 21.14 | 19.72 | x | x |
| BROOK | 66.1-70.4 | 6.74 | 11.36 | 16.08 | 20.94 | 25.69 | 29.54 | 33.18 | 39.77 |
| DHLIII | 68.1-70.4 | 6.04 | 9.88 | 12.45 | 16.49 | x | x | x | x |
| FAIR | 65.4-69.4 | 2.91 | 4.35 | 4.52 | 6.77 | 9.89 | x | x | x |
| FRB-S.L. | 70.1-71.4 | 10.29 | 14.88 | 13.83 | 11.69 | 11.15 | 16.11 | x | x |
| MPS | | x | x | x | x | x | x | x | x |
| WHAR-III | 70.2-71.4 | 9.9 | 19.46 | 27.16 | 31.09 | 35.60 | 41.89 | 44.94 | 48.25 |
| STANF | | x | x | x | x | x | x | x | x |
| WHAR-AN | | x | x | x | x | x | x | x | x |

[a]Source: Frommand Klein (1973).

[b]BEA, Bureau of Economic Analysis; BROOK, Brookings econometric models; DHLIII, University of Michigan; FAIR, Fair model, Princeton University; FRB-S.L., Federal Reserve Bank of St. Louis; MPS, FRB-MIT model; WHAR-III, Wharton Quarterly model; STANF, University of Stanford annual models; WHAR-AN, Wharton annual model.

[c]The percentage error was estimated as $\frac{SE}{n-1}$. Except for the Stanford and Wharton annual models, all periods are quarterly estimations.

Table 6. A comparison of GNP forecasting accuracy from several macro-econometric models of the U.S. economy (in constant dollars)[a]

| Model[b] | Period of Simulation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| | | % Forecast Error for Sampling Periods[c] | | | | | | | |
| BEA | 61.1-67.4 | 1.97 | 3.49 | 5.68 | 6.94 | 8.12 | 8.94 | x | x |
| BROOK | 59.1-65.4 | 3.70 | 4.66 | 5.01 | 5.13 | 5.19 | 5.25 | 5.32 | 5.57 |
| DHLIII | 61.1-67.4 | 2.86 | 4.94 | 7.27 | 8.52 | x | x | x | x |
| FAIR | 62.1-67.4 | 2.81 | 4.14 | 4.32 | 4.22 | 3.61 | x | x | x |
| FRB-SL | 61.1-67.4 | 2.88 | 4.09 | 4.77 | 4.98 | 4.69 | 4.33 | 4.43 | 4.72 |
| MPS | 61.1-67.4 | 2.63 | 3.67 | 3.98 | 4.36 | 5.50 | 5.90 | 6.30 | 6.70 |
| WHAR-III | 61.1-67.4 | 3.08 | 3.91 | 4.32 | 4.52 | 5.05 | 5.43 | 5.62 | 6.82 |
| STAMF | 55-66 | 7.04 | 8.48 | 7.49 | 7.37 | 7.36 | 7.27 | x | x |
| WHAR-AN | 61-67 | 6.20 | 7.08 | 6.37 | 8.84 | 10.87 | x | x | x |
| | | % Forecast Error Outside the Sampling Periods | | | | | | | |
| BEA | 69.1-71.2 | 3.51 | 9.05 | 11.54 | 11.02 | 8.42 | 6.83 | x | x |
| BROOK | 66.1-70.4 | 5.86 | 9.64 | 13.40 | 16.41 | 18.78 | 20.45 | 21.24 | 24.22 |
| DHL-III | 68.1-70.4 | 5.16 | 8.38 | 9.96 | 12.08 | x | x | x | x |
| FAIR | 65.4-69.4 | 3.12 | 4.74 | 4.71 | 5.40 | 6.61 | x | x | x |
| FRB-SL | 70.1-71.4 | 6.81 | 8.54 | 8.36 | 10.25 | 8.33 | 10.86 | x | x |
| MPS | | x | x | x | x | x | x | x | x |
| WHAR-III | 70.2-71.4 | 10.39 | 16.89 | 22.02 | 24.58 | 26.97 | 28.81 | 27.29 | 26.33 |
| STAMF | | x | x | x | x | x | x | x | x |
| WHAR-AN | | x | x | x | x | x | x | x | x |

[a]Source: Fromm and Klein (1973).

[b]BEA, Bureau of Economic Analysis; BROOK, Brooking econometric models; DHLIII, University of Michigan; FAIR, Fair model, Princeton University; FRB-SL, Federal Reserve Bank of St. Louis; MPS, FRB-MIT model; WHAR-III, Wharton Quarterly model; STANF, University of Stanford annual models; WHAR-AN, Wharton annual model.

[c]The percentage error was estimated as $\frac{SE}{n-1}$. Except for the Stanford and Wharton annual models, all periods are quarterly estimations.

contraint will dictate a monetarist framework, as monetary information is easier to obtain because of the special government links with international financial institutions. Thus, in the end it looks as if for developing nations data and not theory will dictate which model should be constructed to explain the economy.

## Macroeconometric Models and LDCs

Since 1960 a good deal of work has been done to produce macroeconometric models in developing nations. Most of the work has been done by Klein or his associates at the University of Pennsylvania as reported in his 1968 and 1975 papers. In a 1977 report of Wharton Econometric Forecasting Associates, it is specified that as part of the Orbis projects, macroeconometric models for Africa, Asia, Brazil, Mexico, Venezuela and the rest of Latin America have been constructed.

In general, the basic textbook model adapts itself to these countries since many economic resources are normally traded in some sort of free or mixed enterprise structures.

Stephenson and Itharattana (1977), for instance, have developed a model for the Thai economy based upon the neo-Keynesian framework. Their model takes into account the relevance of the agricultural sector and the high dependence of the Thai economy on foreign trade. Thus, it tries to describe the Thai economy "in an extensive and disaggregated manner as possible, and to investigate the effects of alternative policy proposals with particular emphasis on increasing agricultural production and income"(Stephenson and Itharattana, 1977).

Although limited by data, the model in its version II includes a monetary and price sector besides the traditional aggregate demand oriented real sector. It consists of 55 equations to explain private consumption, government consumption, exports and imports, gross fixed capital formation, output, income distribution, and monetary and price relations. It represents therefore a highly disaggregated model which recognizes many of the special features of a developing nation.

On the other hand, Siri's model of the Central American economies (1977) follows straight down the neo-Keynesian framework in a highly aggregated system which makes all domestic economic results depend on exports of a few agricultural products without a reference to monetary or government activities, and without considering any output, or income distribution constraints. The whole model for five economies consists of 35 equations and 25 identities and requires exogenous predictions of too many independent variables to be safe.

Since economic dualism, strong dependence on foreign trade, and direct government intervention in production and distribution are commonly present in developing nations, these characteristics do impose upon the model builder the need to introduce modifications in the basic framework derived from macroeconometric experiences in developed countries. The first characteristic, dualism in the economy, implies that the basic Keynesian relationships do not uniquely determine the functioning of the economy. Supply and consumption operate in two different spheres, and therefore income distribution must play a relevant role in defining them. Market and price relations produce structural imbalances which cause supply deficiencies in agricultural production, and shift consumption to goods produced with large amounts of capital investment. Another factor is the creation of unemployment and a consequently weak demand for the production of durable goods. Finally, the pattern of industrialization created by this structural imbalance implies strong propensities to import, in turn affecting the foreign sector and existent price and financial relations.

The second characteristic, strong dependence on foreign trade and technological transfers, has a strong impact on aggregate demand and supply, price and wage relations, and upon monetary and fiscal policy. The last characteristic, strong government participation, introduces the need for the specification to portray special institutional relations that such participation provokes in the economic life of the developing nation.

## A Basic Framework for Developing Economies

The anatomy of the model proposed here comes from the basic model (A) specified before, and is adjusted to account for the special characteristics of developing nations. In what follows, a basic structure and implicit functional relation for a macroeconometric model of a developing country will be constructed in a very simple fashion.

The following are the sectors considered essential for the model:

a) Private Demand Sector

b) Government Demand Sector

c) External Sector

d) Potential and Real Output Sector

e) Price and Monetary Sector

f) Income Distribution Sector

### Private demand sector

In most developing nations a mix of private and public economic activities interact in the demand and output markets. Insofar as they do not have a totally planned economy, attention must be paid to private consumption and capital formation. These two basic relationships are considered by defining Equations 23 and 24:

$$C_p = f_{23} (Y_c, Y_w, Y_a) \qquad (23)$$

$$I_p = f_{24} (Y_c, Y_a, O_{-1}) \tag{24}$$

where,

$C_p$ = Private Consumption of Goods and Services,

$I_p$ = Private Investment,

$Y_c$ = Capital Income,

$Y_w$ = Labor Income,

$Y_a$ = Agricultural Income,

$O_{-1}$ = First Lag of Gross National Product.

Since different consumption propensities are likely to exist in this economy, Equation 23 emphasizes the relevance of income distribution in the demand pattern. By the same token, the equation should permit analysis of governmental income distribution policies and their effect on consumption patterns. In the same fashion, Equation 24 stresses the concern with capital formation in a country where income distribution is so unequal that only few can save while others merely subsist. Inclusion of income from capital ($Y_c$) and agricultural income ($Y_a$) allows this equation to capture the influence that income distribution has over investment levels. The other variable ($O_{-1}$) attempts to account for the accelerator effect, and helps to explain the impact of past levels of output on investment decisions. Of course, in this and all other economic sectors discussed here, adequate lag specifications and a more detailed breakdown have to be defined when building a given model.

Government demand sector

The government plays a significant role in the economy as a direct consumer of goods and services and as a producer through its public enterprises. An equational definition to capture this dual role is:

$$C_g = f_{25} (T,N,C_{g-1}) \quad (25)$$

$$I_g = f_{26} (T,FCR,DCR,O_{-1},U) \quad (26)$$

$$C_{pe} = f_{27} (O,Y_{pe},FCR,U) \quad (27)$$

$$I_{pe} = f_{28} (FCR,DCR,O_{-1},U) \quad (28)$$

where

$C_g$ = Government Consumption of Goods and Services,

$I_g$ = Government Investment,

$C_{pe}$ = Public Enterprise Consumption of Goods and Services,

$I_{pe}$ = Public Enterprise Investment,

T = Tax Revenues,

N = Population,

FCR = Total Foreign Credit,

DCR = Total Domestic Credit,

$O_{-1}$ = First Lag of Gross National Product,

U = Unemployment Level,

$Y_{pe}$ = Public Enterprise Income.

The underlying assumptions in Equation 25 are that government consumption is shaped by its income (T), the need to provide services to the population (N), and the fact that expenditures are committed, to a great extent, by the already existing expenditure structure ($C_{g-1}$). Investment behavior, as represented in Equation 26, reflects the goals and restrictions of a developing nation's government. Infrastructure projects ($O_{-1}$), employment goals (U), and financial restrictions (T,FCR,DCR) shape government investment decisions. Finally, Equations 27 and 28 take into account the government's microeconomic intervention in the economy. It is common for public enterprises to exist side by side with private firms; they compete for funds and goods and services in much the same way as private firms do. However, they have a different set of goals; i.e., to provide required outputs and to aid the government in its macroeconomic goals such as employment and price control. Hence, this mix of private and public goals is recognized in the arguments used as explanatory variables in the equations for consumption ($O,FCR,Y_{pe},U$), and investment (FCR,DCR,U).

External sector

Three relations are important in this sector: imports, exports, and import capacity. Klein's suggestion (1968) will be followed to define the ensuing equations.

$$X = f_{29}\ (W.O., rP_x/P_w) \qquad (29)$$

$$M = f_{30}\ (O,\ rP_m/P_d) \qquad (30)$$

$$CM = P_x\ X/P_m \qquad (31)$$

where,

$X$ = Total Exports of Goods and Services,

$M$ = Total Imports of Goods and Services,

$CM$ = Import Capacity,

W.O. = World Production of those goods produced domestically

$rP_x/P_m$ = Relative Price of Exports over Imports,

$r$ = Exchange Rate,

$O$ = Gross National Product,

$P_x$ = Price of Exports,

$P_m$ = Price of Imports,

$P_w$ = World's Price Index of Goods and Services,

$P_d$ = Domestic Prices.

Equation 27 specifies that exports are related to the rest of the world's production of those goods the country produces and to the relative price (including the exchange rate (r) effect) of the goods to be exported in respect to the price of the goods in the rest of the world. Imports, Equation 30, take into account the productive capacity of the economy. The production effect (O), acts in two ways: First, in terms of the need of the system to supply consumption goods not produced in the nation; second, emphasizing the trade dependence on capital goods to maintain the established manufacturing sector of the country. Finally, Equation 31 is an identity reflecting the country's capactiy to import without recurrence to outside credit.

Output and employment sectors

Given the dualism of developing economies, it is convenient to define both potential and real output relations for each productive sector. Klein (1968) has suggested a general relationship of the form:

$$O_p = f_{32} (K_{-1}) \qquad (32)$$

$$LD = f_{33} (O, K_{-1}) \qquad (33)$$

$$O_r = f_{34} (O, X) \qquad (34)$$

where,

$O_p$ = Potential Output,

$O_r$ = Real Output,

LD = Labor Demand,

$K_{-1}$ = Stock of Capital from Previous Periods,

O = Gross National Product,

X = Exports of Goods and Services.

Potential output (Equation 32) is defined as a function of the stock of capital from previous periods alone, considering that it is this latter factor that limits supply responses. In contrast, Equation 33 expresses labor demand as a function of capital stocks ($K_{-1}$), and actual output (O). Finally, real output is defined as a simple response to demand conditions (O,X). Nevertheless, equations where labor plays a stronger role in defining potential output

$$O_p = f_{32'} (K_{-1}, L) \qquad (32')$$

and where prices and factors' costs are used in the determination of real output

$$O_r = f_{33'} (O, P, X, w, r) \qquad (33')$$

may be justifiably preferable.

Price and monetary sector

A monetary sector, no matter how rudimentary, must be included in the model to capture its effects over the real sector of the economy. As Beltran del Río (1975) has stated, (although) "structural imbalances can explain the appearance of inflation, hyperinflation requires a monetary explanation."

At a minimum one should include in the model an explanation of the price level, the money demanded by the public, and wage formation. The equations could be presented as follows:

$$M.M. = f_{35}\ (PM, RR) \qquad (35)$$

$$P.M. = f_{36}\ (PM_{-1}, O, R) \qquad (36)$$

$$I.P. = f_{37}\ (P_x, O_p/O_r) \qquad (37)$$

where,

M.M. = Money Multiplier,

P.M. = Public Preference for Money,

R.R. = Required Reserve Ratio,

R = Rate of Interest

I.P. = Price Index,

$O_p/O_r$ = Ratio of Potential to Real Output.

The money and general price index equations suggested above follow combinations of traditional monetarist and Keynesian theories.

Income distribution sector

Income distribution plays a key role in the model, for it influences the levels of consumption and investment. Given the economy's dualism, a breakdown between urban and agricultural income is also needed. Moreover, income should be divided into that proceeding from capital sources and that from labor activities. Wage determination, however, cannot follow the traditional Phillips curve model alone. Whereas in a developed economy the trade-off between unemployment and inflation is valid, in a developing economy wages are not defined by this mechanism, but rather by one in which labor productivity is confronted with inflation in the organized labor market where only strong firms and labor unions have decision-making power. Finally, government income has to be defined. The tax functions must include direct and indirect sources of revenues and must recognize the institutional pattern of the nation's tax system.

The following set of relations is offered as a simple version for the sector:

$$W_i = f_{38} (O_i/L_i, I.P.) \tag{38}$$

$$TAXD = f_{39} (W_i, O) \tag{39}$$

$$TAXIN = f_{40} (O, M) \tag{40}$$

where,

$W_i$ = Income Earnings for Each Productive Sector,

$O_i/L_i$ = Labor Productivity in Each Productive Sector,

TAXD = Direct Taxes on Income,

TAXIN = Indirect Taxes,

M = Imports of Certain Goods.

Particular versions should, of course, pay attention to each country's peculiarities and institutional set-up in terms of wage rigidities, tax structure, and tariff policies.

## Developing Nations and Econometric Modeling Needs

The process of economic growth is the central purpose of any developing nation. Economic growth means the possibility of economic development with income redistribution, higher levels of employment and improved welfare conditions for the nation's inhabitants.

Economic growth is often equated with industrialization, and in developing economies this process is undertaken by both private investors and the public sector. It therefore appears that if development goals are to be achieved, the public and private sectors of the economy should possess better analytical tools than mere intuition. Macroeconometric models are an initial response to this need for better analytical tools to explore the process of economic growth in developing nations. However, their usefulness will fall short of what could be if they are not complemented with industrial econometric models that permit linkage of the macroeconomic aspects to the microlevel at which the individual firm operates.

There are at least two reasons why governments should be interested in developing industrial econometric models. First, governments in developing nations play an important role in promoting industrial development through fiscal policies aimed at expanding or contracting particular industrial activities. Thus, it would be convenient for them to know the structure of these industries in order to be able to forecast the consequences of their policy decisions in terms of employment, output, and price results.

Second, it is a well-documented fact in developing nations that over time government intervention has progressed from regulation and provision of subsidies to direct intervention in market activities through state-owned firms competing with private firms at the production and marketing levels. Hence, it looks as if better market and product information is needed to plan public enterprise activities and to predict what their role will be and how they will fare in their industrial activities. On the other hand, private investors will not take full advantage of macroeconometric model forecasts unless they can link these results to their activity level and in this manner derive particular answers from general conditions when analyzing alternative policies with the firm's decision support system.

# CHAPTER 3. A DECISION SUPPORT SYSTEM FRAMEWORK FOR DEVELOPING COUNTRIES

The traditional view of management recognizes that it is a process concerned with the achievement of objectives (Cleland and King, 1975). In order to perform this task adequately, managers have to count with a planning tool to evaluate how different courses of action (decisions) might affect the achievement of the firm's objectives.

Thus, the three salient functions of a good decision support system are the identification of the firm's future environments, the identification of opportunity areas for the firm, and the impact on the firm's objective function of one particular decision defined by top management in order to achieve an optimization for the overall firm's components.

A decision support system, therefore, encompasses the process of strategic decision-making which is addressed to the consideration of the alternative allocations of resources which will achieve the firm's goals and objectives in an optimal fashion.

## DSS as a Systems Approach

Cleland and King (1975, p. 15) emphasize that two of the manager's jobs are to achieve overall effectiveness of his organizational environment which invariably involves conflicting organizational objectives. A good decision support system must, therefore, be defined within the systems approach to assemble those parts of the firm's inner and outer environment affecting the overall achievement of its defined objective function. It should include segments which will permit the firm to extend its attention to those events of its operational environment which are not controllable by its own actions (i.e., the macroeconomic situation); segments to observe the impact on events which can only be influenced by the firm's actions (i.e., the industry and demand for its products); and finally, segments to analyze the behavior of those events which are immediately controllable by the firm in order to achieve its purported goals (i.e., production, financial aspects, cost relations). As observed in Figure 1, a decision support system must contain basically three different sets of actions: external occurrences, strategic decisions and operational decisions.

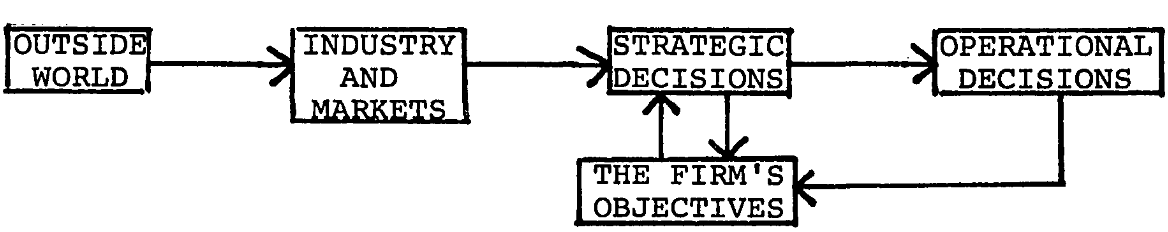


Figure 1. Relations in a decision support system

Although simple, the diagram helps to understand the nature of a decision support system. Those events outside the realm of the firm's possibilities for either control or influence do affect (but are not affected by) the firm's capacity to attain its objective. On the other hand, the firm's strategic decisions (i.e., on pricing, investment) do affect and are affected by its immediate environment, and by its objectives. Finally, those actions which can be totally controlled by the firm are its operational decisions and these are affected by the strategic decisions and affect directly the firm's achievement of its objectives, and through this indirectly the firm's strategic decisions.

Again, an adequate decision support system must include these relations and should be able to simulate them in a dynamic context, comparing different strategic decisions under different outside environments, if it is to be of any help for top management decision-making process to attain the maximization of the firm's objective function.

Yet, since the systems approach just defined does not distinguish between particular environments it is time to pause and consider what should be the main features of a decision support system for firms in developing nations.

In a survey of nearly 2000 corporations in North America and Europe which are either implementing or developing corporate planning models, Naylor and Schauland (1976) found that less than 4 percent of the firms had complete optimization models. This result points out one of the main problems in defining an optimization DSS: Lack of a correct business objective function.

A second problem most DSSs already in existence have is their lack of an adequate linkage to an operational tool to evaluate the firm's macroeconomic environment. Although this may not be relevant in developed countries (and one fails to see why such a statement may be true), it is imperative for a firm in developing nations to include as an input into its DSS the possible conditions of its macroeconomic environment. Thus, in what follows a discussion of these two aspects is given to define the two key segments for a general DSS for firms in developing nations.

