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Distr.
LIMITED
ID/WG.160/8
6 August 1973
ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting on Projections of Industrial Development
Vienna, 27 - 31 August 1973

INDUSTRIAL PROJECTION MODELS FOR DEVELOPING COUNTRIES 1/

by

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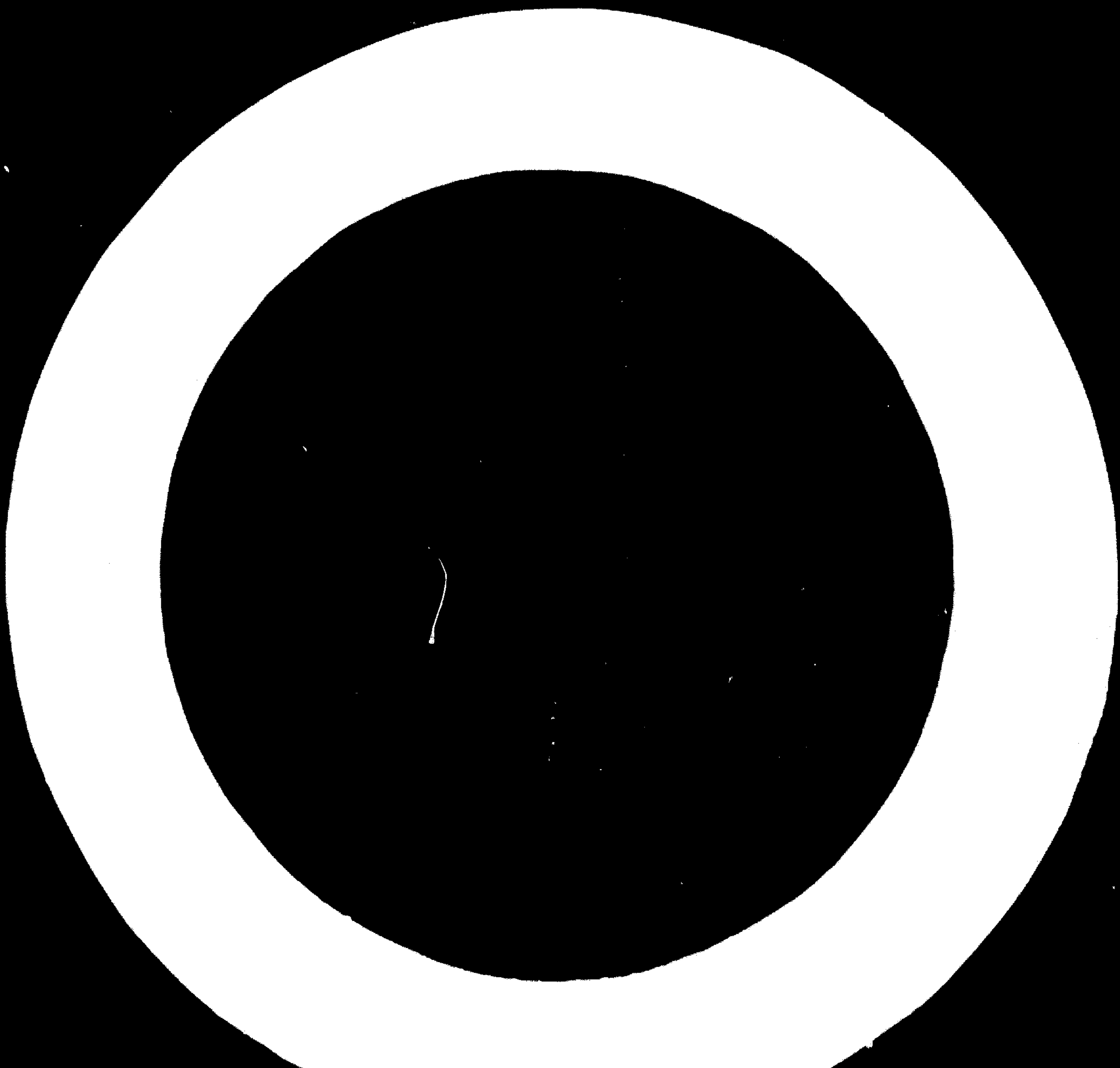
id.73-5629

C O N T E N T S



I. Specification of Models for Developing Economies

The first step in modeling the industrialization process for development is to model the developing economy as such. The interrelationship between the industrial and all other sectors of such economics makes it virtually impossible, or certainly unrevealing to try to study the industrial sector in isolation. I shall proceed in two steps: 1. Discuss the problem of model building, in general, for developing countries, 2. Show how the industrial sector is related to other sectors within the framework of a feasible model of the whole economy.

Special characteristics of the LDC model: For many years, I and my research students have been wrestling with the problem of how to build statistical models of the developing countries.[1] In this effort, numerous research studies and doctoral dissertations have been prepared for a wide variety of countries. Some of these are in Latin America, some in Africa, and some in south or east Asia. Continental nations, island nations, specialized economies, diversified economies have been the subject of a study. Many attempts have been made to capture the quintessence of India's economy through the medium of a model. This has proved to be an elusive case, but one day will turn out to be a fine example. Much of the present paper will be based on the Mexican case because an unusual effort has been made to build a living, on-going model for

[1] See Bibliography

Mexico--one that is repeatedly used in study of the economy, one that is regularly undergoing testing, and one that is becoming increasingly complex in structural detail. The Mexican Model has been adapted to modern computer technology and used in much the same way that U.S. models are used. This makes it a very convenient vehicle from which to carry out the present study.

The distinguishing features of the LDC model that stand out in these previous efforts for India, Mexico, and other countries are:

1. Importance of conditions of domestic supply
2. Reliance on a limited number of exports, often of basic materials.
3. Inequality of income/wealth distribution and influence of this on economic performance.
4. Dependence of money supply on external and domestic balances.
5. Lack of organized domestic capital markets
6. Economic dualism
7. Population pressures
8. Population migration from rural to urban sectors
9. Foreign investment, external debt, interest paid abroad
10. Import substitution
11. Political instability

These features are not present in every developing country, but they are of frequent importance. Most of them are present in some degree in the developing countries and must be taken into consideration as a group in order that we may have a realistic model of the countries being studied. It will not do to employ a standard model specification to cover all developing countries, nor can we adapt the predominant model used in the industrial economies, with minor changes to parameter values, in order to model the developing countries. Each case will have special characteristics among some general ones and must be examined carefully to give display to the above features.

1. The conditions of supply: It is commonly said that the prevailing Keynesian type model for the industrial countries is based largely on demand considerations. Although this may be an overstated charge, it is true that such models devote a great deal of attention to aggregate demand and its most important components. A fundamental reason why it is not a wholly correct view is that factor demand, together with production technology, make up important aspects of supply, and these are customarily present in models for industrial economies.

For the developing economy, we must include conditions of capital formation, capital accumulation, production bottlenecks, labor supply, and technological agricultural relationships for the supply of goods. Potential output, X_t^p, is usually made a function of accumulated capital, K_t a scarce factor

$$X_t^p = F(K_t)$$

This is the main limitation on the supply of goods. Such relationships are developed for each of several sectors. Added technological supply information is provided by the inclusion of input-output system.

For the agricultural sector, which is strategic for food production and sometimes for exports of basic materials, an important aspect is the heavy dependence on natural factors (weather, e.g.) and substantial time delays. Response, in the production of basic materials, either in agriculture or extractive industries, follows world prices for the commodities in question, with a significant time delay. The dynamics of such systems are interesting and lays the developing economy bare to transmission of economic disturbances from the industrial nations because of a comparatively slow adjustment process.

Primary supply, usually takes the form

$$X_t = S(p_t, p_{t-1}, p_{t-2}, \ldots, n_t),$$

where

p_t = "real" price at time t

n_t = natural factors affecting supply of X_t.

Natural factors are more important for agricultural than for mineral products.

2. Reliance on primary commodity exports: The banana-coffee republics of Latin America are described in caricature form as being dependent on the export of these two commodities for the earning of foreign exchange. If primary commodity exports

are used to purchase needed imports of consumer goods and capital items we are faced with a situation in which price-inelastic goods are marketed, subject to needs and desires of the industrial states, in return for the purchase of price elastic finished consumer or producer goods.

Few countries have achieved high rank position among developed or strong growth countries on the basis of export performance of basic materials. For good growth of exports and the internal development of domestic industry through capital imports, there will probably have to be a shift in the composition of exports towards those that have higher growth prospects. A few countries gained economic prosperity in the past through efficient specialization in agriculture, but generally speaking, this will be possible only if there is a shift towards exports of varied industrial goods.

A special case in the world economy for export concentration on basic commodities is the typical oil economy. These are mainly in Latin America and the Middle East. This market is run by the large international oil companies in cooperation with the main producing areas throughout the world. This gives it a large degree of stability. At the moment, the oil-rich nations are enjoying unusually good fotune, and are in a position to use strong export earnings for internal development and industrialization. Some such nations stand on the brink of industrial take-off provided they use their investment accumulation well.

Table 1 shows the commodity composition of developing countries' exports. Food, raw materials, and fuel account for more than 80 percent of their total commodity exports.

Table 2 lists the main exports of each of several developing countries with an indicator in parenthesis of the percentage shares of the total accounted for by each. In this tabulation, it is easy to see at a glance how important oil is for Iran, fish meal for Peru, cocoa for Ghana, etc..