## The Objective Function of the Firm

The formal solution of a decision problem involves the determination of the best available alternative. This concept is itself subject to controversy at the practical level.[1] In particular if one desires to determine the best alternative, one has to start by defining an objective function.

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[1]For years business economists have taken a stand against the profit maximization principle defined as the objective function of the firm in almost all basic microeconomic textbooks.

It is here where problems emerge for firms in developed nations. Yet, to define a general objective function for all firms in developing nations is easier than defining it for its developed nations counterparts.

Since firms in developing nations are subject to strong capital deficiencies, one could accept Simon's "principle of bounded rationality"[1] and assert that managers will select from a number of good-enough alternatives, i.e., the one with the highest probability of success in terms of the level of total profits,[2] because most of any firm's growth and future success will depend on its capacity to reinvest internal funds.

Thus, in general, one can say that after several business alternatives are defined, the DSS should provide expected profits and compare the results in such a fashion that

$$(\text{A is preferred to B}) \Leftrightarrow (\text{PROFITS A} > \text{PROFITS B})$$

where A and B are expected values (or certainty equivalents).

The process should involve a systematic examination and

---

[1]See Miller and Starr (1960) for an extensive discussion of this principle and its application by business executives.

[2]In developed nations the argument is not so simple. The behavioral theory of the firm argues that rather than profit maximization, no clear goal can be defined for a firm unless it is done in a casuistic fashion. See Cyert and March (1963).

comparison of the strategic and operational decisions, a comparison of costs and benefits, and an explicit consideration of uncertainty.

### The Firm's DSS Environment Segments

In developing nations, public sector intervention through fiscal and monetary policies is matched by direct intervention via public enterprises. This creates an urgent need to forecast public policies while at the same time increasing the need for an industry's model capable of predicting relationships between companies in terms of its market behavior and future sales policies.

Thus, the starting point of any sound decision support system is the development of the firm's outside environment. Such a profile must comprehend a macroeconomic forecast segment, and an industry's demand forecast segment.

Few, if any, DSS do have an explicit macroeconomic segment. Since one could have many possibilities, and since macroeconomic events are essential for sound planning, at least one should include naive methods to project variables such as GDP growth rate, inflation, taxation, public spending, etc., optimally. The DSS should be linked to a good macroeconometric model in order to be able to play with it under alternative fiscal and monetary policies deemed possible in the short run.

On the other hand, since public intervention at the industrial level relies primarily on direct intervention, market organization generally permits market power in the form of oligopolistic competition making it necessary for the firm to be aware of how its strategic decisions will alter the industry in terms of its demand growth rate, market share, vertical integration, and government regulation. Thus, an industrial forecasting model, where total industry's sales, and companies' relationships are determined, is required to produce an adequate DSS for developing nations' firms.

The industrial forecasting segment could use one of many possible options ranging from a cascade analysis model[1] which is not an analytic model based explicitly on the theory of the firm, to an industrial microeconometric model which attempts to develop a forecasting model more explicit and quantitatively precise.

No matter which method is used, this decision support

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[1]This model has its origin in a system developed at the Wharton Applied Research Center. See Finnel (1977). It is a descriptive model formulated in an accounting format with six steps: a) Flowchart of the industry and its input-output relations, b) Characterization and description of the industry, c) Analysis of the companies in the industry, d) Characterization and description of the product market, e) Risk analysis to identify threats and opportunities open to the firm, and f) Response to "what if" questions.

system of the firm must include both segments in order to have an idea of how its outside environment affects its strategic and operational decisions and, ultimately, the optimization of its objective function.

## The Firm's DSS Strategic and Operational Segments

Alter (1977) suggested a taxonomy for DSS based upon the functions they perform. Figure 2 presents his taxonomy and makes it possible to provide an initial idea of what process will be needed for the DSS definition.

In fact, Alter's taxonomy is far from being adequate to define a DSS. It only provides an idea of what traditionally

| | | |
|---|---|---|
| FILE DRAWER SYSTEMS<br>DATA ANALYSIS SYSTEMS | DATA RETRIEVAL | DATA ORIENTED |
| ANALYSIS INFORMATION SYSTEMS | DATA ANALYSIS | DATA ORIENTED |
| ACCOUNTING MODELS<br>REPRESENTATION MODELS | SIMULATION | MODEL ORIENTED |
| OPTIMIZATION MODELS<br>SUGGESTION MODELS | SUGGESTION | MODEL ORIENTED |

Figure 2. Alter's suggested taxonomy for DSS (1977)

has been defined as decision support systems. His taxonomy therefore is not correct, since it does mix EDP's with the DSS's functions, and might confuse the reader who may be looking for a definition of a decision support system for his firm. Naylor's (1976b, p. 4) definition is far superior as can be seen in Figure 3 below.

The outputs he includes in the financial model are: An income statement, balance sheet, cash flow statement, and sources and uses of funds statement. His marketing model explains sales and market share by product, and the production model is used to generate for given levels of sales, operating costs and costs of goods sold.

In fact, by adding to Naylor's conception the macroenvironment segment, the industrial segment, and the objective function it is possible to define a general framework for a DSS for firms in developing nations.

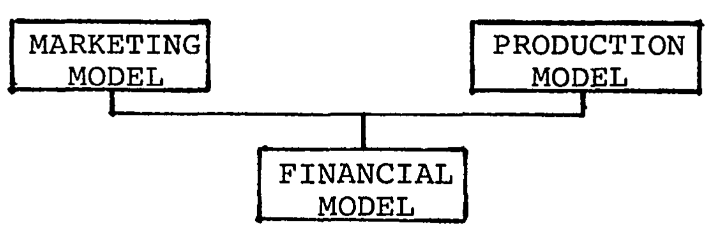


Figure 3. Naylor's conceptual framework for corporate models

Therefore, the decision support system must be defined with the following elements:

1) A macroeconomic segment,

2) An industry's forecasting segment,

3) A marketing segment,

4) A production segment,

5) A financial segment,

6) An objective function for the corporation.

Figure 4 synthesizes the functional elements and relations in the system. Thus a modern DSS should allow for all these segments in order to achieve its purposes of information handling and decision weighing.

Since many of the problems with DSS design and operation rest on how to define the models' operations, a brief explanation of each segment's main components follows.

## Structural Composition of the Models

As stated before, the macroeconomic model should optimally be defined in the form of a macroeconometric model. Although optimal, this solution is not viable for one particular firm, as the cost of building and maintaining such models is high. If one model is not available to the firm, the firm should define what macrovariables are relevant for its planning, such as GDP, prices, etc. Once this definition is attained, a simple linear trend projection, or any other such method, can

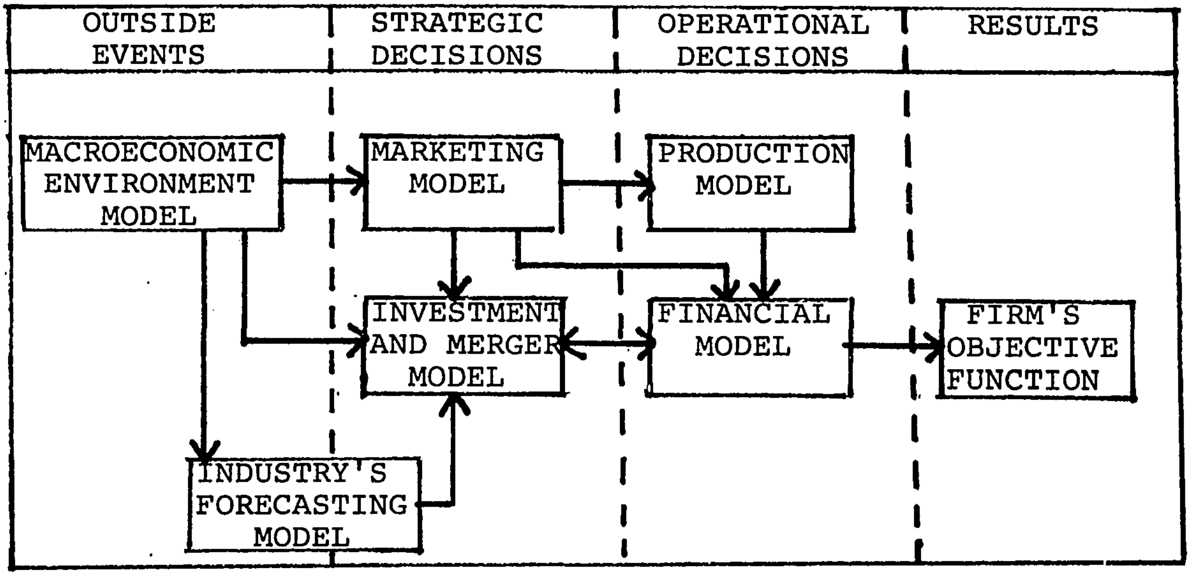


Figure 4. Decisional framework and segment taxonomy for a a decision support system of a firm in a developing nation

be utilized to forecast future values to be used in the macroeconomic segment of the decision support system.

The industry forecasting model should contain the following elements: Product demand functions, industrial capacity, production function, investment function, price determination function and market share determination.

The first three types of functions help on the firm's environment definition and should provide an answer to questions about the future growth of the industry, the competitive behavior of the industry, forecasting of market shares and the basis on which firms do compete for the market. Thus, ideally a cascade model or an industrial microeconometric model must be built for this segment.

The marketing model must enable the firm to analyze and predict its own products' sales and policy alternatives. Given its close link to the industry's model, once the actual form of this segment is chosen, the marketing model should adjust itself to the same methodology, allowing in this fashion a perfect relationship among the firm's strategic decision variables and the industry's variables. This segment will provide the revenue projections and must therefore allow for a simulation approach. Since naive forecasting techniques are void of explanatory power and cannot be used to simulate the effects of alternative marketing strategies, an econometric model or a cascade model must be utilized, thus reaffirming the need to have such a model in the industrial segment.

The production model

Given a sales forecast, its production at a minimum cost is the next firm's decision. As input resources are always scarce in developing nations, two principal policies should be answered by the production model: What inventory policy is optimal, and what input combination minimizes cost.

Activity analysis and decision models are the optimal methodology. They permit the definition of production and inventory policies at a minimum cost, while recognizing input resources constraints.

Use of mathematical programming techniques is the logical extension and should be built into the activity analysis model to obtain not only the cost of operating at different levels of output, but also the optimization of the firm's resource usage process.

## The financial model

Naylor (1976b, p. 5) defines the financial model as "the front-end of every corporation planning system." Basically the financial model is a set of accounting identities that projects financial statements. Thus its construction requires:

1) Accounting identities,
2) Income statement/balance sheet interaction,
3) Cash flow projections,
4) Generation of complete financial reports,
5) Consolidation reports.

Most of the financial models developed to date are recursive or causally ordered models. These models have the computational advantage that solution of the system of equations does not require matrix inversion or some other simulations technique.

## Overall optimization of the system

Finally, once all the segments have been defined in individual form, the fundamental purpose of the decision support system requires from the system the capability to:

1) Identify the pertinent control or strategic variables,
2) Develop good short-term programs,
3) Diagnose deviations, and
4) Have flexibility to adapt to new conditions.

In order to attain the overall effectiveness of the system, and prior to beginning work on the model, the firm should pay attention to the following practical matters: What data base is available? What type of computing equipment is available? Is total simulation of the model possible?

In many developing nations the answer to these questions may be a resounding "No, it is impossible to create a sound DSS".

However, since the model is segmentable, when total optimization is impossible, the creation of part of a DSS is recommendable, as it will provide management with the possibility of taking at least suboptimal decisions for the firm at the strategic, or operational level, and to explore impacts of alternative paths of action on the level of total profits of the firm.

# CHAPTER 4. AN ANAL[illegible] OF THE MACROECONOMETRIC MODEL FOR MEXICO

The first segment for the firm's DSS defined before consists of a macroforecasting model. Since the purpose of this study is to construct the intermediate segments of a DSS for the FIC firm operating in the glass container industry of Mexico, the first step to be taken is to evaluate the one macroeconometric model for Mexico.[1]

It is accepted that econometric models are the best choice for any firm insofar as they provide explicit quantitative assessments on the macrovariables required for the firm's strategic decision segments later to be developed.

The Wharton-Diemex model is the only open-access model existing in Mexico. It provides regular forecasts for the Mexican economy twice a year, and each successive version has tried to approximate more closely the model's structure to the characteristics of the Mexican economy. However, since no publication of the new model named PL3.3 has appeared, the following discussion relies in the Mexican econometric model version V which ceased to be utilized after Mexico's 1976 devaluation of the peso.

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[1] Although in the public sector there exist other macroeconometric models for the Mexican economy, they are not accessible to private firms.

## Structure of the Model

The set of equations defining the structure of the model's version V is presented in its estimated equations in the Appendix. The model is based on the Keynesian paradigm, but since its initial conception, it has taken into account the supply considerations previously mentioned as a characteristic of developing nations. Thus, the model is divided into the following equational blocks.

a) Aggregated Demand Equations

b) Output Equations

c) Capital Formation Equations

d) Potential Output Equations

e) Demographic Relationships

f) Income Distribution Equations

g) Price and Wage Equations.

### Aggregate demand specification

Equations 1 to 65 in the Appendix represent this sector. It consists of two subsectors, domestic demand and foreign demand. The domestic demand subsector is determined by six behavioral equations and six identities. It explains private and public consumption and investment separately. In the process, it does not utilize an income distribution variable, with the only explanatory income variable being lagged personal disposable income. Public consumption, in turn, is explained by tax revenues, without regard for any expenditure motivation.

Explanation of private and public investment is made following the hypotheses of capital shortage advanced by many Latin-American economists; e.g., Navarrete (1974), Solis (1971) and Wionczeck (1974). These hypotheses conclude that in countries where capital is scarce and markets oligopolistic, cost of capital considerations are practically irrelevant in explaining investment behavior, regarding the availability of funds as its main determinant. Thus, a combination of financial credit and previous output are utilized to explain investment behavior in the equations of the model.

As stated above, in a country such as Mexico, income distribution must play a relevant role. Its exclusion, therefore, affects the degree of confidence with which the model's predictions may be accepted. The authors of the model justify the estimations on the grounds that, in spite of being the a priori choice, income distribution fails to account for the dynamics of Mexican consumption and a lagged equation results in an unacceptably high long run propensity to consume out of wage income (Del Río and Klein, 1973).

The second subsector, foreign demand, is very complete. It captures quite accurately the principal exports of Mexico, with perhaps the weakest relation being the equation explaining manufactured goods exports, since it only uses U.S.

domestic product as its explanatory variable. A very interesting equation is the one used to capture the effect of bracero earnings. It employs the ratio of the Mexican minimum urban wage to the U.S. hourly manufacturing rate as an explanatory variable, and it captures quite well the unilateral transfers returned by braceros to their relatives in Mexico.

The import equations are also well-defined. Consumer and capital goods are accounted for with the latter explained using production and capital stock in the manufacturing sector, and foreign reserves, as the explanatory variables. The subsector is completed by including capital payment-relations for money outflows due to loans or dividend obligations, and with equations designed to capture the institutional peculiarities of Mexico's foreign trade (e.g., border transactions with the United States).

The model's import specifications are quite acceptable, as they depict the most relevant features of a developing economy. Capital imports, technical dependence, and the weakening position derived from changes in relative prices and foreign debt claims for repayment, royalties and interests are incorporated. The only observation one can make for the total foreign trade subsector relates to its flexibility, for the export-import content of Mexico's trade balance of goods and services and the proportional contribution to the trade balance of the public and private sectors do change over time. On balance, however, the model does capture the main characteristics of Mexico's aggregate demand, and permits an accurate image of private and public participation.

Output subsystem

This is one of the weakest sectors defined in the model. Both real and potential output relations are defined in a very simple fashion. The potential output equations introduce a truncated version of a full Cobb-Douglas production function with capital as the sole input. Although it is true that capital is important in Mexico as the relevant input in the industrial sector, one might argue that in terms of total potential production labor plays a significant role; in some instances it may even play a limiting role for some industrial activities.

Actual production of goods and services is defined by equations of the following type:

$$X1R = a + bCPR + cEAGR \qquad (41)$$

where,

X1R = Rural production,

CPR = Private consumption,

EAGR = Main agricultural exports.

However, potential output equations are of the following type:

$$X1RP = a + b\ KGF1R2 \quad (42)$$

where,

X1RP = Potential rural production,

KGF1R2 = Federal government capital stock.

This specification completely disregards relative prices and input productivity. As a first approximation these equations might be acceptable, but as Mexico's structural conditions change because of inflationary pressures, relative prices must be included to depict the true nature of today's flow of inputs between all production sectors of the economy.

## Capital formation sector

Lack of pertinent data explains why this sector is so poorly defined. It consists of just one estimated equation to define capital formation in the urban sector (Equation 73 in the Appendix). Furthermore, autocorrelation makes the equation's predictive ability doubtful, adding to the whole sector a sense of weakness in terms of its predictive capacity. Public and private stocks of capital are defined as the sum of new investment plus remaining capital stock after depreciation has been subtracted in accordance with the private and public accounting depreciation rates of .10 and .05 per year, as can be seen in Equations 74 and 75 in the Appendix. Since this sector's information is utilized as input in other important equations of the model, such weakness contributes to a general concern over the model's reliability.

Income distribution specification

The equations in this sector define the public and private distribution of income. Nevertheless, more work is needed to define agricultural and nonagricultural income, as well as capital and labor income for the Mexican economy. The model estimates the rate of change of the wage rate, and from it derives by means of identities all national income accounts up to the definition of per capita personal disposable income. Given the relevance that income distribution plays for consumption and investment in Mexico, it is convenient to provide a better explanation through use of a complete sectorial definition.

Government income, on the other hand, is correctly specified. Equations 118 to 131 take care of all taxes and government revenues as they were defined by Mexican legislation at the time. For instance, Equation 118 reproduced below captures the essence of federal income revenues.

$$TFIC = -1.2747 + 0.04001\ NIC \tag{43}$$

where,

TFIC = Total federal income taxes,

NIC = National income as defined by the model.

Of course, a better specification would be one where capital income and labor income play a part in determining federal income taxes. Again, the problem lies with the definition of income distribution between labor and capital income, and as data become available an income distribution approach to explain government revenues should be tried.

Other sectors equations

A strong asset of this model's version is the definition of Mexico's demographic characteristics. Equations 89 to 104 do account for the migration and unemployment problems inherent in Mexico's economy. It is one of the model's most carefully detailed sectors, given the limitations existing in Mexico due to the lack of accurate data. As an example, Equations 91, 95 and 100 represent an effort to determine rural participation rates, the urbanization process and rural-urban productivity gaps and changes. It is this sector that establishes a precedent for macroeconometric efforts in other developing countries.

With respect to other sectors, this version of the model employs an especially weak conception of financial and price relations, a conception limited to only three equations for the general price level. At present and as a response to Mexico's devaluation and inflationary processes, a financial sector has been incorporated to predict money supply (defined on an M1 basis), and a money multiplier for the system. This version unfortunately has not as yet been published and all that can be known about the financial sector is that it depends on two basic identities.

The identity

$$FAEC + FTOT = FLTNM + MONSPC + FCRR \quad (44)$$

corresponds to the balance sheet of the financial system. The model estimates the components from the side of the liabilities (monetary and nonmonetary). On the side of the assets, international assets and domestic credit to the public sector are estimated independently, which leaves the credit to the private sector as a residual.

The second identity in this sector is the balance of the Bank of Mexico, which gives the assets and liability components of the monetary base. The model estimates the monetary base from the side of the assets. This very important link highlights the critical influence of the foreign sector and government expenditure on monetary policy and then, via prices, on the rest of the economy.

$$FAEC + DEGM + FTPBM = MON + FRESV \quad (45)$$

The monetary base together with the money multiplier, which depends on the public preference for currency and the reserve requirements ratio, determine the level of the money supply.

## Model's Evaluation

In order to test the performance of any particular model, researchers usually utilize some particular statistical measure, such as the mean squared error (MSE), or Theil's coefficient. Attention, however, should be given to its internal consistency, as well as to its multiperiod predictive record.

In order to test the Wharton-Diemex model's internal consistency, two tests have to be carried out. First, in a dynamic context it has to be proven that the model is stable on the basis of its historical simulations. Second, one should check on its parameters' stability conditions. The first condition is met for a linear stochastic model if its characteristic roots are less than unity, and its variance is finite. If the model is nonlinear and stochastic, then to test its consistency, the "stochastic" Liapunov function must vanish as time $\to \infty$. If one finds that the model is not stable this implies that its prediction potential is low, forcing the model builder to revise it.

## Parameter Stability

On the other hand, in order to generate good predictions, the model must incorporate structural shifts observed in the economy. Its ability to do so depends on what is generally known as parameter stability.

In most models time-invariance of the regression parameters is implied when statistical techniques are employed in regression analysis. To adjust the model to shifts occurring in the economy, model builders use a technique named "constant adjustment". The constant term of any equation is adjusted to account for any serial correlation of the structural disturbances and to incorporate any structural shifts. This technique is the one utilized in the Wharton-Diemex model. Two problems emerge, however. First, there is no a priori way of knowing the adjustment factor, and second, this technique does not correct the model's structure, failing to truly represent the economic structure of the Mexican economy.

A technique that would be recommended for the model's estimation, if it was found it had a great variation due to structural shifts, is the use of a generalized estimator which incorporates varying parameter information.

We represent the general model as

$$A\ Y_t = B\ X_t + DU_t \tag{46}$$

with

$$A = A^* + A^{**} \tag{47}$$

$$B = B^* + B^{**} \tag{48}$$

where $Y_t$ represents the sector of endogenous variables, $X_t$ the matrix of predetermined variables, $U_t$ the sector of random disturbances, A, B and D the matrices of parameters, and

(*) and (**) are used to denote the constant matrices and random matrices of corresponding order.

Assume E (A**) = E (B**) = 0 and A** and B** independent of each other, and of $X_t$ and $U_t$. Then let A be of full rank and its inverse $A^{-1}$ exist with probability equal to 1.

Given that, Equation 46 may be represented as

$$Y_t = A^{-1} B X_t + A^{-1} D U_t \tag{49}$$

By substitution of Equations 47 and 48 into 49 and after simplification,

$$Y_t = \beta_t X_t + U^* \tag{50}$$

where

$$\beta_t = A^{-1} B$$

$$U^* = A^{-1} D$$

Since the expected values of A** are zero, and are independent of $X_t$, E (U*) would be equal to zero. Let $E\ (U^* U^{*T}) = \Sigma^*$, then Equation 50 may be estimated using Aitken's generalized least squares estimator:

$$\hat{\beta} = (X^T \Sigma^{*-1} X)^{-1} X^T \Sigma^{*-1} Y \tag{51}$$

The derivation of Equation 51 assumed that true coefficients were fixed and the observed β deviated from the fixed coefficients with mean zero and finite variance.

Obviously, the gain in efficiency using the nonfixed parameter assumption will rest on the characteristics of the deviation β** matrix. The smaller the random component of β, the smaller the efficiency gained in using this estimation method.

Since the Mexican model was estimated using O.L.S. or T.S.L.S. it would be interesting to check on the parameters' stability. To do so one could follow the Cooley-Prescott (1973) methodology.[1]

Specifically, let

$$A_{t+1} = A^*_t + a_t \qquad t=1,\ldots,T \qquad (52)$$

$$A^*_t = A^*_{t-1} + v_t \qquad t=1\ 1,\ldots,T \qquad (53)$$

$$B_{t+1} = B^*_t + b_t \qquad t=1\ 1,\ldots,T \qquad (54)$$

$$B^*_t = B^*_{t-1} + e_t \qquad t=1\ 1,\ldots,T \qquad (55)$$

where $a_t$, $v_t$, $b_t$, and $e_t$ are random disturbance vectors with mean zero, and spedifically with the following properties:

$$E(a_t) = E(v_t) = E(b_t) = E(e_t) = 0 \qquad (56)$$

$$\text{Cov } (a_t) = (1-\rho)\ \sigma^2\ \Sigma a \qquad (57)$$

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[1]The following discussion relies heavily on Cooley and Prescott (1973) and Mahajan (1975).

$$\mathrm{Cov}(v_t) = \rho\ \sigma^2\ \Sigma v \qquad (58)$$

$$\mathrm{Cov}(b_t) = (1-\gamma)\ \sigma^2\ \Sigma b \qquad (59)$$

$$\mathrm{Cov}(e_t) = \gamma\ \sigma^2\ \Sigma e \qquad (60)$$

where $\Sigma a$, $\Sigma v$, $\Sigma b$, $\Sigma e$ are such that one of its elements can be normalized to unity so that

$$\Sigma_i = \begin{bmatrix} 1 & & 0 \\ & \sigma_{22} & \\ 0 & & \\ & & \sigma_{kk} \end{bmatrix} \qquad (61)$$

Then by estimating the model by the Maximum Likelihood method one can find the value of $\gamma_o$ such that it maximizes the ML function,

$$L(\gamma_o) \geq L\ (\gamma i),\ \forall i \quad i=1,2,\ldots,n \qquad (62)$$

If the value found is close to unity, then the model should be estimated under Aitken's GLS, whereas if the value obtained is close to zero, the time invariant assumption is correct. After the model has been subject to the tests just described, one could accept its validity and the next step would be to check into its forecasting track.

Unfortunately, due to the business oriented scheme under which the Wharton-Diemex model is operated, it was impossible to obtain the elements required to perform the tests just described. Therefore, in what follows the model's adequacy to serve as the first segment of the firm's DSS will be justified only in terms of its predictive ability.

## The Model's Forecasting Ability

As stated at the start of this chapter, the model's builders provide a regular set of forecasts every six months. The regular information sent to its suscribers is presented in 11 tables, five of which are mere transformations to current peso estimates. Thus, one table contains the GDP definition in terms of aggregate demand, another contains the foreign sector, and the others provide information on prices and salaries, the financial sector, the public sector, and income distribution.

In terms of its forecasting ability, the model's usefulness is essentially short term. It includes a five-year forecast, but an examination of its percentage error indicates that the medium and long-range forecasts err in an 8 to 11 percent range for the medium term, and a 14 to 23 percent range for the long term.

As can be observed in Table 7, the average error for predictions with respect to the 1976 economic conditions ranges from 5.4 percent when these were made in 1975, to 28.46 percent for predictions made in 1970. Furthermore,

Table 7. A comparison of Diemex-Wharton Model 20 predicted values for variables in 1976

| Row | Prediction Symbol | Variable | 1[a] Jun 71 | 2 Jun 71 | 3 Apr 71 |
|---|---|---|---|---|---|
| 1 | GDPR | Gross Domestic Product | 213.90 | 204.46 | 200.77 |
| 2 | X1R | Primary Sector | 23.13 | 22.13 | 20.23 |
| 3 | X2R | Secondary Sector | 74.71 | 69.81 | 71.48 |
| 4 | X3R | Tertiary Sector | 116.05 | 112.52 | 109.06 |
| 5 | PGNP | Prices | 3.78 | 3.55 | 3.81 |
| 6 | BGSFR | Trade Balance | -3.71 | -2.04 | -2.82 |
| 7 | EGSFR | Exports | 18.37 | 19.29 | 19.20 |
| 8 | MGSFR | Imports | 22.08 | 21.33 | 22.02 |
| 9 | TFC | Government Income | 65.87 | 59.60 | 61.84 |
| 10 | TFIC | Income Tax | 32.60 | 29.66 | 28.45 |

| Row | Prediction Symbol | Variable | 11 Nov 74 | 12 Jan 75 | 13 Jan 75 |
|---|---|---|---|---|---|
| 1 | GDPR | Gross Domestic Product | 203.98 | 202.85 | 206.69 |
| 2 | X1R | Primary Sector | 18.66 | 18.52 | 18.51 |
| 3 | X2R | Secondary Sector | 70.48 | 69.98 | 71.78 |
| 4 | X3R | Tertiary Sector | 114.84 | 114.35 | 116.49 |
| 5 | PGNP | Prices | 6.14 | 6.12 | 6.27 |
| 6 | BGSFR | Trade Balance | -4.87 | -4.92 | -5.48 |
| 7 | EGSFR | Exports | 32.12 | 22.99 | 22.49 |
| 8 | MGSFR | Imports | 27.99 | 27.91 | 27.96 |
| 9 | TFC | Government Income | 119.41 | 118.56 | 122.77 |
| 10 | TFIC | Income Tax | 61.96 | 61.56 | 63.60 |

[a] Columns 1-20 contain forecasted values for the 1976 values of the variables. Actual values are reported in the last column. Column 1 lists predictions made 6 years in advance. Column 20 lists values predicted in July 1965. Repeated dates imply more than one forecast under diverse assumptions.

| 4<br>Nov 72 | 5<br>Nov 72 | 6<br>Sep 73 | 7<br>Nov 73 | 8<br>Dec 73 | 9<br>Apr 74 | 10<br>June 74 |
|---|---|---|---|---|---|---|
| 206.52 | 200.86 | 209.08 | 205.39 | 203.48 | 202.22 | 205.08 |
| 19.56 | 19.03 | 18.59 | 18.78 | 18.61 | 19.36 | 19.55 |
| 71.81 | 68.74 | 73.09 | 70.47 | 69.32 | 68.62 | 70.09 |
| 115.15 | 113.08 | 117.41 | 116.14 | 115.55 | 114.24 | 115.44 |
| 4.03 | 3.92 | 4.75 | 5.05 | 5.13 | 4.87 | 5.01 |
| -4.87 | -3.64 | -5.72 | -5.83 | -5.02 | -6.92 | -5.08 |
| 20.66 | 20.95 | 20.89 | 21.44 | 21.27 | 20.33 | 20.55 |
| 25.54 | 24.59 | 26.61 | 27.28 | 26.29 | 27.25 | 25.61 |
| 67.15 | 65.50 | 67.58 | 70.56 | 70.90 | 78.25 | 79.98 |
| 30.88 | 30.31 | 34.10 | 34.23 | 34.55 | 37.96 | 39.86 |

| 14<br>Jan 75 | 15<br>May 75 | 16<br>Jul 75 | 17<br>Jul 75 | 18<br>Dec 75 | 19<br>Mar 76 | 20<br>Jul 76 | Actual Values 1976 |
|---|---|---|---|---|---|---|---|
| 205.26 | 202.58 | 200.71 | 201.29 | 195.12 | 189.71 | 195.52 | 189.71 |
| 18.35 | 18.28 | 19.29 | 18.33 | 18.17 | 17.82 | 17.86 | 17.02 |
| 71.08 | 69.94 | 68.10 | 68.31 | 68.34 | 66.48 | 68.86 | 71.04 |
| 115.83 | 114.36 | 114.32 | 114.66 | 108.60 | 105.41 | 108.80 | 101.65 |
| 6.23 | 6.23 | 6.31 | 6.32 | 6.20 | 6.24 | 6.25 | 6.37 |
| -5.99 | -7.56 | -8.33 | -8.39 | -7.96 | -7.80 | -7.49 | -8.83 |
| 21.70 | 20.94 | 19.94 | 19.88 | 18.86 | 18.75 | 15.38 | 16.88 |
| 27.70 | 28.51 | 28.27 | 28.27 | 26.83 | 26.55 | 22.88 | 24.10 |
| 121.23 | 119.84 | 120.19 | 120.82 | 122.62 | 120.16 | 131.18 | 135.61 |
| 62.92 | 60.24 | 60.27 | 60.81 | 60.47 | 69.07 | 63.23 | 64.30 |

given a year and a half time lapse between the prediction time and the year predicted, the percentage error reached values of over 8.75 which can be considered high, and makes the predicted values for the medium and long term of little use for informational purposes in the firm's decision support system. One is left with the feeling that the model's forecasting ability is quite reliable for short-run predictions, but is generally unreliable for long-range forecasts due to its parameter instability.

## Summary

Rather than constituting a mere academic exercise, the construction of a macroeconometric model in developing nations should respond to specific applications. The model just described appeared as an answer to Mexican industry's desire to possess an analytical tool with which to predict changes in the macroeconomic environment. Unfortunately, use of the model has been to a large extent limited to comparing its predictions about the future state of the Mexican economy with the actual outcomes. Twice a year the results are released and discussed in a general meeting of sponsors and operators. These sessions serve a dual purpose; (1) obtaining a detailed explanation of the operators' assumptions for the simulation results, and (2) providing them with adequate feedback so as to attempt to have the most accurate environments fed into the model for the next forecast.

As long as this remains the only input for the firm, the use of the model is too limited, and it represents a waste of time and resources. Although the model's structural relations are basic to the predictions, they are seldom, if ever, discussed. The real usefulness of the model will not be achieved unless its private and public sponsors utilize the results for something more than sole ratification of their nonquantitative forecasts. What is needed is to establish the linkage that will channel the macroeconometric results to the firm's microeconometric level as one input in the supporting decision system in order to optimize its policy decision on pricing, investment, and production strategies. The next chapter is devoted to the construction of such a linkage system between the results of the Mexican macro-econometric model and the decision support system of one firm operating in the glass container industry of Mexico.

# CHAPTER 5. THE MICROECONOMETRIC MODEL OF MEXICO'S GLASS CONTAINER INDUSTRY

Accepting the Wharton-Diemex model as the first segment for the DSS of the FIC glass container company, this chapter is devoted to constructing a microeconomic demand model for the firm which will serve as the required link between the exogenous segment of the macroeconomic environment, and the endogenous segments. As the firm dominates the industry in such a complete fashion (as may be recalled from Chapter 1), by constructing the firm's marketing model, the industry's forecasting model will also be attained.

## Specification of the Model

Glass containers are demanded as an input by producers of consumer goods. Hence, their demand is essentially a derived demand. To define the connection between the macro-variables and the firm's products, it is therefore necessary to determine the relationships tying the macroenvironment, its impact on consumer's demand for final goods, and the resulting derived demand for glass containers. Figure 5 presents the model's flow of activities.

The diagram shows the three main blocks of the information system to be built:

a) Macroeconomic Forecasting

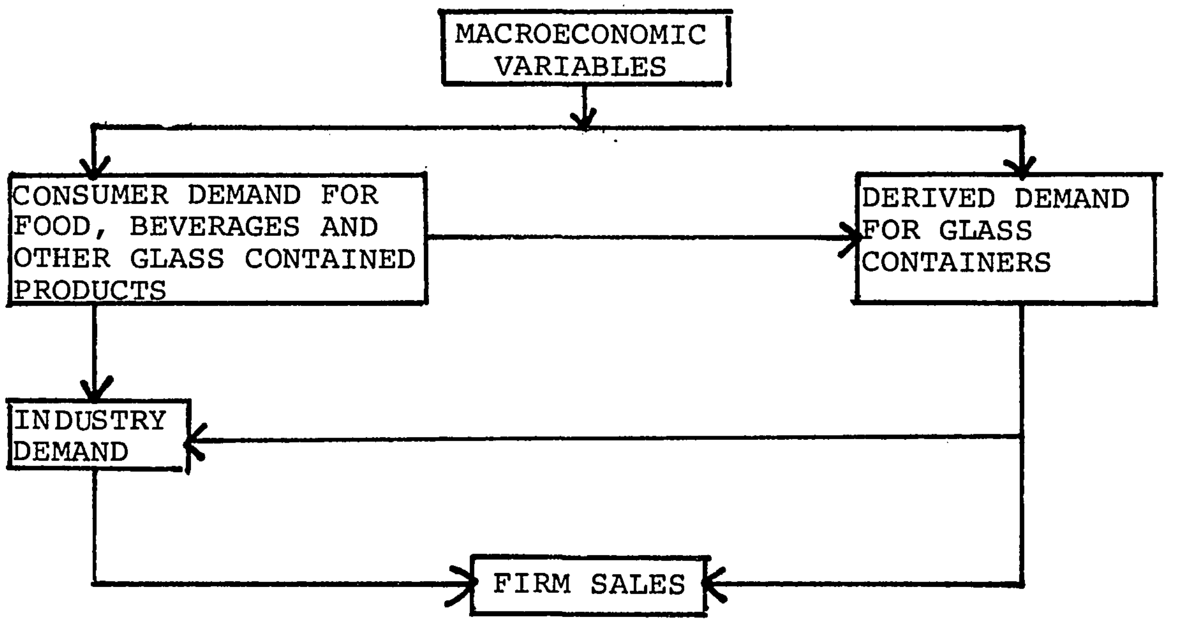


Figure 5. Model's flow

b) Consumer Demand Forecasts

c) Glass Container Demand

The macroeconometric model devised by Wharton-Diemex provides those variables--gross national product, general price index, personal disposable income, etc.--needed as primary inputs into the system.

The task to be performed is, therefore, to specify the relations defining the consumer demand for those goods utilizing glass containers and the derived demand for the firm's glass containers.

Figure 6 presents the subcomponent of the model referred

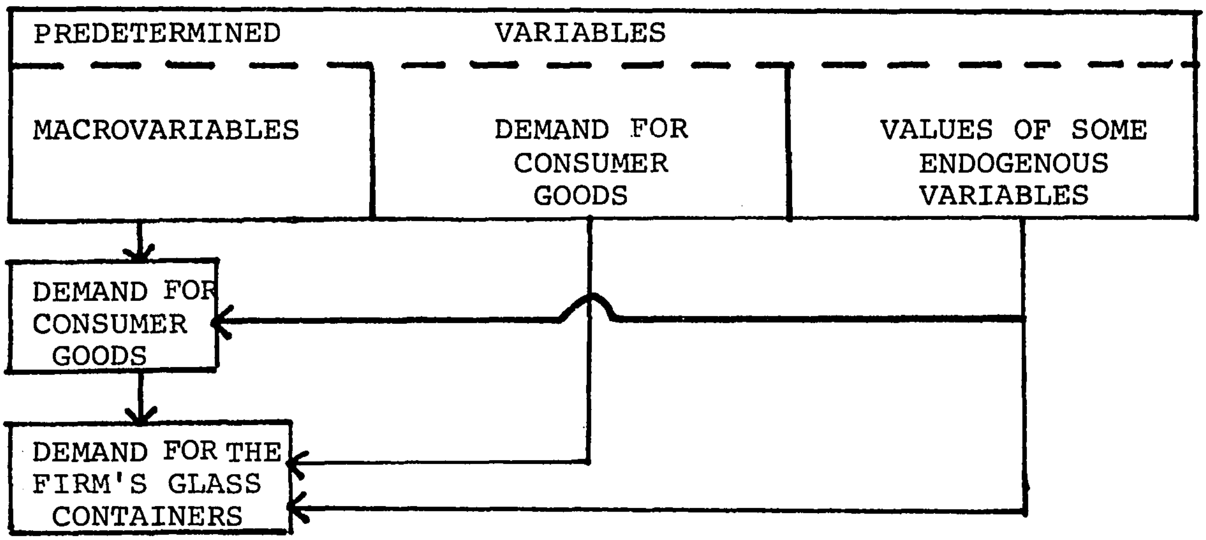


Figure 6. Model's estimation block structure

to as the estimation block. Broadly speaking, the lines of economic causality run as follows. First, those macroeconomic variables taken as exogenous to the model, along with other predetermined variables (i.e., consumer demand for the good in previous periods), serve to estimate the good's market demand. These estimated values, in turn, are taken as a new set of predetermined variables, which, in conjunction with some macroeconomic variables are used in the estimation of the firm's glass container products for the prediction of its sales. Given this process of causality, the estimation blocks can be considered as recursive in the model. Since the macroeconomic variables are exogenous to the system as a whole, the econometric estimation corresponds to a block recursive process.

Finally, the subcomponent of the models referred to as the block simulation routine is presented in Figure 7.

The simulation routine proceeds as follows: After a set of macrovariables is brought into the system, the solution of the demand for the consumer products block is generated. Once this has been done, the results are fed into the glass container's block along with the values of some macroeconomic variables, in this manner obtaining the requisite data to forecast the firm's sales of each product. Ideally, after finishing the process, the information would be fed into the firm's operational segments to forecast production, costs and financial results of any pricing, or merging policy defined by management.

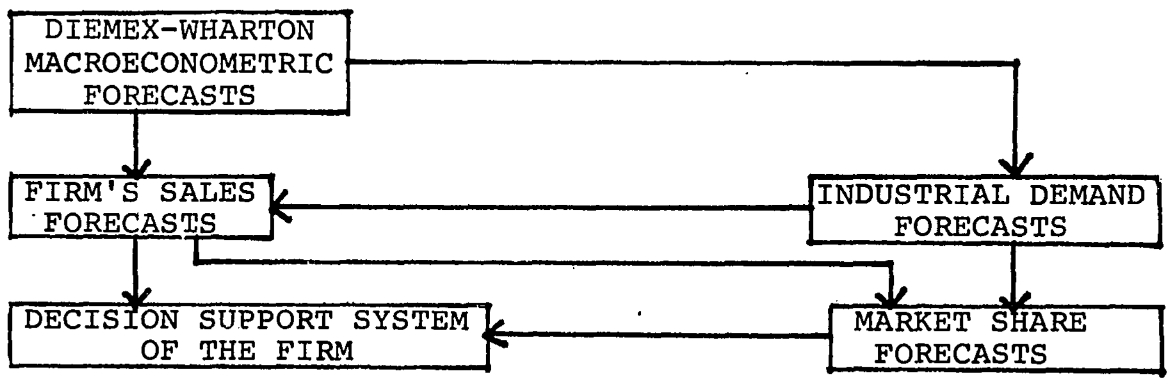


Figure 7. Model's simulation routine structure

Figure 7 allows one to follow the process when several time periods are to be forecast. Since the blocks are independent, the only remaining thing to do is to repeat the process after a solution of the initial period has been reached, for as many periods as one wishes to forecast.

## Discussion of the Equations

As depicted, the model consists of two equational blocks. The description of the equations for each block was defined according to the principal consumer products which use glass containers and according to the firm's production lines. Mexico's glass industry relies heavily on the construction, automobile, food and beverage, pharmaceutical, and industrial cleaning industries.