Finally, Tables 3, 4, and 5 give the geographical locations of export shares in the world Tin, Rubber, and Coffee markets. These are commodity markets that are entirely in developing countries.

Table 1

Developing Countries: Commodity composition of Exports 1955-66

	1955-56	1960-61	1965-66
Food	32	29	28
Raw materials	29	27	22
Fuels	25	29	31
Chemical	1	1	1
Machinery	1	1	1
Other manufactures	12	12	16
Total	100	100	100

Source: U.N. World Economic Survey, 1967, p. 44.
Based on table 24.

Table 2

Main Exports of Selected Developing Countries

Country	Main exports (1963-1965)
Iran	Fuel (88)
Israel	Fresh citrus fruit (14), fruit and vegetable juices (3)
Korea, Republic of	Fish (11), silk (5), iron ore (5), tungsten (4),
Sabah	wood (57), rubber (12), copra (6)
China (Taiwan)	Sugar (24), bananas (7), rice (7), vegetables (5)
Liberia	Iron-ore (68), rubber (26)
Jordan	Fertilizers (31), tomatoes (15), watermelon (7)
Sierra Leone	Diamonds (58), iron-ore (17), palm kernels (8)
Chad	Raw cotton (78), live animals (8)
Central African republic	Diamonds (48), cotton (21), coffee (20)
Congo (Brazzaville)	Diamonds (43), wood (38), fuel (3)
Gabon	Wood (38), manganese ore (23), fuel (15), uranium (9)
Peru	Fish meal (21), copper (17), cotton (14), sugar (9)
Jamaica	Sugar (27), alumina (23), bauxite (21)
Trinidad	Fuel (82), sugar (7), bananas (8)
Lebanon	Citrus fruit (9), apples & pears (8), dried beans (8)
Panama	Bananas (46), fish (10), sugar (3)
Rhodesia[c]	Tobacco (33), asbestos (8), copper (4)
Kenya	Coffee (29), tea (13), sisal (13)
Kuwait	Fuel (99)
Nicaragua	Cotton (44), coffee (18), meat (6)
Guayana	Bauxite (35), sugar (34), rice (13)

Mozambique	Cotton (18), cashew nuts (17), sugar (10), sisal (8)
Saudi Arabia	Fuel (99)
Philippines	Cocoanut products (34), wood (20), sugar (19)
Tanzania (United Republic)	Sisal (31), cotton (17), coffee (14), Diamonds (10)
Surinam	Bauxite (77), rice (5), fish (2)
Iraq	Fuel (93)
Thailand	Rice (35), rubber (17), tin (8)
Honduras	Bananas (40), coffee (18), wood (10) raw cotton (4)
Angola	Coffee (45), diamonds (15), sisal (8)
El Salvador	Coffee (51), cotton (22)
Zambia[c]	Copper (91), lead and zinc (4)
Nigeria	Ground nuts and oil (20), fuel (18), cocoa (17)
Guatemala	Coffee (49), cotton (18), bananas (5), sugar (4)
Venezuela	Fuel (94)
Sudan	Cotton (52), ground-nuts (12), gum arabic (10)
Uganda	Coffee (52), raw cotton (26), copper (10)
Barbados	Sugar (84), rum (5)
Mexico	Raw cotton (18), sugar (8), coffee (7), fish (5)
Malaysia	Rubber (47), tin (26), iron-ore (6), palm oil (5)
Ethiopia	Coffee (60), hides and skins (9), linseed (10)
Paraguay	Meat (30), wood (15), raw cotton (8), tobacco (8)
Chile	Copper (58), iron-ore (11), crude fertilizers (5)

India	Jute (19), tea (15)
Morocco	Phosphate (25), oranges (11)
Dominican Republic	Sugar (50), coffee (14), cocoa (7), tobacco (7)
Cameroon	Cocoa (24), coffee (24), aluminum (18)
Mauritius	Sugar (95), tea (2)
Argentina	Meat (23), Wheat (17), maize (11), wool (19)
Ecuador +	Bananas (57), coffee (13), cocoa (12)
United Arab Republic	Cotton (53), rice (10)
Cyprus	Copper (22), citrus fruit (17), potatoes (12)
Syria	Cotton (48), barley (3), wheat (5)
Costa Rica	Coffee (44), bananas (26), sugar (5) meat (5)
Pakistan	Jute (35), raw cotton (14), rice (4)
Bolivia	Tin (36), silver (7), lead (6)
Cuba	Sugar (37)
Ghana	Cocoa (67), wood (13), diamonds (5), manganese (4)
Tunisia	Olive oil (20), natural phosphates (17), wine (13)
Ceylon	Tea ([illegible]), rubber (16), coconut oil (7)
Madagascar	Coffee (29), spice (12), sugar (19), sisal (13)
Burma	Rice (62)
Brazil	Coffee (50), cotton (7), iron ore (6), cocoa (3)
Sarawak	Fuel (38), wood (25), rubber (22), pepper (10)
Haiti	Coffee (47), sugar (8), sisal (8)
Colombia	Coffee (68), fuel (16), bananas (3)