In 1976 sales of containers represented 55.5 percent of the total sales of the glass industry. To define an adequate market representation in the model, an analysis of the relative importance of each type of glass container was carried out. Tables 8 and 9 show that glass containers are sold primarily as bottles, flasks, tubes, and ampules. Bottles represent the principal component of total sales, and are used by the beer, soft-drink, wine, liquor, and cleaning product industries. In turn, flasks are employed as containers by the food and beauty products industries, and tubes and ampules are an input of the pharmaceutical industry. Given the relative importance of each specific type of glass

Table 8. Sales of Mexico's glass industry[a]-- 1972 - 1973 - 1974[b]

| Item | Volume | | | | | Value[c] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual | | | % Change | | Actual | | | % Change | |
| | 1972 | 1973 | 1974 | 1974/72 | 1974/73 | 1972 | 1973 | 1974 | 1974/72 | 1974/73 |
| FLAT GLASS | | | | | | | | | | |
| Total Value (000 Pesos) | | | | | | 403 | 562 | 553 | 37.2 | -1.6 |
| Sheet Glass (000 $M^2$) | 9256 | 13156 | 8876 | 6.7 | -24.9 | 140 | 209 | 182 | 30.0 | -12.9 |
| Float Glass (000 $M^2$) | 7821 | 10046 | 8501 | 8.7 | -15.4 | 205 | 270 | 270 | 31.7 | (-) |
| Automotive Glass (000 $M^2$) | 610 | 1100 | 950 | 55.7 | -13.6 | 27 | 58 | 54 | 100.0 | -6.9 |
| Cut Glass (000 $M^2$) | 1355 | 1206 | 1634 | 20.6 | 35.5 | 32 | 25 | 47 | 46.9 | 88.0 |
| Other (Mil. Pesos) | | | | | | -- | -- | | | |
| GLASS CONTAINERS | | | | | | | | | | |
| Total Value (M.Pesos) | | | | | | 1532 | 1739 | 1715 | 12.0 | -1.4 |
| Bottles (M.Pesos) | 1741 | 1883 | 2129 | 22.3 | 13.1 | 935 | 1055 | 1428 | 52.7 | 35.4 |
| Flasks (M.Pesos) | 107 | 129 | 154 | 43.9 | 19.4 | 48 | 64 | 94 | 95.8 | 46.9 |
| Ampules (M.Pesos) | 216 | 218 | 242 | 12.0 | 11.0 | 28 | 28 | 32 | 14.3 | 14.3 |
| Tubes (M.Pesos) | 36 | 55 | 18 | -50.0 | -59.1 | 14 | 18 | 3 | -79.6 | -83.3 |
| Crystal Ware (M.Pesos) | 396 | 436 | 49 | -87.6 | -88.8 | 460 | 521 | 41 | -91.1 | -92.1 |
| Other (M.Pesos) | | | | | | 47 | 53 | 117 | 148.9 | 120.8 |

[a]Source: General Statistics Bureau (1974-1978).

[b]Preliminar.

[c]Millones de pesos. (-) no data available.

Table 9. Glass production according to principal products for 1975 and 1976[a]

| | | Volume | | Value[b] | |
|---|---|---|---|---|---|
| | | 1975 | 1976 | 1975 | 1976 |
| Sheet Glass Production | | | | 64,105 | 72,279 |
| Sheet Glass | Millares de $m^2$ | 891 | 1,111 | | |
| | t. | 4,604 | 6,316 | 17,885 | 24,664 |
| Cut Glass | Millares de $m^2$ | 284 | 210 | | |
| | t. | 1,497 | 1,111 | 4,995 | 4,133 |
| Automobile Glass | Millares de $m^2$ | 109 | 112 | | |
| | t. | 545 | 560 | 6,459 | 7,608 |
| Float Glass | Millares de $m^2$ | 1,030 | 953 | | |
| | t. | 5,150 | 4,765 | 34,763 | 35,874 |
| Other | | | | 157 | 215 |
| Glass Containers Production | | | | 177,867 | 189,932 |
| Bottles | Millares de piezas | 182,122 | 175,746 | 147,718 | 158,493 |
| Flasks | " " | 14,610 | 13,256 | 9,783 | 11,563 |
| Tubes | " " | 930 | 978 | 207 | 215 |
| Ampules | " " | 21,413 | 16,538 | 3,418 | 2,890 |
| Crystal Ware | " " | 4,828 | 5,083 | 4,723 | 4,668 |
| Other | " " | | | 12,018 | 12,103 |
| Other Glass Ware | | | | | |
| Crystal Ware | Millares de piezas | 12,094 | 14,338 | 34,518 | 41,789 |
| Refractario | " " | 7,091 | 6,219 | 19,649 | 18,678 |
| Tubes | " " | 2,473 | 1,590 | 2,292 | 1,446 |
| Other | | | | 167 | -- |

[a]Source: General Statistics Bureau (1974-1978).

[b]In millions of pesos.

container, the marketing subcomponent of the model is defined by the following seven markets:

1) Beer demand
2) Soft-drinks demand
3) Wine and liquor demand
4) Food products demand
5) Pharmaceutical products demand
6) Industrial cleaning products demand
7) Beauty products demand.

On the other hand, the firm's sales block is defined by:

1) Sales of beer bottles
2) Sales of soft-drink bottles
3) Sales of wine and liquor bottles
4) Sales of food flasks
5) Sales of industrial cleaning containers
6) Sales of pharmaceutical containers
7) Sales of beauty products containers.

## Consumer's demand equations

This section contains the implicit equational specifications deemed adequate for the following products: beer, soft-drinks, wines and liquors, food products, pharmaceutical products, industrial products, and beauty products.

<u>The beer market equations</u>

$$COTN = COTNB + COTNH + COTNBA \quad (63)$$

$$COTNB = f(DIPRN, IPCERB, IPCERH, IPCERBA, \% POB) \quad (64)$$

$$COTNH = f(DIPRN, IPCERB, IPCERH, IPCERBA, \% POB) \quad (65)$$

$$COTNBA = f(DIPRN, IPCERB, IPCERH, IPCERBA) \quad (66)$$

where

COTN = Per capita demand of beer

COTNB = Per capita demand of beer in bottles

COTNH = Per capita demand of beer in cans

COTNBA = Per capita demand of beer in barrels

DIPRN = Personal disposable income

IPCERB = Average price of beer in bottles

IPCERH = Average price of beer in cans

IPCERBA = Average price of beer in barrels

% POB = Percentage of Mexico's population within the 18-35 age group.

The equations have as explanatory variables the traditional income, price and population variables. However, following talks with the beer industry people,[1] it was decided to include the population group

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[1]In particular with people of Cervecería Cuauhtémoc, S.A.

within the ages of 18 to 35 years, because it is argued they follow a new pattern of consumption away from beer in barrels, and more towards the new disposable containers. Thus, in Equations 64 and 65, % POB is included as an explanatory variable to take into account this new trend.

The soft drink market After a careful examination of brand participation in the market, it was concluded that besides Coca Cola and Pepsi Cola, only four other brands merited a specific estimation. These brands are: Squirt, Fanta, Seven Up and a national brand Refrescos Pascual. Together they represent 85-90 percent of yearly total sales.

Given that firms compete for the buyers' peso, it is assumed that the direction of causality between all firms is multidirectional and that quantities and prices are jointly determined. Yet, as particular prices are set by government as a uniform price, depending only upon bottle size, and since it was impossible to obtain information on per-size sales, it was decided to include as the price variable the average price of soft drinks registered in the market.

On the other hand, Coca Cola and Pepsi Cola spend large amounts of money in advertising campaigns. It would have been optimal to have this as another explanatory variable, but since it was not possible to obtain the necessary information, it was decided to include as a proxy for it the percentage of total population living in urban areas thought of as the more exposed to the firms' publicity.

Thus, the following equations define the market:

BOTN = CTL + PTLN + SAUTLN + FALN + PASLN + SPUN + RTN (67)

CTLN = (DIPRN, IPB, % PUB) (68)

PTLN = f(DIPRN, IPB, % PUB) (69)

SQUTLN = f(DIPRN, IPB) (70)

FALN = f(DIPRN, IPB) (71)

PASLN = f(DIPRN, IPB) (72)

SPUN = f(DIPRN, IPB) (73)

RTN = f(DIPRN, IPB) (74)

where

BOTN = Per capita volume of soft drinks demanded

CTLN = Per capita volume of Coca Cola demanded

PTLN = Per capita volume of Pepsi Cola demanded

SQUTLN = Per capita volume of Squirt demanded

FALN = Per capita volume of Fanta demanded

PASLN = Per capita volume of Pato Pascual demanded

SPUN = Per capita volume of Seven Up demanded

RTN = Per capita volume of rest of the soft drinks demanded

IPB = Average price of soft drinks in the market

% PUB = Percentage of urban population.

Relations 67 to 74 were defined to capture the relative participation of each soft drink label in the Mexican market.

All lesser brand names with regional coverage were included in a single equation estimated as a remainder (RTN).

Wine market Lack of detailed information posed a problem when defining the demand equation. In a recently published study, CAINTRA (Mexico's Industrial Association) specifies that this market is supplied by 68 firms, and that their supply corresponds to demand rather closely. The same source states that inflationary pressures and competition from beer represent the two main factors affecting the industry's demand (see CAINTRA's report, 1976, pp. 61-66).

Thus, given the lack of adequate information and what is suggested by CAINTRA's study, a single aggregated equation for the entire market is defined below.

$$VYLN = f(DIPRN, 12B, IPCER) \quad (75)$$

where

VYLN = Per capita volume demanded of wines and liquors

12B = Price index for 210 types of wine and liquor in the market

IPCER = Price index of beer.

Food market equations This market was the most troublesome to define because of the large number of products it holds. In its study CAINTRA (1976) mentions more than 100 different products in the market, and disaggregates the industry in seven groups.

In order to come out with a homogeneous disaggregation, CAINTRA's classification was discussed with people from FIC's marketing section. After carefully considering all products, a breakdown of the market into four categories, each with several products, was defined as follows:

1) Edible oils
2) Preserves and canned foods
3) Instant coffee
4) Baby foods.

Edible oils — The following equations were defined for the edible oils subsector.

$$TAN = AMCN + ACAU + ASOU + AJON \quad (76)$$

$$AMCN = f(DIPRN, PAM) \quad (77)$$

$$ACAN = f(DIPRN, PAC, \% PUB) \quad (78)$$

$$ASON = f(DIPRN, PAS, \% PUB) \quad (79)$$

$$AJON = f(DIPRN, PAJ) \quad (80)$$

where,

TAN = Per capita volume of edible oil consumed
AMCN = Per capita volume of mixed edible oil consumed
ACAN = Per capita volume of safflower oil consumed
ASON = Per capita volume of soy oil consumed
AJON = Per capita volume of sesame oil consumed
PAM = Average price of mixed oil in the market
PAC = Average price of safflower oil in the market
PAJ = Average price of sesame oil in the market
PAS = Average price of soy oil in the market

Mexico's edible oil market consists of mixed oil, safflower oil, soy oil and sesame oil. Of those, safflower oil and soy oil are practically all consumed in urban areas, whereas mixed oils by reason of their price are consumed by low income groups and in rural areas. Therefore, given Mexico's special characteristics, edible oils do not compete with each other in terms of price.

Equations 76 to 80 reflect this peculiar behavior. However, although relative price may not be a factor, producers of safflower oil and soy oil do advertise heavily. Again, to account for publicity effects over demand, a proxy variable, urban population (% PUB), was included in demand Equations 78 and 79.

Preserves and canned foods The market for canned foods is located in urban areas. The main products canned in Mexico are: soups, mole, mustard, marmalade, mayonnaise, and fruits and vegetables. These products do not compete with one another. Rather, given Mexico's marketing system where supermarkets compete against traditional "mercados", competition for canned products comes from their price differential against fresh products.

The equations proposed below follow this idea. The relative price differential, in terms of the general consumer price index, is taken as the relevant price variable along with income, and urban population.

Therefore, the following equations are defined:

TOPRN = COSN + MOLN + MOSN + MEFN + MAYN + FYLN (81)

COSN = f(DIPRN, PCO, % PUB) (82)

MOLN = f(DIPRN, PMOL) (83)

MOSN = f(DIBRN, PMOS, % PUB) (84)

MEFN = f(DIPRN, PME, % PUB) (85)

MAYN = f(DIPRN, PMAY, % PUB) (86)

FYLN = f(DIPRN, PA, % PUB) (87)

where,

COSN = Per capita volume of canned soups consumed

MOLN = Per capita volume of canned mole consumed

MOSN - Per capita volume of mustard consumed

MEFN - Per capita volume of marmalade consumed

MAYN = Per capita volume of mayonnaise consumed

FYLN = Per capita volume of canned fruit and vegetables consumed

PCO = Relative price of canned soups in the market

PMOL = Relative price of canned mole in the market

PMOS = Relative price of canned mustard in the market

PME = Relative price of marmalade in the market

PMAY = Price of mayonnaise in the market

PA = Price index for canned foods.

Instant coffee    This product has shown strong market variations in terms of price and quantity in recent years. It would have been desirable to explain this market by taking into account the behavior of different brands in order to capture the effects of changing tastes and attitudes. Unfortunately, lack of data makes this unfeasible, and a single equation had to be specified.

CSN = f(DIPRN, PCS)    (88)

where

CSN = Per capita consumption of instant coffee

PCS = Average price of instant coffee in the market.

Baby foods    One firm, Gerber, controls 80 percent of total sales in this market. Since only data on sales of this firm were available, they were assumed to be the sole relevant variable in determining this market demand. The rest of the total per capita demand was solved by use of a transformation. The equation for this market is:

PGN = f(DIPRN, PG, % PI)    (89)

where

PGN = Per capita consumption of Gerber products

PG = Average price of Gerber products in the market

% PI = Percentage of population within the 0-4 age bracket.

Finally, the following identity closes out the food market,

TALN = TAN + TOPRN + CSN + PGN (90)

The pharmaceutical market In this and the remaining markets it was not possible to obtain information on total sales. Therefore, since total production is included in the Banco de Mexico data on gross domestic product, those values are used as a proxy value for sales in each market. The equation for the pharmaceutical sector is,

VPFN = f(DIPRN, IPF) (91)

where

WPFN = Value of per capita production

IPF = Average price of pharmaceutical products.

Beauty products market The equation for this market is,

VPPN = f(DIPRN, IPP, % PUB) (92)

where

VPPN = Value of per capita production

IPF = Average price of beauty products in the market

The industrial market This market was divided into bleaching products and detergents. The following are the equations defined:

TPIN = DELN + BLLN (93)

DELN = f(DIPRN, PDL) (94)

BLLN = f(DIPRN, PBL) (95)

where

TPIN = Per capita volume of industrial products consumed

DELN = Per capita volume of liquid detergents consumed

BLLN = Per capita volume of liquid bleaches consumed

PDL = Average price of liquid detergents in the market

PBL = Average price of liquid bleaches in the market.

After having defined the consumer market demands for final products, it is appropriate to specify the derived demand relations for glass containers. Before doing so, it is important to note that the values used in the derived demand equations are given in total terms. This implies multiplying the values obtained in per capita terms by total population before proceeding to utilize the values in the derived demand equations. Hence, some additional identities are required:

$$COBQ = COTNB \times N \tag{96}$$

$$BOTQ = BOTN \times N \tag{97}$$

$$VYLQ = VYLN \times N \tag{98}$$

$$TALQ = TALN \times N \tag{99}$$

$$VPFQ = VPFN \times N \tag{100}$$

$$VPPQ = VPPN \times N \tag{101}$$

$$TPIQ = TPIN \times N \tag{102}$$

where each term ending in Q represents its counterpart in per capita terms but now transformed into total value; N represents total population.

Glass containers demand relations

This sector contains eight equations:

$$TDIVQ = DICEQ + DISOQ + DIVIQ + DIALQ + DIMEQ + DIINQ + DIPEQ \quad (103)$$

$$DICEQ = f(COBQ, IPLC, IPEH) \quad (104)$$

$$DISOQ = f(BOTQ, IPLS, IPEH) \quad (105)$$

$$DIVIQ = f(VYLQ, IPV) \quad (106)$$

$$DIALQ = f(TALQ, IPLA) \quad (107)$$

$$DIEMEQ = f(VPFQ, IPLM) \quad (108)$$

$$DIINQ = f(TPIQ, IPI) \quad (109)$$

$$DIPEQ = f(VPPQ, IPLP) \quad (110)$$

where

TVIVQ = Firm's total sales of glass containers

DICEQ = Firm's total sales of beer containers

DISOQ = Firm's total sales of soft drink containers

DIVIQ = Firm's total sales of wine and liquor containers

DIALQ = Firm's total sales of food containers

DIMEQ = Firm's total sales of pharmaceutical containers

DIINQ = Firm's total sales of industrial containers

DIEPEQ = Firm's total sales of beauty products containers

IPLC = Price index for beer glass containers

IPEH = Price index for tin containers

IPLS = Price index for soft drink glass containers

IPV = Price index for liquor and wine glass containers

IPLA = Price index for food glass containers

IPLM = Price index for pharmaceutical glass containers

IPI = Price index for industrial glass containers

IPLP = Price index for beauty products glass containers.

To estimate the firm's share of total industry production, a final equation was specified:

$$TII = f\ (GDP, IPEV) \tag{111}$$

where

TII = Glass container industry's total sales

GDP = Gross domestic product

IPEV = Price index for glass containers.

## Empirical Results

All equations were estimated using O.L.S. As stated before, the model is block recursive. Yet, values generated in the demand block are used as predetermined variables at the glass container block. As Bentzel and Hansen (1954) and Kmenta and Gilbert (1968) have shown this could possibly create correlation among errors, hence the need for another method of estimation.

Two reasons decided the use of O.L.S. First, given the small number of observations in the data set, use of a more sophisticated method of estimation might have yielded a not too different result, since in a small sample situation it is not possible to claim a priori that another method is superior to O.L.S. Second, the purpose of this work is to define a DSS segment usable by firms in developing nations to link the macroenvironment to the firm's strategic decision segment. Many firms in developing nations do not yet have the required software to handle sophisticated techniques, and it is hoped that by proving that simple techniques can be utilized in the construction and estimation of this segment, it will be possible to convince them to follow the path to construct similar models which will link any macroeconomic forecasting system to the production and financial systems that many actually do have in operation.

The data used were obtained from published sources such as the Revista de Estadística of the Commerce Department, the Annual Report of Banco de Mexico, and the Estadística Industrial Annual of the General Direction of Statistics of the Planning Department. Some, however, were obtained directly from the firm involved in this study, and in accordance with its wish the data bank is not included.

Two final comments deserve mention. First, there is considerable discussion as to whether personal disposable income or consumption expenditures should be used as the income variable when estimating demand relations. In this case the argument is academic. Data on personal consumption expenditures are not available in Mexico as in the United States. Further, personal disposable income is given by the macroeconomic forecasts of the Wharton-Diemex model, and since the main purpose of the construction of the microeconomic model is to provide a bridge between macroinformation and the firm's decision support system the choice is clear. Hence, personal disposable income was used as a proxy in most cases, with the average wage chosen in a few where, according to the results, it proved to be a better explanatory variable.

Second, following the work of Houthakker and Taylor (1966), demand analysis has recognized the need to specify dynamic relations to account for habit formation and stock influences. All equations estimated were tried in one form or another. Once more, pragmatic considerations on the usefulness of the forecasts dictated the choice of any one equation to conform the model for simulation purposes. However, the whole set of equations tried is given in the Appendix, thereby permitting a check for results of other specifications different to those chosen here for the simulation exercises.

## Equations Selected

The equations selected to conform the microeconometric simulation model are presented below. The $\bar{R}^2$ figure is adjusted for degrees of freedom. The numbers in parentheses below the coefficients give the estimated t value for the parameter. D.W. stands for the Durbin Watson statistic, and S.E. presents the standard deviation of the estimated errors in each equation. Finally, n indicates the number of observations in each equation.

### Equations of the beer market

Four equations determine this market:

$$COTN = COBN + COLN + CEBN \tag{112}$$

$$COBN = \underset{(1.3977)}{5.7369} + \underset{(4.7079)}{7.0451}\ DIPRN - \underset{(-3.758)}{6.839}\ IP/P \tag{113}$$

$\bar{R}^2 = 0.7275$ D.W. $= 0.9205$

S.E. $= 1.1365$ n $= 13$

$$COLN = \underset{(1.0127)}{3.2346} + \underset{(1.9158)}{0.4164}\ COLN_{-1} + \underset{(1.5203)}{0.8251}\ DIPRM - \underset{(-2.6986)}{1.5159}\ P/PG \tag{114}$$

$\bar{R}^2 = 0.892$ D.W. $= 1.4929$

S.E. $= 0.4626$ n $= 13$

$$\text{CEBN} = \underset{(2.525)}{0.844} + \underset{(0.516)}{0.0493}\ \text{DIPRN} - \underset{(-0.9731)}{0.0497}\ \text{IPB/P}$$

$$- \underset{(-2.302)}{0.0195}\ \text{TIME} \qquad (115)$$

$\bar{R}^2 = 0.784$ D.W. = 2.7607

S.E. = 0.0359 n = 13

where

COTN = Per capita consumption of beer

COBN = Per capita consumption of beer in bottles

COLN = Per capita consumption of canned beer

CEBN = Per capita consumption of beer in barrels

DIPRN = Personal disposable income in per capita terms

IP/P = Average price of beer in bottle in the market

IPB/P = Average price of beer in barrel in the market

TIME = A variable representing the passage of time.

It appears canned beer demand is influenced by previous consumption. The result is reasonable if one accepts that, in general, consumption of this type of beer is a luxury in Mexico, and is therefore subject to a habit relationship. Dynamic versions were tried for all relations, but they were rejected either because of low explanatory power or because of having the wrong signs in the parameters. All equations chosen are acceptable. They have adequate explanatory power and a reasonable economic foundation. The exception is Equation 113 which presents autocorrelation. Lack of adequate software and the fact that it is the only autocorrelated equation in the whole model determined its inclusion. Examination of the results leads one to conclude that consumption of beer in barrels is losing ground, whereas consumption of beer in bottles exhibits a strong negative price response. The most stable relation is consumption of beer in cans; this to be expected since its consumers are people at highest income levels in Mexico. In terms of the firm, these results have some interesting economic implications. Price stability and income increases are significant for the glass container industry, as they imply strong sales of bottled beer and therefore of glass containers. On the other hand, as prices increase, sales of glass containers will tend to decrease as a result of the lower expected consumption of bottled beer.

Soft-drink market equations

Seven equations define this market, as the equation for Pato Pascual never produced an adequate fit.

$$BOTN = CTLN + PTLN + SGUTLN + FALN + SPUN + RTN \tag{116}$$

$$\underset{}{CTLN} = \underset{(-2.5234)}{-103.9946} + \underset{(3.9854)}{38.4134}\ DIPRN - \underset{(-1.9843)}{11.2867}\ IPBE/P \tag{117}$$

$\bar{R}^2 = 0.6427$ D.W. $= 2.6719$

S.E. $= 4.6823$ $n = 10$

$$PTLN = \underset{(2.2641)}{48.825} + \underset{(0.295)}{1.2679}\ DIPRN - \underset{(-4.3513)}{12.271}\ PBE/P + \underset{(0.4834)}{0.0954}\ PTLN \qquad (118)$$

$\bar{R}^2 = 0.8519$ D.W. = 2.189

S.E. = 2.085 n = 10

$$FALN = \underset{(-4.5344)}{-28.7443} + \underset{(5.867)}{9.0167}\ DIPRN - \underset{(-1.3167)}{3.5886}\ IPBE/P \qquad (119)$$

$\bar{R}^2 = 0.8045$ D.W. = 2.52991

S.E. = 0.9593 n = 10

$$SPUN = \underset{(-1.969)}{-10.2693} + \underset{(1.9795)}{2.6019}\ DIPRN + \underset{(1.7205)}{0.1829}\ TIME \qquad (120)$$

$\bar{R}^2 = 0.8736$ D.W. = 2.6155

S.E. = 0.4338 n = 10

$$SQUTLN = \underset{(-2.654)}{-4.5788} - \underset{(-1.0452)}{0.7748}\ IPBE/P + \underset{(4.3499)}{1.8283}\ DIPRN \qquad (121)$$

$\bar{R}^2 = 0.681$ S.W. = 2.341

S.E. = 0.261 n = 10

$$RTN = \underset{(7.503)}{63.887} - \underset{(-3.5522)}{44.8616}\ IPBE/P + \underset{(3.78)}{6.542}\ TIME \qquad (122)$$

$\bar{R}^2 = 0.5773$ D.W. = 2.744

S.E. = 5.6317 n = 10

where,

BOTN = Total per capita sales of soft-drinks

CTLN = Per capita sales of Coca Cola

PTLN = Per capita sales of Pepsi Cola

FALN = Per capita sales of Fanta

SQUTLN = Per capita sales of Squirt

SPUN = Per capita sales of Seven Up

RTN = Per capita sales of other soft-drink brands in the market

IPBE/P = Average index price of soft-drinks in the market.

Most of the equations selected are static. Generally, the criterion of predictive power determined use of the equation. However, this was not the only criterion followed. The number of observations was so small that estimation of a dynamic equation à la Houthakker-Taylor left only four degress of freedom and produced rather unreliable results. The t values were also considered, and in some cases preference was given to the equation with the higher estimated t values, as in the case for the Seven Up equation. After estimation of a dynamic equation, the result was satisfactory in terms of predictive power; nevertheless, the sign of the lagged variable was not as expected and since the t value was not significant a decision was made to drop the equation and accept the static version.

Since no canned soft-drinks are produced in Mexico, the economic explanation provided by the set of equations permits determination of the increase in bottle consumption that will result from changes in the principal economic variables. The price term is significant at the 5 percent level in most equations (except the Fanta and Squirt ones). Even for these latter two, the coefficients are almost within one and one-half standard deviations, and were considered reasonably valid. The price effect is, in general, quite strong, and confirms the recent trend of developments in this market as inflation took hold in Mexico. Soft-drink prices have increased in a two-year cycle for the past six years. As prices increased in the first year, sales of soft-drinks slowed down or even decreased. However, in the following year once the market and price stabilized, the relative price decline (when evaluated with respect to the general price index increase) implied a strong recovery in sales. On the other hand, looking at the income term in most equations, it appears as if it is quite strong. Thus, it is once more concluded that sales of glass containers are strongly influenced by price and income fluctuations through their effect on soft-drink market demand.

Wine and liquor market

The following equations were estimated to conform this market:

$$VYLN = -1.3326 + 0.2605\ WRR \qquad (123.a)$$
$$(-8.1952)\ (10.9226)$$

$\bar{R}^2 = 0.951$ D.W. = 1.6419

S.E. = 0.039 n = 7

$$VYLN = -2.3765 + 0.5663\ DIPRN \qquad (123.b)$$
$$(-1.32625)\ (1.5716)$$

$\bar{R}^2 = 0.1968$ D.W. = 0.628

S.E. = 0.126 n = 7

$$VYLN = 0.1877 + 1.2532\ VYLN_{-1} - 0.449\ DIPRN \qquad (123.c)$$
$$(0.465)\ (11.678)$$

$\bar{R}^2 = 0.971$ D.W. = 2.3716

S.E. = 0.0238 n = 7

where the newly included variables are:

VYLN = Per capita consumption of wine and liquors

WRR = Per capita average worker's salary.

Equation 123.a was chosen in view of its high statistical significance and correct signs. Although several versions with a price term were run, none provided the correct expected sign, and in some cases inclusion of this variable changed the sign in other variables as can be seen in the following examples:

$$VYLN = -3.402 + 0.3647\ I\ 2/P + 0.6351\ DIPRN_{-1} \qquad (123.d)$$

$$VYLN = 0.1629 + 0.0066\ I\ 2/P - 0.419\ DIPRN + 1.2502\ VYLN_{-1} \quad (123.e)$$

where

I 2/P = Price index for 200 beverages.

These results are no doubt a consequence of the small number of observations and the lack of an adequate price variable. Since it was impossible to solve this problem, it was deemed preferable to drop the variable price altogether.

An interesting thing to notice is the fact that only when average salary was used as the income variable did any equation provide a correct result. If one looks at the consumers of this type of product, such a result is reasonable. Wine and liquor are bought primarily in urban areas and by middle income consumers. Thus, the variable can be thought of as a proxy variable for the income of the middle income population group, and it is logical that it was the only income variable producing correct results.

Food products market

Equations 124 to 128 define the edible oil subsector:

$$TAN = AMCN + ACAN + ASON + AJON \quad (124)$$

$$AMCN = -3.9428 + 0.2824\ AMCN_{-1} + 1.077\ DIPRN - 0.0187\ PAM/P \qquad (125)$$
$$\quad (-1.3256) \quad (0.838) \quad (1.5578) \quad (-0.0544)$$

$\bar{R}^2 = 0.573$     D.W. = 1.7816

S.E. = 0.4755     n = 13

$$ACAN = -1.4474 - 0.1517\ PAC/P + 0.5385\ WRR \qquad (126)$$
$$\quad (-1.8162) \quad (-1.3004) \quad (5.491)$$

$\bar{R}^2 = 0.7037$     D.W. = 1.8722

S.E. = 0.2524     n = 13

$$ASON = -1.5546 + 0.3126\ ASON_{-1} + 0.3564\ WRR - 0.0565\ PAS/P \qquad (127)$$
$$\quad (-2.0758) \quad (1.1973) \quad (2.7905) \quad (-0.6556)$$

$\bar{R}^2 = 0.8725$     D.W. = 1.8562

S.E. = 0.1415     n = 13

$$LAJON = -1.2207 - 0.0351\ PAJ/P + 0.684\ DJPRN - 0.1732\ TIME \qquad (128)$$
$$\quad (-0.9261) \quad (-0.305) \quad (1.9641) \quad (-4.3401)$$

$\bar{R}^2 = 0.8341$     D.W. = 1.3462

S.E. = 0.969     n = 13

Equations 129 to 135 represent the preserves and canned foods subsector of this market:

$$TOPRN = COSN + MOLN + MOSN + MEPN + MAYN + FLYN \qquad (129)$$

$$LCOSN = \underset{(-0.7328)}{-1.888} + \underset{(11.8897)}{3.3146}\ LDIPRN - \underset{(-2.9892)}{1.9867}\ LPCO/P \tag{130}$$

$\bar{R}^2 = 0.9316$ D.W. $= 0.9203$

S.E. $= 0.1289$ $n = 16$

$$MOLN = \underset{(-0.1527)}{-0.0008} + \underset{(1.715)}{0.626}\ MOLN_{-1} + \underset{(0.8137)}{0.0036}\ DIPRN + \underset{(0.4728)}{0.0008}\ DIPRN_{-1} \tag{131}$$

$\bar{R}^2 = 0.7979$ D.W. $= 2.0951$

S.E. $= 0.001$ $n = 16$

$$MOSN = \underset{(5.781)}{0.0076} + \underset{(10.375)}{0.8775}\ MOSN_{-1} + 0.003\ DIPRN - \underset{(-4.7119)}{0.0009}\ PMOS/P \tag{132}$$

$\bar{R}^2 = 0.890$ D.W. $= 2.1465$

S.E. $= 0.0005$ $n = 16$

$$LMEFN = \underset{(-7.7829)}{-7.5433} + \underset{(0.2459)}{0.0052}\ TIME + \underset{(3.5181)}{2.729}\ LDIPRN \tag{133}$$

$\bar{R}^2 = 0.912$ D.W. $= 1.4255$

S.E. $= 0.116$ $n = 16$

$$MAYN = \underset{(-1.6634)}{-0.1383} + \underset{(0.8837)}{0.2854}\ MAYN_{-1} + \underset{(1.9454)}{0.0523}\ DIPRN + \underset{(0.8464)}{0.038}\ \Delta DIPRN \tag{134}$$

$\bar{R}^2 = 0.893 \qquad D.W. = 2.0243$

$S.E. = 0.1448 \qquad n = 16$

$$LFYLN = \underset{(-0.3569)}{-0.5809} + \underset{(1.0297)}{1.1176}\ DIPRN - \underset{(0.5376}{0.283}\ LPFY2/P + \underset{(0.7542)}{0.2998}\ FLYN_{-1} \qquad (135)$$

$\bar{R}^2 = 0.670 \qquad D.W. = 2.01$

$S.E. = 0.1044 \qquad n = 13$

Finally, the food products market sector is completed with Equations 136 and 137 for instant coffee and baby products:

$$ESN = \underset{(0.7816)}{0.1108} - \underset{(-3.362)}{0.0023}\ PCS/P + \underset{(1.0935)}{0.0303}\ DIPRN + \underset{(0.4904)}{0.1134}\ CSN_{-1} \qquad (136)$$

$\bar{R}^2 = 0.738 \qquad D.W. = 1.686$

$S.E. = 0.0185 \qquad n = 13$

$$PGN = \underset{(0.1024)}{0.2127} + \underset{(1.1037)}{0.2736}\ PGN_{-1} + \underset{(0.9853)}{0.3469}\ DIPRN - \underset{(-2.0431)}{5.5886}\ PG/P \qquad (137)$$

$\bar{R}^2 = 0.9125 \qquad D.W. = 2.330$

$S.E. = 0.1304 \qquad n = 10$

with the following closing identity and variables definition:

$$TALN = TAN + TOPRN + CSN + PGN \quad (138)$$

where:

TALAN = Total per capita food products consumed

TAN = Total per capita edible oils consumed

TOPRN = Total per capita preserves and canned foods consumed

CSN = Total per capita instant coffee consumed

PGN = Total per capita Gerber baby food products consumed

AMCN = Per capita mixed oils consumed

PAM/P = Average price of mixed oils in the market

ACAN = Per capita consumption of safflower oil

PAC/P = Average price of safflower oil

ASON = Per capita consumption of soybean soil

PAS/P = Average price of soybean oil in the market

LAJON = Logarithm of per capita consumption of sesame oil

LPAJ/P = Logarithm of the average price of sesame oil in the market

COSN = Per capita consumption of canned soups

MOLN = Per capita consumption of canned mole

MOSN = Per capita consumption of mustard

MEFN = Per capita consumption of marmalade

MAYN = Per capita consumption of mayonnaise

FYLN = Per capita consumption of canned fruit and vegetables

LCOSN = Logarithm of per capita consumption of canned soups

LDIPRN = Logarithm of per capita disposable income

LPCO/P = Logarithm of the average price of canned soups in the market

PMOS/P = Average price of mustard

LMEFN = Logarithm of per capita consumption of marmalade

LEYLN = Logarithm of per capita consumption of canned fruits and vegetables

PCS/P = Average price of instant coffee

PG/P = Average price of Gerger baby food products.

In choosing the equations for this market, the idea that food consumption of packed food displays a strong dependence on consumer habits played a relevant role. As a consequence, this market has a considerable number of dynamic relations (eight out of twelve selected equations). On the other hand, since the purpose of the whole estimation is to use the forecasts in the projection of the demand for glass containers, relative prices of products were not included. Rather, deflated product prices were used in the estimation. This simplified the estimation process and reduced the risk of collinearity in the equations estimated in each subsector.

Some equations deserve further comment. Equations 126 and 127 contain the average wage as the income explanatory variable. Taking into account what this represents once again makes sense. These equations explain the demand for soy and safflower edible oil, and these are nontraditional products in the Mexican cuisine which appeal to specific consumers. Thus, WRR is taken once more as a proxy variable for the income of urban and more sophisticated consumers. Equations 130, 133 and 135 are in logarithmic form. Linear specifications proved unsuccessful and forced the choice of this specification. Two examples are given below for the marmalade and fruit and vegetable products:

$$\underset{(-7.2841)}{MEFN = 0.079} + \underset{(10.8276)}{0.207\ DIPRN} + \underset{(2.9239)}{0.0026\ PMEFN/P}$$

$$\bar{R}^2 = 0.483 \qquad D.W. = 0.870 \tag{133}$$

$$FYLN = \underset{(0.6179)}{1.4824} + \underset{(0.5685)}{0.1875\ DIPRN} - \underset{(0.593)}{0.238\ PFYLN/P}$$

$$+ \underset{(1.425)}{0.516\ FYLN_{-1}} \tag{134}$$

$$\bar{R}^2 = 0.518 \qquad D.W. = 0.418$$

In the first case, the price term displays the wrong sign, and this is further complicated by a high estimated t value. In the second equation none of the parameters is significant, and the equation has a lower explanatory power than the logarithmic one selected.

The results for the price terms are interesting. In almost all cases they are small (practically irrelevant) indicating that in this market the inflationary pressures occurring in Mexico today should not have a strong effect.

The model's consumer demand block is completed with the following three estimated equations and ten identities.

The pharmaceutical market

$$\underset{}{VPFN} = \underset{(-1.5019)}{-0.0472} + \underset{(4.6740)}{0.0192}\ DIPRN - \underset{(-0.0317)}{0.0006}\ IPF/P \qquad (139)$$

$\bar{R}^2 = 0.9334$ D.W. $= 1.052$

S.E. $= 0.00283$ n $= 16$

where

VPFN = Per capita value of pharmaceutical products

IPF/P = Price index of pharmaceutical sector.

The beauty product market

$$VPPN = \underset{(1.1696)}{0.0095} + \underset{(10.5719)}{0.5912}\ VPPN_{-1} + \underset{(2.999)}{0.003}\ DIPRN - \underset{(-2.8562)}{0.0512}\ IPP/P \qquad (140)$$

$\bar{R}^2 = 0.9952$ D.W. $= 3.2146$

S.E. $= 0.00045$ n $= 16$

where

VPPN = Per capita value of beauty products

IPP/P = Price index of the beauty products sector.

<u>The industrial products market</u>

$$\underset{}{VPJN} = \underset{(-1.9795)}{-0.003} + \underset{(2.1185)}{0.0013}\ DIPRN + \underset{(5.8552)}{0.7851}\ VPJN_{-1} \qquad (141)$$

$\bar{R}^2 = 0.9658$ D.W. $= 2.4753$

S.E. $= 0.0005$ $n = 16$

where

VPJN = Per capita value of the industrial products sector.

It is interesting to observe how strong the phenomenon of consumer habit appears to be in Equation 140. It is obvious that people who care about their appearance tend to maintain a stable consumption of this kind of product. On the other hand, the equation for industrial cleaning products (Equation 141) is also quite significant with a high habit formation term. No price variable was used, as its inclusion produced the poor results in Equation 141.a below.

$$VPJN = \underset{(-4.67)}{-0.016} + \underset{(10.7489)}{0.0054}\ DIPRN + \underset{(2.291)}{0.0036}\ PVTJN/P \qquad (141.a)$$

The additional identities required to transform the results of this block into values suitable for estimation of the sales block are given in Equations 142 to 151.

(31) COBQ = COBN x N (142)

(32) BOTQ = BOTN x N (143)

(33) VYLQ = VYLN x N (144)

(34) TAQ = TAN x N (145)

(35) TOPRQ = TOPRN x N (146)

(36) CSQ = CSN x N (147)

(37) PGQ = PGN x N (148)

(38) VPFQ = VPFN x N (149)

(39) VPPQ = VPPN x N (150)

(40) VPJQ = VPJN x N (151)

where N stands for total population.

Glass containers demand equations

As previously stated, the demand for glass containers is a derived demand. In fact, sales of the firm's glass containers are so specific that its production lines are separated to match each one of the market products defined above. Hence, the relations estimated in the sales block correspond to such a division, and are presented in Equations 152 to 161.

$$DICEQ = \underset{(0.8489)}{140.72} - \underset{(0.7883)}{517.98}\ IPLC/IPEM - 22.9164\ TIME$$

$$+ \underset{(1.2805)}{0.2416}\ DICEQ_{-1} + \underset{(3.6186)}{0.2129}\ COBQ \qquad (152)$$

$\bar{R}^2$ = 0.664 D.W. = 2.91

S.E. - 16.3405 n = 10

$$DISOQ = \underset{(0.4179)}{114.2668} - \underset{(-0.8161)}{786.95}\ IPLS/P + \underset{(3.1626)}{0.0267}\ BOTQ$$

$$+ \underset{(0.2632)}{0.1063}\ DISQ_{-1} \qquad (153)$$

$$\bar{R}^2 = 0.8604 \qquad D.W. = 2.5059$$

$$S.E. = 28.05375 \qquad n = 10$$

$$DIVIQ = \underset{(2.617)}{125.4994} + \underset{(8.8093)}{1.6126}\ VYLQ - \underset{(-0.494)}{31.516}\ IPV/P \qquad (154)$$

$$\bar{R}^2 = 0.9277 \qquad D.W. = 2.91$$

$$S.E. = 4.0793 \qquad n = 10$$

$$DACEQ = \underset{(1.0226)}{25.1687} - \underset{(-2.3175)}{64.9622}\ IP/P + \underset{(4.9799)}{0.2605}\ TAQ \qquad (155)$$

$$\bar{R}^2 = 0.8205 \qquad D.W. = 2.2208$$

$$S.E. = 8.5079 \qquad n = 10$$

$$DOCQ = \underset{(-0.3889)}{-68.3526} + \underset{(2.1984)}{1.1361}\ TOPRQ - \underset{(-0.7915)}{401.4719}\ IP/P \qquad (156)$$

$$\bar{R}^2 = 0.6954 \qquad D.W. = 2.605$$

$$S.E. = 19.9626 \qquad n = 10$$

$$DCSQ = \underset{(-0.1224)}{6.8277} + \underset{(1.2901)}{0.2336}\ DCSQ_{-1} - \underset{(-0.7524)}{179.372}\ IP/P$$

$$+ \underset{(3.3524)}{11.4136}\ CSQ \qquad (157)$$

$$\bar{R}^2 = 0.9053 \qquad D.W. = 2.07153$$

$$S.E. = 7.2885 \qquad n = 10$$

$$DIPEQ = \underset{(4.8487)}{63.405} - \underset{(-1.8078)}{26.2304}\ IPLP/P + \underset{(5.2103)}{27.734}\ VPPQ \tag{158}$$

$\bar{R}^2 = 0.7821$ D.W. $= 1.8142$

S.E. $= 4.7478$ $n = 10$

$$DIMEQ = \underset{(1.2988)}{345.60} + \underset{(0.323)}{31.812}\ VPFQ - \underset{(-1.176)}{6166.9}\ (IPLM/P)$$

$$- 0.949\ DIMEQ_{-1} + \underset{(-1.259)}{53.643}\ TIME \tag{159}$$

$\bar{R}^2 = 0.880$ D.W. $= 1.999$

S.E. $= 26.612$ $n = 10$

$$DIIQ = \underset{(1.3578)}{8.9046} + \underset{(0.2993)}{4.9926}\ VPJQ + \underset{(2.6269)}{0.6975}\ DIINQ_{-1} \tag{160}$$

$\bar{R}^2 = 0.7371$ D.W. $= 2.1209$

S.E. $= 3.3316$ $n = 10$

$$TDIVQ = DICEQ + DISOQ + DIVIQ + DACEQ + DOCQ + DCSQ + DIEPEQ + DIMEQ + DIIQ \tag{161}$$

where

DIECEQ = Firm's sales of beer containers

IPLC/IPEN = Relative price index between glass and tin containers

DISOQ = Firm's sales of soft-drink containers

IPLS/P = Price index of soft-drink glass containers

DIVIQ = Firm's sales of wine and liquor containers

IPV/P = Price index of wine and liquor glass containers

DACEQ = Firm's sales of edible oil glass containers

IP/P = Relative price index between glass and plastic edible oil containers

DOCQ = Firm's sales of canned soup and preserves glass containers

DCSQ = Firm's sales of instant coffee glass containers

DIPEQ = Firm's sales of beauty product glass containers

IPLP/P = Relative price index between glass and plastic containers for beauty products

DIMEQ = Firm's sales of pharmaceutical glass containers

IPLM/P = Price index of pharmaceutical glass containers.

Three aspects were instrumental in deciding what equations to choose for this block: the predictive power of the equation, the signs of its coefficients, and its dynamic properties.

Any equation that had these three properties was preferred over others which might be considered superior in one aspect alone; e.g., higher predictive power but the wrong sign. The reason for considering these as the relevant criteria is based upon the desire to link the model to the firm's decision support system and upon the belief that stock considerations play a pertinent role in this inflationary period of Mexico's history.

In general, the coefficients of the market demand variables are robust, implying that market conditions in those markets strongly influence the resulting demand for glass containers. This result was expected beforehand, since glass containers demand is a derived demand. There is little the firm can do about this; its vulnerability will increase if prices of other containers, such as plastic containers, do not increase as rapidly as its own prices. To account for this, all the equations of those glass containers subject to competition from plastic have as the price variable the relative price of glass containers over plastic containers. Examination of the results illustrates that, as the price differential diminishes, sales are strongly affected. The obvious recommendation is that the firm try to keep the differential as high as possible to expand or maintain its container market share. In fact, with the exception of soft-drinks, wine and liquors, and industrial cleaning products, the firm has to pay attention to this differential if it does not want to be displaced from the rest of its markets by plastic containers.

Perhaps the most unusual result was the one obtained in the estimated coefficient of the stock variables, as represented by the lagged value of sales. The sign is positive in almost all equations. This result is explainable after looking at the historical period used for estimation. The 1967-1976 period contains some of the most inflationary years in Mexican history. After the initial inflation shock, expenditures by Mexico's public authorities coupled with international inflation acted as a guarantee of further and stronger rates of inflation in Mexico. Any rational firm buying glass containers must have tended to augment inventories, action indicated in the positive value of the lagged term. Thought of it as a permanent condition for the future is not possible as Mexico's economic conditions are rapidly improving in terms of inflation control. In fact, one is inclined to predict that as Mexico's economic situation stabilizes, the variable will tend to acquire its expected sign.

## Simulation of the Model

The test of any model is not only how well it performs for individual equations, but also how it functions as a complete system in predictive and simulation tests. The preceding sections of this chapter have been concerned with the specification and estimation of the set of relations describing glass container sales for a private firm in Mexico. This section, using Equations 112 to 161, applies them to simulate the endogenous variables of the two blocks for the period 1972 to 1976. Such an exercise generates the evaluation of the model's predictive ability and permits the derivation of a forecasting exercise to provide information for the firm's decision support system in the period 1978-1981.

The computer printout for the simulation of this model over the period 1972 to 1976 is presented in the Appendix. The computational package of the University of Pennsylvania which uses a modified Siedel's iterative procedure,[1] was employed and the simulation was performed on an IBM 370/158 machine installed at the Instituto Technologico de Monterrey. Table 10 presents the results for the principal endogenous variables in the two blocks together with their respective Theil (1966) value used to evaluate the model's predictive power. Theil's coefficient is a summary forecast error measure defined as the square root of the ratio of the sum of squared forecast errors to the sum of squared actual changes.

$$U = \sqrt{\frac{\sum_{t=1}^{m} (e_t + n)^2}{\sum_{t=1}^{m} (A_t + \bar{n} A_t)^2}}$$

where

e = Forecast error

A = Actual value of variable

m = Number of forecasts of horizon n

n = Forecast horizon

t = Period in which forecast is made.

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[1]The name of the program utilized is SIMUL, and was developed at Wharton's Economic Unit.

Table 10. Results for the principal endogenous variables[a]

| Variable | 1972 | | 1973 | | 1974 | |
|---|---|---|---|---|---|---|
| | P[b] | A | P | A | P | A |
| COBN | 25.39 | 26.125 | 28.22 | 28.348 | 29.11 | 30.61 |
| BOTN | 201.93 | 207.11 | 231.25 | 223.34 | 227.34 | 208.84 |
| VYLN | 0.34 | 0.35 | 0.45 | 0.44 | 0.52 | 0.47 |
| TAN | 4.34 | 5.08 | 4.99 | 4.70 | 4.91 | 5.35 |
| TOPRN | 8.40 | 8.20 | 8.13 | 7.97 | 8.07 | 8.70 |
| CSN | 0.12 | 0.11 | 0.14 | 0.14 | 0.15 | 0.14 |
| PGN | 1.13 | 1.23 | 1.38 | 1.49 | 1.60 | 1.42 |
| VPFN | 0.047 | 0.051 | 0.050 | 0.054 | 0.052 | 0.054 |
| VPPN | 0.027 | 0.027 | 0.029 | 0.029 | 0.030 | 0.029 |
| VPJN | 0.013 | 0.014 | 0.014 | 0.014 | 0.015 | 0.015 |
| DICEQ | 136.03 | 108.2 | 164.25 | 156.10 | 200.94 | 214.60 |
| DISOQ | 330.12 | 307.7 | 370.43 | 333.4 | 379.25 | 403.0 |
| DIVIQ | 134.93 | 134.0 | 142.91 | 144.4 | 147.48 | 143.0 |
| DACEQ | 47.45 | 38.21 | 45.93 | 63.57 | 66.66 | 66.70 |
| DOCQ | 115.55 | 87.80 | 112.55 | 118.91 | 135.40 | 139.0 |
| DCSQ | 42.22 | 47.51 | 59.95 | 56.17 | 72.86 | 66.7 |
| DIPEQ | 80.23 | 79.70 | 83.94 | 85.10 | 94.16 | 95.1 |
| DIMEQ | 371.2 | 390.7 | 388.21 | 411.5 | 423.1 | 402.6 |
| DIIQ | 40.52 | 38.4 | 39.4 | 39.0 | 40.14 | 45.2 |
| TDNQ | 1298.25 | 1232.32 | 1407.57 | 1408.15 | 1560.19 | 1575.9 |

[a]The table contains only those values used in the simulation of the firm's sales.

[b]Values in millions.

| 1975 | | 1976 | | Theil Coefficient |
|---|---|---|---|---|
| P | A | P | A | |
| 28.04 | 29.07 | 27.27 | 26.95 | .0142 |
| 218.73 | 242.77 | 196.88 | 191.87 | .0282 |
| 0.55 | 0.55 | 0.63 | 0.67 | .0289 |
| 5.51 | 4.74 | 5.87 | 5.70 | .0523 |
| 8.48 | 8.49 | 8.33 | 8.69 | .0021 |
| 0.14 | 0.12 | 0.16 | 0.16 | .0394 |
| 1.57 | 1.62 | 1.61 | 1.62 | .0361 |
| 0.049 | 0.049 | 0.048 | 0.044 | .0323 |
| 0.029 | 0.029 | 0.029 | 0.029 | .0174 |
| 0.015 | 0.016 | 0.016 | 0.016 | .0213 |
| 183.91 | 167.4 | 167.93 | 182.8 | .0510 |
| 444.36 | 463.5 | 398.38 | 412.9 | .0317 |
| 155.95 | 159.3 | 168.66 | 167.8 | .0118 |
| 61.71 | 61.0 | 75.11 | 78.0 | .0730 |
| 110.41 | 100.3 | 168.12 | 188.8 | .0627 |
| 61.65 | 59.8 | 94.51 | 97.85 | .0321 |
| 94.93 | 95.9 | 94.23 | 92.6 | .0062 |
| 416.5 | 381.0 | 452.6 | 473.1 | .0298 |
| 44.87 | 38.3 | 40.38 | 41.1 | .0471 |
| 1574.29 | 1526.5 | 1659.92 | 1734.95 | .0166 |

The Theil coefficient has the following significant characteristics. First, it is based on squared errors. Large errors are penalized out of proportion to their size. Second, it is a relative measure being free of measurement problems and ranging from zero when the forecast is right on target, to one in the opposite case. Finally, it can be decomposed to show the importance of various sources of forecast error such as bias (see Epps, 1975, for an excellent explanation of this decomposition).

Taken as a whole, the solutions derived from the 1972-1976 period are fairly accurate. Not once does the model err in a single direction in its predictive solutions, leading one to believe in its lack of bias. The Theil coefficients are rather small, with the largest one corresponding to prediction of edible oil sales, having a value of only .07 (which implies a quite acceptable accuracy). Still, caution is in order when forecasting outside the sample period. The model's accuracy corresponds to data where particular conditions have prevailed in the Mexican economy, and care must be exercised in trying to adapt the model to changing conditions. In particular, the positive stock effect obtained when estimating the sales equations is correct as long as present economic conditions prevail.

A first recommendation, therefore, is to reestimate this model as new data become available, assuming that the firm wants to maintain it in operational form for its decision support system. Also to be observed from the estimation exercise is that the market demand block generally has higher prediction ratings than the sales block. At any rate, the last period results are quite close to actual values, indicating that the model tends to closely simulate present reality; it thereby provides confidence in the short-run predictions of any forecasting exercise. Moreover, given the small sample situation, it is to be expected that if a larger number of observations were available the results would be improved, for it appears that the model's structure is very acceptable.

## A Forecasting Exercise

Given the forecast values of the macroeconomic variables and after having confirmed the model's predictive ability, the discussion turns to using the model with forecasting purposes for the firm. Aggregate economic variables such as personal disposable income, the implicit price deflator, average wage earnings, and population increases are obtained from the Wharton-Diemex 1977-1981 forecast produced in October of 1977. These values are contained in the Appendix along with the values of all simulation exercises in a computer printout.

Three forecasting exercises were carried out to analyze sales under diverse economic conditions and/or firm pricing policies. The first simulation is the control solution which serves as a reference point for comparative purposes, since it is made under what are thought to be normal economic conditions and a static pricing policy for the firm. This control solution takes the Wharton-Diemex control solution results as the expected values of the forecasting period.

The firm's pricing policy is then analyzed under the assumption that in 1978 all glass container prices will rise by 24.9 percent. Thereafter, it is postulated that the firm will maintain annual price increases to match the expected rate of inflation. The second simulation exercise maintains the same general economic conditions given in the Wharton-Diemex control solution, but examines a pricing policy in which the firm raises glass container prices by a constant 5 percent over and above inflation rates between 1979 and 1981.

The last simulation analyzes the probable impact of a new ad valorem tax recently suggested by the Mexican government on the beer and soft-drink industries. This simulation follows the same pricing policy established in the control solution, but increases the prices of beer and soft-drinks by 5 percentage points over the expected rate of inflation for the 1978 to 1981 period. A condensed report for some of the product markets and all of the firm's sales is presented in Tables 11, 12 and 13, and will serve to analyze the model's predictions for each of the simulation exercises mentioned before.

The control solution foresees as a result of the firm's pricing policy, an increase in total glass container sales of 8.12 percent for 1978. For the years 1979-1981, when the firm increases its prices at the same rate as the inflation rate, total sales continue to increase at an annual average rate of around 5 percent. The implication for the firm of this result depends, of course, upon the realization of the model's expected results. In turn, these are based on the assumption that in the coming years the government will pursue a stabilization policy based upon reduced public expenditure increases and a strong emphasis on price controls. Through April of 1978 this policy has been maintained by the Mexican government, and there existed a strong feeling that it would be continued at least for the following two years. Thus, price stability and moderate income growth are the basis for the model's forecasted 5 percent rise in annual firm's sales.

With regard to specific glass container sales, the following remarks may be made. Soft-drink and food containers respond in a very stable fashion, with annual rates of increase of between 4 and 12 percent. The model makes it possible to affirm that in the short and medium range both

Table 11. Control solution

| Variable | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|
| BOTN | | | | | |
| % Change | 5.34 | 7.39 | 8.95 | 8.04 | 9.8 |
| COBN | | | | | |
| % Change | 2.34 | 3.60 | 5.27 | 4.74 | 6.7 |
| VYLN | | | | | |
| % Change | -15.22 | 12.83 | 18.23 | 15.75 | 20.2 |
| VPPN | | | | | |
| % Change | 0.87 | 2.06 | 3.48 | 4.06 | 5.28 |
| VPFN | | | | | |
| % Change | 6.9 | 4.2 | 6.9 | 5.8 | 8.9 |
| VPJN | | | | | |
| % Change | 1.7 | 2.2 | 3.2 | 3.7 | 4.8 |
| DISOQ | 449.98 | 478.66 | 512.17 | 545.52 | 588.32 |
| % Change | 16.4 | 6.4 | 7.0 | 6.5 | 7.8 |
| DICEQ | 189.93 | 185.9 | 186.3 | 185.2 | 194.3 |
| % Change | 28.06 | 0.5 | 0.2 | -0.5 | 4.9 |
| DIVIQ | 184.09 | 191.14 | 201.72 | 212.98 | 229.75 |
| % Change | 11.63 | 3.83 | 5.54 | 5.58 | 7.87 |
| DALQ | 448.42 | 509.80 | 544.90 | 573.53 | 647.04 |
| % Change | 0.0 | 4.38 | 6.89 | 5.25 | 12.82 |
| DIPEQ | 94.37 | 96.07 | 97.75 | 99.78 | 102.52 |
| % Change | 3.0 | 0.73 | 1.75 | 2.07 | 2.75 |
| DIMEQ | 426.01 | 518.5 | 490.77 | 576.34 | 558.05 |
| % Change | -9.9 | 21.7 | -5.35 | 17.44 | -3.18 |
| DIIQ | 41.75 | 42.32 | 42.86 | 43.43 | 44.09 |
| % Change | 1.59 | 1.35 | 1.30 | 1.33 | 1.50 |
| TONQ | 1870.55 | 2022.38 | 2076.44 | 2236.82 | 2364.05 |
| % Change | 0.56 | 8.12 | 2.67 | 7.72 | 5.69 |

products will be the basis for the firm's stable rises in total sales. Unexpectedly, sales of glass containers for the beer industry show low and even negative rates of increase. Examination of the time series for this variable produces an explanation for the model's prediction. After high rates of increase in sales for the years 1973 and 1974 (45.36 and 40.21 percent, respectively), sales of bottles decreased by 24.43 percent and 3.35 percent in the years 1975 and 1976. This cyclical pattern makes it difficult for the model to capture the real sales trend, thereby generating a prediction for a low rate of sales growth of this container. On the other hand, the model forecasts a stabilizing increase in consumer demand for beer, and it is therefore possible to infer that this will bring about a more stabilized demand for glass containers bound in the 2 to 4 percent per year range.

Forecasts for the edible oil market are very reassuring. Annual increases of 6.32 percent in 1978 to 16 percent in 1981 are forecast for sales of this kind of containers. Such a result has implications for the firm's sales and production policies. It makes this market a very attractive one, and attention should be paid to meeting this expected demand for containers. Finally, one type of container whose forecasts do not appear to coincide with the product market demand forecast is that for containers of pharmaceutical goods. Even though the model predicts a very stable increase in the market demand for pharmaceutical goods (ranging from a 4.21 percent increase in 1978 to an 8.95 percent increase in 1981), forecasted sales of glass containers demonstrate cyclical behavior, with too large an increase for 1978 (21.7 percent), and a decrease of 3.2 percent in 1981. It seems reasonable to assume that the model needs to be disaggregated in this particular market in order to solve this apparent inconsistency of its predictions.

It can be concluded that, in general, the totality of the model's control solution forecasts are reasonable (with the exceptions already mentioned), and that its usefulness is very acceptable for the firm's evaluation of any pricing policy and production policy to be undertaken in the next four years.

## Alternative Simulations

Table 12 permits the analysis of "what if" questions under a different pricing policy defined for the 1979-1981 period. When compared to the results obtained under the control solution, the first thing that is noticed is the stability of the values found. The price increase established under the new pricing policy changes total sales by a very small amount, reflecting the feeling that the model does possess strong stability in regard to the prices of

Table 12. Simulation 5% in containers

| Variable | 1979 | 1980 | 1981 |
|---|---|---|---|
| DISOQ | 508.6 | 539.27 | 579.34 |
| % Change | 6.26 | 6.03 | 7.43 |
| A with control solution | -0.79 | -1.14 | -1.02 |
| DICEQ | 183.64 | 180.3 | 187.03 |
| % Change | -1.22 | -2.7 | 3.73 |
| A W.C.S. | -1.4 | -2.7 | -3.80 |
| DIVIQ | 201.72 | 211.90 | 227.94 |
| % Change | 5.54 | 5.05 | 7.57 |
| A W.C.S. | 0.0 | -0.53 | -0.79 |
| DALQ | 539.70 | 564.90 | 634.51 |
| % Change | 5.87 | 4.67 | 12.32 |
| A W.C.S. | -1.00 | -1.52 | -1.97 |
| DIPEQ | 97.09 | 98.68 | 100.97 |
| % Change | 1.05 | 1.64 | 2.32 |
| A W.C.S. | -0.88 | -1.11 | -1.53 |
| DIMEQ | 467.84 | 560.40 | 519.96 |
| % Change | -9.77 | 19.79 | -7.22 |
| A W.C.S. | -4.90 | -2.8 | -7.00 |
| DIIQ | 42.86 | 43.43 | 44.09 |
| % Change | 1.30 | 1.33 | 1.50 |
| A W.C.S. | 0.0 | 0.0 | 0.0 |
| TONQ | 2041.4 | 2198.8 | 2293.9 |
| % Change | 0.94 | 7.71 | 4.32 |
| A W.C.S. | -1.73 | -17.3 | -3.06 |

glass containers. Analysis of specific changes in sales for each glass container type should permit the firm to define a sales and production policy which will allow it to maximize its revenues. Thus, results for each of the firm's principal glass containers are analyzed below.

<u>Soft-drink containers</u>

Price increases have the effect of increasing sales of this kind of container by only 0.79 percent in 1979, 1.14 percent in 1980, and 1.02 percent in 1981. The implications are clear for the firm. This represents a very strong market with a highly inelastic price demand capable of absorbing an increase in prices large enough to cover high cost increases (equal to the forecast inflation rate, in addition to an extra 5 percent) to increment total revenues.

<u>Beer containers</u>

The price increase affects this product in a stronger fashion. Sales decreased 1.14 percent in 1979, 2.7 percent in 1980, and 3.8 percent in 1981. Therefore, this market has a stronger long-run impact than does the soft-drink market. On the other hand, the short-run response is small, indicating an inelastic short-run demand which over time (as substitution to other containers results), becomes more elastic. Yet, the reduction is not too bad, for sales do in fact increase from one year to the next, thus allowing the firm to increase its total sales.

### Wine and liquor containers

As expected, this is a remarkably strong market for the firm. As long as no other type of container is demanded by this industry, the response to price increases of glass containers will continue to be weak and the firm will be able to pass on increased costs and/or larger profit margins to the producer of wine and liquors.

### Food containers

Changes in sales are quite similar to those found in the soft-drink market. Percentage decrease vary from 1 percent for the 1979 projection to 2 percent for the 1981 prediction. Again, as the price differential between glass, aluminum, and plastic containers remains high, a 5 percent increase in glass container prices does not appear to make much difference, and the firm does have the possibility of increasing its profits through price increases that are higher than the expected increase in costs.

### Pharmaceutical containers

This is the only case where a moderate elasticity appears in the simulation. The difference between the control solution results and this simulation ranges from a 5 percent decrease in sales for 1979 to a 7.22 decrease for

1981. The market is, therefore, a difficult one for the firm to increase its price. The firm will have to weigh the loss of sales against the gain in revenues, and consequently it would probably be adequate policy to maintain price increases of this container at the same rate of increase as that of expected inflation.

## Conclusion

In general, comparison of the two solutions would lead one to define a production and pricing policy moving away from the pharmaceutical sector toward control of the other glass container types. Of course, no policy can be defined here, for the lack of analysis at the operational segments of the firm's DSS avoids any decision. Unfortunately, such information was not provided, and it was impossible to work out an overall policy analysis.

## Second alternative simulations

The second simulation analyzes the impact that the new ad valorem tax on beer and soft-drinks might produce on the firm's sales of glass containers via its effect on reducing market sales of the two products. After interviewing executives in these two industries, it was judged that the final impact on consumer prices would stay within a range of 5 to 10 percent. For the simulation it was decided to take the lower limit as the final price increase. Table 13 presents

Table 13. Simulation--impact of ad valorem tax in soft-drink beer

| Variable | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|
| DISOQ | 468.47 | 500.40 | 533.20 | 575.57 |
| % Change | 4.10 | 6.81 | 6.55 | 7.95 |
| A with control solution | -2.25 | -2.35 | -2.31 | -2.21 |
| DICEQ | 176.18 | 172.84 | 170.11 | 178.16 |
| % Change | -4.73 | -1.89 | -1.58 | 4.73 |
| A W.C.S. | -5.51 | -7.78 | -8.87 | -9.05 |
| TPNQ | 2002.47 | 2051.24 | 2209.37 | 2335.17 |
| % Change | 7.05 | 2.44 | 7.71 | 5.69 |
| A W.C.S. | -1.07 | -1.22 | -1.24 | -1.23 |

the results of this simulation in terms of the sales of the two glass containers. When compared to those results obtained in the control solution, the meaning of derived demand for a product is better understood. Sales of soft-drink containers, which behaved very stable under the increase in price just analyzed, fall in this case by an average annual rate of 2.25 percent. The effect on beer containers is even stronger. Sales declined 5.51 percent for 1978, and reached a peak decline of 9 percent in 1981 in relation to their control values counterpart. It is interesting that the derived effect of a price increase on the final consumer good influences the firm's sales more than its own actions.

Factors affecting the consumer markets upon which the firm has little if any control are bound to affect its pricing and production policy in a stronger fashion than would be desirable. In fact, one is tempted to recommend a price reduction in glass containers in order to reduce the expected impact of a sales decline resulting from the tax imposition. However, given the previously noted price inelasticities, this kind of policy may lead only to further revenue losses for the firm, and is not therefore recommended. Since Mexico's public authorities are bound to continue regulating and interfering in consumer markets, unless inflation is controlled, the sales of the firm's glass containers will be influenced not only by its own policies, but also by events in those final goods industries that utilize glass containers.

# CHAPTER 6. CONCLUSIONS

"Management's function is to coordinate and interrelate the activities of the various functional areas and optimize the objectives of the total organization" (Burch et al., 1974, p. 10).

Although a great deal of information about the various aspects of any firm's activities is made available to top management, it is becoming increasingly difficult and expensive for managers to keep abreast of them and to analyze the impact of many events upon those activities. This problem has led many corporations to develop more comprehensive and sophisticated methods of analyzing its environment in order to better evaluate opportunities and appraise different strategic decisions.

Yet, firms from developed countries have realized that it is no longer feasible to base their policy formulation and decision making on independent analyses of individual units of the corporation. They now recognize a growing need to analyze in a simultaneous fashion, and as a single system, all strategic decisions which affect and are affected by interrelated economic and political events.

On the other hand, in developing countries, it is difficult for the top management of a firm with interrelated subsystems to coordinate in an efficient and optimum manner, the activities and opportunities of any portion of the firm. Recently, management science has helped to build in an easier way planning models. As a result, corporate planning models have appeared to evaluate alternative policies, to provide financial projections, to facilitate long-term planning to make decisions, and to facilitate short-term planning.[1]

Still, as Naylor's (1975, p. 3) study indicates, few firms with less than $100 million dollars of sales do operate any decision support system, and very few firms in developing nations have established any type of decision support models for strategic decision evaluation, as the result of lack of an adequate data base, or a failure to have adequate computer facilities. Yet, current trends in computer hardware, corporate modeling software, and telecommunications equipment make the building of decision support systems for small firms an easy task, if an adequate conception of the system can be provided.

To this end, this study has provided the framework needed for strong public intervention in the economic via direct regulation and direct partitipation in production and distribution activities, business firms face an even stronger need to have operational models to help them explore the

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[1]For an excellent description on how these models are used in many corporations see Naylor (1975, p. 4).

implications of strategic and environmental assumptions of the public sector. Furthermore, in general, firms in developing countries operate in an oligopolistic structure, and in an economic environment where inputs are scarce.

For these firms, the inability to plan ahead and be aware of what might happen as the result of any strategic decision, could diminish its odds of performing successfully, and could drive them to a situation that, if continued, would exclude them from the market they operate in. Post-war business planning has undergone two distinct phases. At the beginning, the approach was essentially an extension of long-range budgeting and sales forecasting, where last and present performance was simply extrapolated into the future on the basis of simple statistical techniques. Today a more active outlook is being performed in corporate planning. The systems approach philosophy is now the manner in which large corporations' management views the need to transform simple electronic data processing systems into a complete decision support system for firms in developing nations.

A DSS consisting of a macroeconomic segment, a strategic decision segment, an operational decision segment and an objective function was advanced for firms in developing nations, and the reasons to include those segments in the system are clear. First, a comprehensive view of planning in a decisional framework such as that in a developing nation requires that the organization extend its attention beyond the boundaries of those things which are immediately controllable to encompass the environmental aspects which only influence the organization. Hence, a system defining the firm as a subsystem of a larger system is a necessity if one is to perform comprehensive planning.

Second, since strategic decisions usually encompass such divergent activities as futurism and policy evaluation, a segment which in a logical way forecasts and evaluates the interrelations between the firm's policies and its market evolution is required.

Third, the operational decision segment is required if one desires to have a view of planning which extends deeply into the environment of the organization to optimize its own activities. Finally, since the systems view can simulate different alternatives, the decision support system must contain an objective function if specific choices are to be made by management.

In developing nations a few firms have developed financial or production models to help management in decision making. Thus, it was the objective of this work to appraise and develop the required models for the first two segments of the recommended DSS.

Econometric modeling was chosen as the ideal technique given its provision of explicit quantitative assessments, as well as for its forecasting and simulation properties. In order to perform a real test, a private firm on the Mexican glass industry was chosen to build its industry's microeconometric model and link it to Wharton-Diemex macroeconometric model of the Mexican economy.

Although certain peculiarities of the Wharton model did not permit an adequate evaluation of its stability conditions, it was decided to use it as the model to represent the macroenvironment under which the firm exists because it is the only "open access" model in Mexico.

After an examination of the marketing relations faced by the firm, a firm-industry model was built for the company. The model used for simulation was presented, and several applications to test different firm's pricing policies, and a government tax surcharge were made to simulate and forecast the firm's relative situations.

Simulation of the model over the sample period to obtain an indication of the fit and of its forecasting ability was performed for the 1972-1976 period. Simulation results show satisfactory U Theil's values, and gave no indication of a consistent pattern on errors. Almost all variables are well-predicted and the model as a whole appears acceptable for forecasting purposes.

An initial forecast was made for the 1977-1981 period under expected assumptions for the macroeconomic variables, and the firm's pricing policy. This forecast, named the control solution, served as the benchmark against which results for three simulations under different pricing or tax assumptions were compared. The results show that the firm has a great vulnerability to outside events indicating a high dependence on its macroenvironment. On the other hand, the results also suggest that the firm's products are quite price inelastic and therefore, that in pricing its products, the firm has a big margin to maximize its income.

Although it was not possible to perform a complete test on the proposed DSS, it was possible to test the benefits derived to the firm from building a microeconometric demand model in terms of its decision-making process. It serves to indicate that with proper operational segments, the firm could count with a complete DSS to evaluate long- and short-term policies and improve its performance in the glass container industry.

## Further Extensions

The model proposed appears to be an adequate possibility for DSS in firms operating in developing nations. Yet, the mechanism is not totally defined and is subject to improvements at the strategic decision segments, as well as at the operational decision segments. Ideally, a complete system should be able to reach a complete overall optimization process. Thus, mathematical programming models should be built to optimize production, and financial models are needed to evaluate the firm's financial and profit conditions after a strategic decision on pricing, investment or merger is proposed.

Hopefully, one can say that this work has served to show the applicability of econometric models in DSS of the firm, and to show that even for nations with many problems in terms of data or computer facilities, there exists the possibility of doing some part of a complete DSS and using it to evaluate strategic decisions of the firm.

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I am also thankful to my parents who taught me to always finish what is started in life, and never be discouraged by events.

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# APPENDIX: THE WHARTON-DIEMEX VERSION V OF THE MEXICAN MACROECONOMETRIC MODEL

## 1. GENERATION OF AGGREGATE DEMAND

### Generation of Doemstic Demand

**Private and consumption per capita**

$$CPRN = \underset{(2.337)}{0.104888} + \underset{(3.6918)}{0.39560}\ DIPRN + \underset{(32.0987)}{0.34350}\ \underline{DIPRN1} + \underset{(1.0605)}{0.11960}\ \underline{DIPRN2} \qquad (1)$$

$$\sum_{i=0}^{2} w(i) = 0.8587$$

$R^2 = 0.9877$  SE = 0.0215  DW = 2.0793  $F(2,13) = 603.3416$

**Public Consumption**

$$CFR = \underset{(-4.817)}{-0.68719} + \underset{(32.961)}{0.60410}\ TR \qquad (2)$$

$R^2 = 0.9837$  SE = 0.2247  DW = 1.2862  $F(1,17) = 1086.4641$

**Private gross, fixed investment**

$$IPR = \underset{(3.111)}{1.37663} - \underset{(-2.702)}{0.76030}\ DUMPO + \underset{(2.521)}{0.05611}\ \underline{KPR1} + \underset{(2.3973)}{0.18120}\ DGDPR + \underset{(5.2569)}{0.34350}\ \underline{DGDPR1} + \underset{(4.6544)}{0.33410}\ \underline{DGDPR2} \qquad (3)$$

$$\sum_{i=0}^{2} w(i) = 0.8588$$

$R^2 = 0.9552$  SE = 0.4816  DW = 2.0697  $F(4,11) = 80.9639$

Public gross, fixed investment

$$IGR = \underset{(-0.405)}{-0.16872} + \underset{(3.310)}{0.83383}\ DDBGR + \underset{(4.907)}{0.40620}\ TRDGR + \underset{(2.636)}{0.20362}\ FBGFR \quad (4)$$

$F^2 = 0.9765$ SE = 0.3603 DW = 2.1081 F(3,15) - 250.3858

Investment of federal government organizations and enterprises

$$IGOER = \underset{(3.004)}{0.62296} + \underset{(10.581)}{0.32234}\ \underline{FBGR1} + \underset{(5.6944)}{1.35670}\ DDBGR$$

$$+ \underset{(2.1109)}{0.5008}\ \underline{DDBGR1} \quad (5)$$

$$\sum_{i=0}^{1} w(i) = 1.8575$$

$R^2 = 0.9185$ SE = 0.3766 DW = 1.2617 F(3,12) - 57.3715

Inventory changes

$$ICHR = \underset{(1.889)}{0.31206} + \underset{(2.061)}{2.5922}\ DPGNP + \underset{(2.5810)}{0.05210}\ DGDPR + \underset{(6.1489)}{0.07080}\ \underline{DGDPR1}$$

$$+ \underset{(4.3152)}{0.06330}\ \underline{DGDPR2} + \underset{(1.6367)}{0.03730}\ \underline{DGDPR3} \quad (6)$$

$$\sum_{i=0}^{3} w(i) = 0.2235$$

$R^2 = 0.8515$ DE = 0.1610 DW = 2.0251 F(3,12) = 29.6755

Private consumption

$$CPR = CPRN \times N \quad (7)$$

Consumption

$$CR = CPR + CGR \quad (8)$$

Gross, fixed investment

IR = IPR + IGR (9)

Investment: Gross fixed plus inventory changes

ITR = IR + ICHR (10)

Public investment net of federal organizations and enterprises investment

IGGR. = IGR - IGOER. (11)

Domestic aggregate demand

CITR = CR + ITR (12)

Generation of Foreign Demand

(Exports)

Exports of cotton

ECOTR = 1.74205 - 3.41745 COCOT2 + 0.52469 PROCOT1 (13)
(8.999) (-5.489) (3.683)

$R^2$ = 0.6156 SE = 0.1944 DW = 1.7479 F(2,16) = 15,4124

Relative price of Mexican to Brazilian coffee

PCFMB = PCOFM / PCOFB (14)

Exports of coffee

ECOFR = 0.64692 + 0.77732 ECOFR1 - 0.44755 PCFMB (15)
(1.883) (5.044)

$R^2$ = 0.5741 SE = 0.1076 DW = 2.3463 F(2,16) = 13.1329

<u>Relative price of Mexican to Philippines sugar</u>

$$PSGMP = \underline{PSUGM} \,/\, \underline{PSUGPH} \qquad (16)$$

<u>Exports of sugar</u>

$$ESUGR = \underset{(-1.087)}{-0.13087} + \underset{(2.831)}{0.44480}\ \underline{IPUSF} + \underset{(4.814)}{0.20956}\ \underline{DUMCU}$$

$$- \underset{(-1.872)}{0.27291}\ PSGMP \qquad (17)$$

$R^2 = 0.9311$ SE = 0.0441 DW = 2.6200 $F(3,15) = 82.1127$

<u>Exports of nonferrous metals; lead, copper and zinc</u>

$$EMETR = \underset{(0.351)}{0.27415} - \underset{(-8.258)}{0.56093}\ \underline{DUMRS} + \underset{(1.083)}{1.57891}\ \underline{PRMET}$$

$$- \underset{(-0.221)}{0.20054}\ \underline{COMET} \qquad (18)$$

$R^2 = 0.8974$ SE = 0.1062 DW = 2.4087 $F(3,15) = 53.4719$

<u>Exports of lead</u>

$$ELEAR = \underset{(-0.888)}{-0.19166} - \underset{(-4.113)}{0.16455}\ \underline{DUMRS} + 3.03442\ \underline{PRLEA}$$

$$- \underset{(-1.000)}{0.61904}\ \underline{COLEA} \qquad (19)$$

$R^2 = 0.9228$ SE = 0.04596 DW = 1.6541 $F(3,15) = 72.7337$

<u>Consumption of copper in the period of U.S. restrictions</u>

$$COCDU = \underline{COCOP} \times \underline{DUMRS} \qquad (20)$$

<u>Production of copper in the period of U.S. restrictions</u>

$$PRODUC = \underline{PRCOP} \times \underline{DUMRS} \qquad (21)$$

Exports of copper

$$ECOPR = \underset{(2.297)}{1.13451} - \underset{(-2.106)}{1.09724}\ \underline{DUMRS} - \underset{(-2.306)}{16.04651}\ \underline{PRCOP} + 19.8862$$

$$+ \underset{(2.627)}{19.88620}\ PRCDU + \underset{(1.717)}{7.69851}\ \underline{COCOP} - \underset{(-2.552)}{11.75707}\ \underline{COCDU} \qquad (22)$$

$R^2 = 0.9088$ SE = 0.04806 DW = 2.1233 F(5,13) - 36.8633

Exports of manufactured goods

$$EGMFR = \underset{(-6.711)}{-1.17954} + \underset{(9.114)}{0.00052}\ GNPUR \qquad (23)$$

$R^2 = 0.8201$ SE = 0.10685 DW = 0.6438 F(1,17) = 83.0712

Tourism and border exports

$$ETBR = \underset{(-5.071)}{-2.39964} + \underset{(1.947)}{0.02245}\ \underline{RDPAV} + \underset{(7.854)}{0.75075}\ \underline{DUMDV}$$

$$+ \underset{(7.039)}{0.00238}\ DIUR \qquad (24)$$

$R^2 = 0.9594$ SE = 0.1888 DW = 2.5961 F(3,15) = 142.8593

Exports of labor per worker

$$EBRRL = \underset{(8.407)}{0.09415} - \underset{(-3.551)}{0.01248}\ DUMBR - \underset{(-2.947)}{0.07318}\ \underline{WRMMUC}$$

$$- \underset{(-3.322)}{0.01846}\ X1RL \qquad (25)$$

$R^2 = 0.9152$ SE = 0.0038 DW = 1.8624 F(3,15) = 65.7711

Production of cold and silver

$$EAAR = (\underline{EAADC} \times REX) / PGNP \qquad (26)$$

### Exports of zinc

$$\mathrm{EZINR} = \mathrm{EMETR} - \mathrm{ELEAR} - \mathrm{ECOPR} \qquad (27)$$

### Exports of agricultural goods

$$\mathrm{EAGR} = \mathrm{ECOTR} + \mathrm{ESUGR} + \mathrm{ECOFR} \qquad (28)$$

### Exports of goods explained by the model

$$\mathrm{EGER} = \mathrm{EAGR} + \mathrm{EMETR} + \mathrm{EGMFR} \qquad (29)$$

### Exports of other goods

$$\mathrm{EOGR} = ((\underline{\mathrm{EGDC}} \times \underline{\mathrm{REX}}) \,/\, \mathrm{PGNP}) - \mathrm{EGER} \qquad (30)$$

### Exports of goods

$$\mathrm{EGR} = \mathrm{EGER} + \mathrm{EOGR} \qquad (31)$$

$$\mathrm{EGC} = \mathrm{EGR} \times \mathrm{PGNP} \qquad (32)$$

### Exports of labor: Bracero earnings

$$\mathrm{EBRR} = \mathrm{EBRRL} \times \mathrm{L1} \qquad (33)$$

### Other exports in trade account

$$\mathrm{EOTR} = (\underline{\mathrm{EOTDC}} \times \underline{\mathrm{REX}})\ \mathrm{PGNP} \qquad (34)$$

### U.S. gross national product

$$\mathrm{GNPUR} = (\mathrm{GNPUDC} \times \mathrm{REX}) \,/\, \mathrm{PGNP} \qquad (35)$$

### U.S. disposable personal income

$$\mathrm{DIUR} = (\underline{\mathrm{DIUDC}} \times \underline{\mathrm{REX}}) \,/\, \mathrm{PGNP} \qquad (36)$$

Total trade export-: Goods, services and factors

$$EGSFR^* = EGR + EBRR + EAAR + EOTR + ETBR \qquad (37)$$

(Imports)

Imports of consumer goods

$$\begin{aligned} MCONR = {} & \underset{(1.295)}{0.23921} + \underset{(2.222)}{0.00426}\ CR + \underset{(2.4134)}{0.11120}\ FRR + \underset{(3.9358)}{0.1233}\ \underline{PRR1} \\ & + \underset{(1.6357)}{0.07370}\ \underline{FRR2} \end{aligned} \qquad (38)$$

$$\sum_{i=0}^{2} w(i) = 0.3082$$

$R^2 = 0.6926$ SE = 0.1209 DW = 2.1126 $F(3,12) = 12.2677$

Imports of capital goods

$$\begin{aligned} MCAPR = {} & \underset{(7.625)}{1.78374} - \underset{(-5.197)}{0.13774}\ X2R + \underset{(2.656)}{0.23077}\ FRR + \underset{(4.9568)}{0.33850}\ IR \\ & + \underset{(0.7785)}{0.0430}\ \underline{IR1} \end{aligned} \qquad (39)$$

$$\sum_{i=0}^{1} w(i) = 0.3815$$

$R^2 = 0.9218$ SE = 0.1449 DW = 2.7021 $F(4,11) = 45.1882$

Imports of raw materials and fuels

$$MRR = (\underline{MRDC} \times \underline{REX}) / PGNP \qquad (40)$$

Tourism and border imports

$$MTBR = \underset{(-6.497)}{-1.05262} + \underset{(16.955)}{0.26925}\ CMC \qquad (41)$$

$R^2 = 0.9409$   $SE = 0.1446$   $DW = 1.1732$   $F(1,17) = 287.4587$

Private payments of interest and dividends abroad

$$MPPR = \underset{(1.938)}{0.16413} + \underset{(8.120)}{0.01082}\ X23R \qquad (42)$$

$R^2 = 0.7830$   $SE = 0.12309$   $DW = 0.8460$   $F(1,17) = 65.9364$

Public payments of interest abroad

$$MIGR = \underset{(-1.996)}{-0.06879} + \underset{(9.854)}{0.05542}\ DEGER \qquad (43)$$

$R^2 = 0.8422$   $SE = 0.07264$   $DW = 0.6560$   $F(1,17) = 97.0940$

Imports of production goods

$$MPGR = MCAPR + MRR \qquad (44)$$

Imports of goods

$$MGR = MPGR + MCONR \qquad (45)$$

$$MGC = MGR \times PGNP \qquad (46)$$

Imports of factors of production

$$MFR = MPPR + MIGR \qquad (47)$$

Other imports in trade account

$$MOTR = (\underline{MOTDC} \times \underline{REX}) / PGNP \qquad (48)$$

Total trade imports: Goods, services and factors

MGSFR* = MGR + MTBR + MFR + MOTR (49)

Weighted price index of main exporting countries to Mexico

PEUEJ = 0.63 PEUS + 0.25 PEEU + 0.04 PEJP (50)

Annual change in price index of main exporting countries to Mexico

DPEUEJ = PEUEJ - PEUEJ1 (51)

Price index of imports

$$PM = \underset{(12.371)}{1.32176} + \underset{(4.696)}{3.92619}\ TFMGC + 5.03750\ DPEUEJ + \underset{(1.1100)}{2.15990}\ \underline{DPEUE1} \qquad (52)$$

$$\sum_{i=0}^{1} w(i) = 7.1973$$

$R^2 = 0.7684$ SE = 0.1331 DW = 0.9219 $F(3,12) = 17.5894$

Rate of change of import price index

PM% = (PM - PM1) / PM1 (53)

Capacity to import: Export earnings deflated by imports price index

CMC = ((EGSFR*) x PGNP) / PM (54)

(Balance of Trade of Net Foreign Demand)

Balance of goods

EGR = EGR - MGR (55)

Balance of tourism and border transaction

BTBR = ETBR - MTBR (56)

Balance of goods and services

BGSR* = BGR + BTBR (57)

Balance of factors

BFR* = EBRR - MFR (58)

Balance of other items in trade account

BOTR = EOTR - MOTR (59)

Balance of trade: Goods, services and factors

BGSFR* = BFR + BTBR + BFR* + BOTR + EAAR (60)

Balance of goods and services in NIA (conciliation)

BGSR = BFSR* + SDBGSR (61)

Balance of factors in NIA (conciliation)

BFR = BFR* + SDEFR (62)

Balance of trade: Goods, services and factors in NIA

BGSFR = BGSR + BFR (63)

## Total Aggregate Demand

### Gross national product

GNPR = GITR + BGSFR (64)

GNPC = BNPR x PGNP (65)

## GENERATION OF VALUE-ADDED OUTPUT

### Output originating in primary sector

$$X1R = 1.54792 + 0.17425\ CPR + 1.15516\ EAGR. \quad (66)$$
$$(2.167) \quad (30.559) \quad (4.070)$$

$R^2 = 0.9816$ SE = 0.4133 DW = 1.2108 F(2,16) = 489.6113

### Output originating in secondary sector

$$X2R = -4.16634 + 0.63336\ IR + 0.35448\ CR \quad (67)$$
$$(-6.160) \quad (4.113) \quad (9.552)$$

$R^2 = 0.9965$ SE = 0.5996 DW = 1.0393 F(2,16) = 2534.3875

### Output originating in tertiary sector

$$X3R = -2.06446 + 0.59023\ ETBR + 0.57309\ CR \quad (68)$$
$$(-4.317) \quad (2.557) \quad (52.772)$$

$R^2 = 0.9980$ SE = 0.5303 DW = 1.2959 F(2,16) = 4510.9609

### Gross domestic product

GDPR = X1R + X2R + X3R (69)

GDPC = GDPR x PGNP (70)

Annual change in gross domestic product

DGDPR = GDPR - GDPR1 (71)

Gross domestic urban product

X23R = X2R + X3R (72)

## CAPITAL FORMATION

Capital stock in the urban sector

K23R = -4.43803 + 0.97649 KR (73)
(-47.108 (899.786)

$R^2$ = 1.000 SE = 0.1444 DW = 0.3752 F(1,17) = ***

Private capital stock

KPR = IPR + 0.90 KPR1 (74)

Public capital stock

KGR = IGR + 0.95 KGR1 (75)

Capital Stock

KR = KPR + KGR (76)

Capital stock of federal government in rural sector

KGF1R = KR - K23R (77)

Private depreciation

DPR = 0.10 KPR1 (78)

Public depreciation

$$DGR = 0.05\ \underline{KGR1} \qquad (79)$$

Depreciation

$$DR = DPR + DGR \qquad (80)$$

$$DC = DR \times PGNP \qquad (81)$$

CREATION OF CAPACITY: POTENTIAL VALUE-ADDED PRODUCTION

Rural capacity

$$\underset{}{X1RP} = \underset{(-8.144)}{-12.49223} + \underset{(17.487)}{4.41883}\ \underline{KGF1R2} \qquad (82)$$

$R^2 = 0.9442$ SE = 0.6933 DW = 0.3739 F(1,17) = 305.7893

Urban capacity

$$X23RP = \underset{(5.044)}{6.83255} + \underset{(45.072)}{0.81752}\ \underline{K23R1} \qquad (83)$$

$R^2 = 0.9912$ SE = 2.1628 DW = 0.4497 F(1,17) = 2031.5142

Capacity

$$XRP = X1RP + X23RP \qquad (84)$$

Unused rural capacity

$$UXLRP = X1RP - X1R \qquad (85)$$

Unused urban capacity

$$UX23RP = X23RP - X23R \qquad (86)$$

Unused capacity

UXRP = XRP - GDPR (87)

Annual chance in used urban capacity

DUX23P = UX23RP - UX23RP1 (88)

## DEMOGRAPHY PROCESSES AND LABOR SUPPLY

Population

N = NG x N1 (89)

Urban-rural potential productivity caps

DX231P = (X23RP / NURB) - (X1RP / NRUL) (90)

Ratio of urban to total population: Urbanization

NURBN = 0.36908 + 0.00849 T + 0.00280 DX231P
(208.854) (251.877) (7.6985)

+ 0.00360 DX231P1 + 0.00290 DX231P2 + 0.00150 DX231P3
(8.8262) (3.5369)
(91)

$\sum_{i=0}^{3} w(i) = 0.0107$

$R^2$ = 1.000 SE - 0.0001 DW 5.5279 F(3,12) = ***

Urban population

NURB = N x NURBN (92)

Rural population

NRUL = N - NURB (93)

Annual change in rural potential productivity

$$DX1PRU = (X1RP / NRUL) - (\underline{X1RP1} / \underline{NRUL1}) \quad (94)$$

$$\begin{aligned} L1NRU = {} & \underset{(87.379)}{0.38528} - \underset{(-0.974)}{0.00196}\ DUMRE - 0.32790\ DX1PRU \\ & - \underset{(-3.8388)}{0.51720}\ \underline{DX1PRU1} - \underset{(-9.3369)}{0.54270}\ \underline{DX1PRU2} - \underset{(-2.7378)}{0.37870}\ \underline{DX1PRU3} \\ & - \underset{(-5.6660)}{0.00070}\ \underline{DUX23P} - \underset{(-9.6770)}{0.00110}\ \underline{DUX23P1} - \underset{(-5.6311)}{0.00110}\ \underline{DUX23P2} \\ & - \underset{(-3.1876)}{0.00070}\ \underline{DUX23P3} \end{aligned} \quad (95)$$

$\sum_{i}^{3} w_1(i) = -1.7665$ $\qquad$ $\sum_{i}^{3} w_2(i) = -0.0036$

$R^2 = 0.9867$ $\quad$ SE = 0.0013 $\quad$ DW = 2.2905 $\quad$ F(5,10) = 223.1250

Rural labor force

$$L1 = L1NRU \times NRUL \quad (96)$$

Urban potential productivity

$$X23PNB = X23PR / NURB \quad (97)$$

Urban potential productivity in the revised data period

$$X23PBD = X23PNB \times \underline{DUMRE} \quad (98)$$

Unused urban productive capacity in the revised data period

$$UX23RD = UX23RP \times \underline{DUMRE} \quad (99)$$

Urban labor participation rate

$$L23NB = 0.68591 - 0.12852\ X23PNB + 0.10019\ X23PBD$$
(36.351) (-20.934) (8.301)

$$- 0.30454\ \underline{DUMRE} + 0.00301\ UX23RP - 0.00242\ UX23RD \quad (100)$$
(-6.967) (4.700) (-3.419)

$R^2 = 0.9674$ SE = 0.00241 DW = 1.9357 F(5,13) = 107.9482

Urban labor force

$$L23 = L23NB \times NURB \quad (101)$$

Labor force

$$L = L1 + 123 \quad (102)$$

Rural labor productivity

$$X1RL = X1R / L \quad (103)$$

Urban labor productivity

$$X23RL = X23R / L23 \quad (104)$$

## INCOME DISTRIBUTION

### National Income Breakdown: Wage and Nonwage Income

Average minimum daily wage rate (current pesos per worker)

$$WMAC = (\underline{WMRC} \times L1 + WMUC \times L23) / L \quad (105)$$

Ratio of minimum rural wage rate to U.S. manufacturing wage rate

$$WRMMUC = \underline{WMRC} / (\underline{WRFUDC} \times \underline{REX}) \quad (106)$$

$$WRC\% = 0.01307 - 0.00356\ UX23RP + 1.68756\ PGNP\% \quad (107)$$
$$(1.305) \quad (-2.530) \quad (18.430)$$

$R^2 = 0.9659$ SE = 0.0156 DW = 1.3768 F(2,16) = 256.1040

Average annual wage rate

WRC = (1.0 + WRC%) x WRC1 (108)

Wage income

WIC = WRC x L (109)

Labor unit cost

WRCA = WRC / (GDPR / L) (110)

Rate of change of labor unit cost

WRCA% = (WRCA - WRCA1) / WRCA1 (111)

Net national product

NNPC = GNPC - DC (112)

Model's national income

NIC: = NNPC - TNIC (113)

National income

NIC = NIC + SDNIC: (114)

NIR = NIC / PGNP (115)

Nonwage income

NWIC = NIC - WIC (116)

Disposable income per capita

$$DIPRN = ((NIC - TFIC.) / PGNP) / N \quad (117)$$

## Public Income and Finance

Federal income taxes

$$\underset{(-4.201)}{TFIC. = -1.27427} + \underset{(20.957)}{0.04001} \; NIC \quad (118)$$

$R^2 = 0.9605$ SE = 0.6501 DW = 1.0844 F(1,17) = 439.2012

Federal export taxes

$$TFEC. = \underset{(5.975)}{0.35076} + \underset{(7.625)}{1.02380} \; \underline{DUMTFE} + \underset{(11.527)}{0.06586} \; EGC \quad (119)$$

$R^2 = 0.9038$ SE = 0.0811 DW = 1.4300 F(2,16) = 85.5648

Federal import taxes

$$TFMC. = \underset{(-4.206)}{-1.45476} + \underset{(10.235)}{0.23801} \; MGC \quad (120)$$

$R^2 = 0.8522$ SE = 0.5258 DW = 0.8140 F(1,17) = 104.7648

Federal sales taxes

$$TFSC. = \underset{(-4.317)}{-0.23470} + \underset{(31.564)}{0.00962} \; GDPC \quad (121)$$

$R^2 = 0.9822$ SE = 0.1167 DW = 0.7020 F(1,17) = 996.2786

Federal nontax income

$$TFPAC. = \underset{(2.865)}{0.24270} + \underset{(15.392)}{0.00750} \; GDPC + \underset{(13.926)}{2.67050} \; \underline{DUMTPC} \quad (122)$$

$R^2 = 0.9692$ SE = 0.1810 DW = 2.6903 F(2,16) = 284.6804

Other federal taxes

TFOC: = 0.7211 + 0.11610 TFC (123)
(5.696) (12.821)

$R^2$ = 0.9008 SE = 0.2797 DW = 2.2890 F(1,17) = 164.3864

Nonfederal taxes: D.F., state and local

TNFC = -0.84372 + 0.37313 TFC (124)
(-6.827) (42.213)

$R^2$ = 0.9900 SE = 0.2730 DW = 2.1512 F(1,17) = 1781.9036

Federal indirect or nonincome taxes

TFNIC. = TFMC. + TFEC. + TFSC. + TFOC: + TFPAC. (125)

TFNIC = TFNIC. + SDTENC (126)

Indirect or nonincome taxes

TNIC = TFNIC + TNFC (127)

Rate of change of indirect taxes

TNIC% = (TNIC - TNIC1) / TNIC1 (128)

Federal taxes

TFC = TFIC. + TFNIC (129)

Taxes

TC = TFC + TNFC (130)

TR = TC / PGNP (131)

Average tariff on imports of goods

TFMGC = TFMC. / MGC (132)

Public expenditure

$$GR = CGR + IGR \qquad (133)$$

$$GC = GR \times PGNP \qquad (134)$$

Public surplus or deficit

$$GSC = TC - GC \qquad (135)$$

Taxes plus public depreciation

$$TRDGR = TR + DGR \qquad (136)$$

Public foreign debt

$$DBGER = (\underline{DBGEDC} \times \underline{REX}) / PGNP \qquad (137)$$

Annual change in public foreign debt

$$DDBGR = DBGER - \underline{DBGER1} \qquad (138)$$

Banking system credit to the federal government

$$FBGFR = \underline{FBGFC} / PGNP \qquad (139)$$

Foreign reserves

$$FRR = (\underline{FRDC} \times \underline{REX}) / PGNP \qquad (140)$$

## PRICE FORMATION

Rate of change of the general price index: GNP deflator

$$\underset{}{PGNP\%} = \underset{(4.007)}{0.01667} + \underset{(4.103)}{0.38848} \; WRCA\% + \underset{(2.680)}{0.32394} \; PM\% + \underset{(0.236)}{0.00746} \; TNIC\% \qquad (141)$$

$R^2 = 0.9520$   SE = 0.0100   DW = 2.3499   F(3,15) = 119.8805

General price index: GNP deflator

PGNP = (1.0 + PGNP%) x PGNP1 (142)

Annual change in the general price index

DPGNP = PGNP - PGNP1

We list now alphabetically the symbols used and their meanings. The symbols are of two kinds: Simple, or consisting of only one letter; and compound, or consisting of two or more letters and numbers. In the case of the compound symbols, the final letters and numbers have the following meanings:

Ending in C : current billion pesos

Enging in R : real billion pesos of 1950

Ending in DC : current billion dollars

Ending in L : per worker of the productive sector in question

Ending in N : per capita

Ending in % : annual rate of change

Ending in 1, 2, or 3 : lags of one, two or three previous years.

All predetermined variables (exogenous or lagged endogenous) are underlined. The only exception to these rules are two compound symbols: L1 and L23, rural and urban labor force. The number endings here do not mean lags, but primary and secondary plus tertiary productive sectors, respectively. They are not, thus, underlined. The abbreviations NIA and BOP mean National Income Accounts and Balance of Payments Account.

B

| | | |
|---|---|---|
| BFR | = | balance of productive factors in NIA |
| BFR* | = | balance of productive factors in BOP |
| BGR | = | balance of goods in BOP |
| BGSFR | = | balance of goods, services and factors or net foreign demand in NIA |
| BGSFR* | = | balance of goods, services and factors or net foreign demand in BOP |
| BGSR | = | balance of goods, tourism and border transactions in NIA |
| BGSR* | = | balance of goods, tourism and border transactions in BOP |
| BOTR | = | balance of other items in current account in BOP |
| BTBR | = | balance of tourism and border transactions in BOP |

C

| | | |
|---|---|---|
| CGR | = | public consumption |
| CITR | = | domestic or internal aggregate demand |
| CMC | = | capacity to import or current earnings deflated by import price-index |
| COCDU | = | COCOP multiplied by DUMRS |
| DODOP | = | domestic, physical consumption of copper (millions of tons) |
| COCOT | = | domestic, physical consumption of cotton (millions of bales) |
| COLEA | = | dpmestic, physical consumption of lead (millions of tons) |
| COMET | = | domestic, physical consumption of nonferrous metals: lead, copper, sinz (millions of tons) |
| CPR | = | private consumption per capita (thousands of 1950 pesos per person) |
| CR | = | consumption |

D

| | | |
|---|---|---|
| DBGEDC | = | public external debt |
| DBGER | = | public external debt |
| DC | = | depreciation |
| DDEGR | = | change in public external debt |
| DGDPR | = | change in gross domestic product |
| DGR | = | public depreciation |
| DIPRN | = | disposable personal income per capita (thousands of 1950 pesos per person) |
| DIUDC | = | disposable personal income in the U.S. |
| DIUR | = | disposable personal income in the U.S. |

| | |
|---|---|
| DPEUEJ | = change in export price index, PEUEJ, of main exporting countries to Mexico |
| DPGNP | = change in GNP price deflator |
| DPR | = private depreciation |
| DR | = depreciation |
| DUMBR | = dummy for government restrictions to the bracero program; 1.0 for 1965-68, 0.0 elsewhere |
| DUMCU | = dummy for U.S. suspension of sugar buying from Cuba; 1.0 for 1960-68, 0.0 elsewhere. |
| DUMDV | = dummy for after-effects of devaluation of 1954; 1.0 for 1956-61, 0.0 elsewhere |
| DUMPO | = dummy for political change in Mexico: presidential transitions and other major political events; 1.0 for 1952-53, 1958-59, 1964-65, and 1961-63; 0.0 elsewhere |
| DUMRE | = dummy for census revisions of labor data; 1.0 for 1960-68, 0.0 elsewhere |
| DUMRS | = dummy for U.S. trade protection to its nonferrous metal producers; 1.0 for 1958-68, 0.0 elsewhere |
| DUMTFE | = dummy for exceptional federal exports tax collection; 1.0 for 1955-56, 1961 and 1967; 0.0 elsewhere |
| DUMPTC | = dummy for exceptional federal nontax collection; 1.0 for 1965, 0.0 elsewhere |
| DUX23P | = change in idle urban productive capacity |
| DX1PRU | = change in rural potential population productivity |
| DX231P | = gaps between urban and rural potential population productivity |

E

| | |
|---|---|
| EAADC | = net production of gold and silver |
| EAAR | = net production of gold and silver |
| EAGR | = main agricultural goods exports: cotton, coffee and sugar |
| EBRR | = labor exports of bracero earnings |
| EBRRK | = labor exports of bracero earnings per Mexican worker (thousands of 1950 pesos per worker) |
| ECOFR | = exports of coffee |
| ECOPR | = exports of copper |
| ECOTR | = exports of cotton |
| EGC | = goods or merchandise exports |
| EGDC | = goods or merchandise exports |
| EGER | = goods exports, explained by equations in the model |
| EGMFR | = manufactured goods exports |
| EGR | = goods or merchandise exports |
| EGSTFR* | = exports of goods, services and factors or total trade exports |

| | |
|---|---|
| ELEAR | = lead exports |
| EMETR | = nonferrous metals exports: Lead, copper and zinc |
| EOGR | = other goods exports |
| EOTDC | = exports of other items in current account |
| EOTR | = exports of other items in current account |
| ESUGR | = sugar exports |
| ETBR | = tourism and border exports |
| EZINR | = zinc exports |

F

| | |
|---|---|
| FBGFC | = domestic banking credit to the federal government |
| FBGFR | = domestic banking credit to the federal government |
| FRDC | = foreign reserves |
| FRR | = foreign reserves |

G

| | |
|---|---|
| GC | = public expenditure |
| GDPC | = gross domestic product |
| GDPR | = gross domestic product |
| GNPC | = gross national product |
| GNPR | = gross national product |
| GNPUDC | = U.S. Gross national product |
| GNPUR | = U.S. gross national product |
| GR | = public expenditure |
| GSC | = government surplus or deficit |

I

| | |
|---|---|
| ICHR | = inventory investment |
| IGGR. | = government fixed, gross investment |
| IGOER. | = federal organizations and enterprises fixed, gross investment |
| IGR | = public gross, fixed investment |
| IPR | = private gross, fixed investment |
| IPUSF | = U.S. index of industrial production of food and beverages (157-59 = 1.0) |
| IR | = gorss fixed investment |
| ITR | = investment |

K

| | |
|---|---|
| KGF1R | = federal government capital stock in the rural sector |
| KGR | = government capital stock |

KPR = private capital stock
KR = capital stock
K23R = private and federal government capital stock in urban sector

L

L = labor force (millions of workers)
L1 = labor force in rural or primary sector (millions of workers)
L1NRU = rural labor participation rate: Ratio of labor force over population in rural sector
L23 = labor force in urban or secondary and tertiary sector (millions of workers)
L23NB = urban labor participation rate: Ratio of labor force over population in urban sector

M

MCAPR = capital goods imports
MCONR = consumption goods imports
MFR = factor imports
MGC = goods or merchandise imports
MGR = goods or merchandise imports
MGSR* = imports of goods, services and factors or total trade imports
MIGR = government payments of interest to foreign bond holders
MOTDC = imports of other items in current account
MOTR = imports of other items in current account
MPGR = imports of production goods
MPPR = private payments of profits to foreign stockholders
MRDC = imports of raw materials and fuels
MRR = imports of raw materials and fuels
MTBR = imports of tourist and border transactions

N

N = population (millions of persons)
NG = population rate of growth
NIC = national income in NIA
NIC: = national income generated by the model
NIR = national income
NNPC = net national product
NRUL = rural population (millions of persons)

NURB = urban population (millions of persons)
NURBN = ratio of urban to total population
NWIC = nonwage income

P

PCFMB = ratio of Mexican over Brazilian price of coffee
PCOFB = Brazilian price of coffee (dollars per hundred lbs.)
PCOFM = Mexican price of coffee (dollars per hundred lbs.)
PEEU = European (EEC plus EFTA) export price index (1953 = 1.0)
PEJP = Japanese export price index (1960-62 = 1.0)
PEUEJ = weighted export price index of main exporting countries to Mexico (U.S., Europe and Japan) weights of 1968
PEUS = U.S. export price index (1958 = 1.0)
PGNP = GNP price deflator (1950 = 1.0)
PGNP% = GNP price deflator rate of change
PM = price index (1950 = 1.0)
PM% = imports price index rate of change
PRCDU = PRCOP multiplied by DUMRS
PRCOP = domestic, physical copper production (thousands of tons)
PRCOT = domestic, physical cotton production (thousands of tons)
PRLEA = domestic, physical lead production (thousands of tons)
PRMET = domestic, physical nonferrous metals production: Lead, copper and zinc (thousands of tons)
PSGMP = ratio of Mexican over Philippines price of sugar
PSUGM = price of Mexican sugar (dollars per hundred lbs.)
PSUGPH = price of Philippines sugar (dollars per hundred lbs.)

R

RDPAV = paved roads (thousands of kilometers)
REX = rate of exchange (dollars per peso)

S

SBGSFR = discrepancy between NIA and BOP data on balance in current account

<u>SDBFR</u> = discrepancy between NIA and BOP data on balance of factors
<u>SDBGSR</u> = discrepancy between NIA and BOP data on balance of goods and services
<u>SDNIC</u>: = discrepancy between NIA data and the model's identity of national income
<u>SDTFNC</u> = discrepancy between two data sources used on federal indirect or nonincome taxes

T

<u>T</u> = time (1948 = 1.0)
TC = total taxes and nontaxes
TFC = federal government taxes
TFEC. = federal export taxes
TFIC. = federal income taxes
TFMC. = federal import taxes
TFMGC = rate of taxation on imported merchandise
TFNIC = federal indrect or nonincome taxes
TFNIC. = federal indirect or nonincome taxes
TFOC: = other federal taxes
TEPAC. = federal nontax income: "productos, derechos y aprovechamientos"
TFSC = federal sales taxes: ingresos mercantiles
TNFC = nonfederal taxes: D.F., state and local
TNIC = total indirect or nonincome taxes
TNIC% = total indirect taxes rate of growth
TR = total taxes and nontaxes
TRDGR = total taxes plus public depreciation

U

UXPR = idle capacity
UX1RF = rural idle capacity
UX23RD = UX23RP multiplied by <u>DUMRE</u>
UX23RP = urban idle capacity

W

WIC = wage income
WMAC = daily, average minimum wage rate (current pesos per worker)
<u>WMRC</u> = daily, minimum rural wage rate (current pesos per worker)
<u>WMUC</u> = daily, minimum urban wage rate (current pesos per worker)

WRC = yearly average wage rate (thousand current pesos per worker)
WRC% = yearly, average wage-rate rate of growth
WRCA = unit labor cost or ratio of average wage rate to labor productivity
WRCA% = unit labor cost rate of change
WRFUDC = U.S. hourly manufacturing wage rate (dollars per worker)
WRMMUC = ratio of daily, minimum urban wage to U.S. hourly manufacturing rate converted into current pesos

X

X1R = rural production
X1RL = rural labor productivity (thousands of 1950 pesos per worker)
X1RP = potential rural production or rural capacity
X2R = secondary production
X3R = tertiary production
X23R = urban production
X23PBD = X23PNB multiplied by DUMRE
X23PNB = potential urban population productivity (thousands of 1950 pesos per urban person)
X23RL = urban labor productivity (thousands of 1950 pesos per worker)
X23RP = potential urban production or urban capacity
XRP = potential production or capacity