Indonesia	Fuel (38), rubber (33)
Congo (Dem. Rep. of)[c]	Copper (48), palm products (9), gem diamonds (8)
Uruguay	Wool (45), meat (32), hides (9), linseed oil (2)

c = average 64-65

f = average 63-64

() = % of total exports

Source, U.N. Commodity survey, 1967, UNCTAD. pp. 31-37.

Table 3

Tin exports of the six most import exporters of tin

(Nearly 90% of total supply)

Country	1960	1963	1964	1963-1965 production as % of world product.
	(Millions of dollars)			
Malaysia	165	212	236	41
% of total exports	17	24	26	
Bolivia	42	57	81	16
% ...	65	71	72	
Thailand	25	36	46	11
% ...	6	8	8	
Indonesia	54	19	--	10
% ...	6	3	--	
Nigeria	17	25	35	6
% ...	3	4	5	
Congo (Democratic Republic)	27	19	39	4
% ...	5	7	7	
Total				88

Source: UNCTAD Commodity Survey, 1966. U.N. p. 56 from Table IIC-3.

Table 3 (Cont.)

Percentage share of the Major Commodity Groups in Total Value of Exports of Developing Countries, by Region, 1964

	Latin America	Africa	Middle East	Asia	Total Developing Countries
Agriculture 1964	58	56	15	57	48
Minerals and metals, 1964	12	16	2	8	10
Fuels 1964	26	21	77	6	31
Manufactures 1964	4	7	6	29	11
Total Exports, 1964	100	100	100	100	100

Source: U.N., UNCTAD Commodity Survey, 1966, New York, 1966. p. 77, Table IV A-2.

Table 4
Rubber as a Percentage of Total Exports by Value of Selected Producing Countries.

Country	1960	1961	1962	1963	1964
Malaysia	57.8	51.3	48.5	48.1	44.9
Indonesia	33.1	44.8	44.9	38.9	43.8
Vietnam (Republic of)	56.1	61.9	67.0	43.9	68.7
Thailand	29.9	21.3	22.2	19.7	16.5
Ceylon	20.6	15.0	16.0	14.8	15.5
Nigeria	8.5	6.3	6.8	6.3	5.5

Source: UNCTAD Commodity Survey, 1966, U.N., P. 62, Table II C-5.

Table 5

Coffee Export Earnings for Selected Developing Countries. (Thousands U.S. Dollars), 1965

Latin American Countries	Coffee Earnings	% of Total Exports
Brazil	707,000	44.3
Colombia	344,000	62.4
Costa Rica	46,000	41.1
Dominican Republic	22,000	17.9
Ecuador	37,000	24.5
El Salvador	96,000	50.8
Guatemala	86,000	46.0
Haiti	20,000	55.6
Honduras	23,000	18.3
Mexico	76,000	6.7
Nicaragua	28,000	18.2
Peru	29,000	4.5
Africa		
Congo (Democratic Republic of)	25,000	8.1
Ethiopia	70,000	58.8
Ghana	894	----
Nigeria	2,251	0.5
Central African Republic	5,000	18.5
Ivory Coast	112,000	42.6
Madagascar	29,000	31.5
Tanzania (Republic of)	24,000	13.6
Uganda	79,000	48.5
Kenya	39,000	26.9

[a] figures for 1964

Source: U.N. Commodity Survey, UNCTAD, New York, 1966, p. 94 Table II-A.

3. Inequality of income and wealth distributions: It has generally been found that income and wealth are more inequitab distributed in poor, developing countries than in advanced, industrial countries. In the case of the developing country there are usually very large masses of poor people and a few at the top with immense resources. This kind of skewed distribution gives rise to big inequality coefficients that describe distributions in a traditional way in the case of the developing countries. This has important implications for the saving and capital formation processes that underlie economic growth. Table 6 shows relative income distribution frequencies at different positions above and below mean income. Developing countries have higher frequencies than do industrial countries at positions below national means. At the other extreme, developing countries show high frequency at income levels more than twice the national mean. Developing countries have high frequencies at both ends of the scale; this makes for inequality. For moderate size income--between the mean and twice the mean--frequencies are high in the industrial countries.

Overall concentration coefficients in Table 7 are much higher for developing than for developed countries.

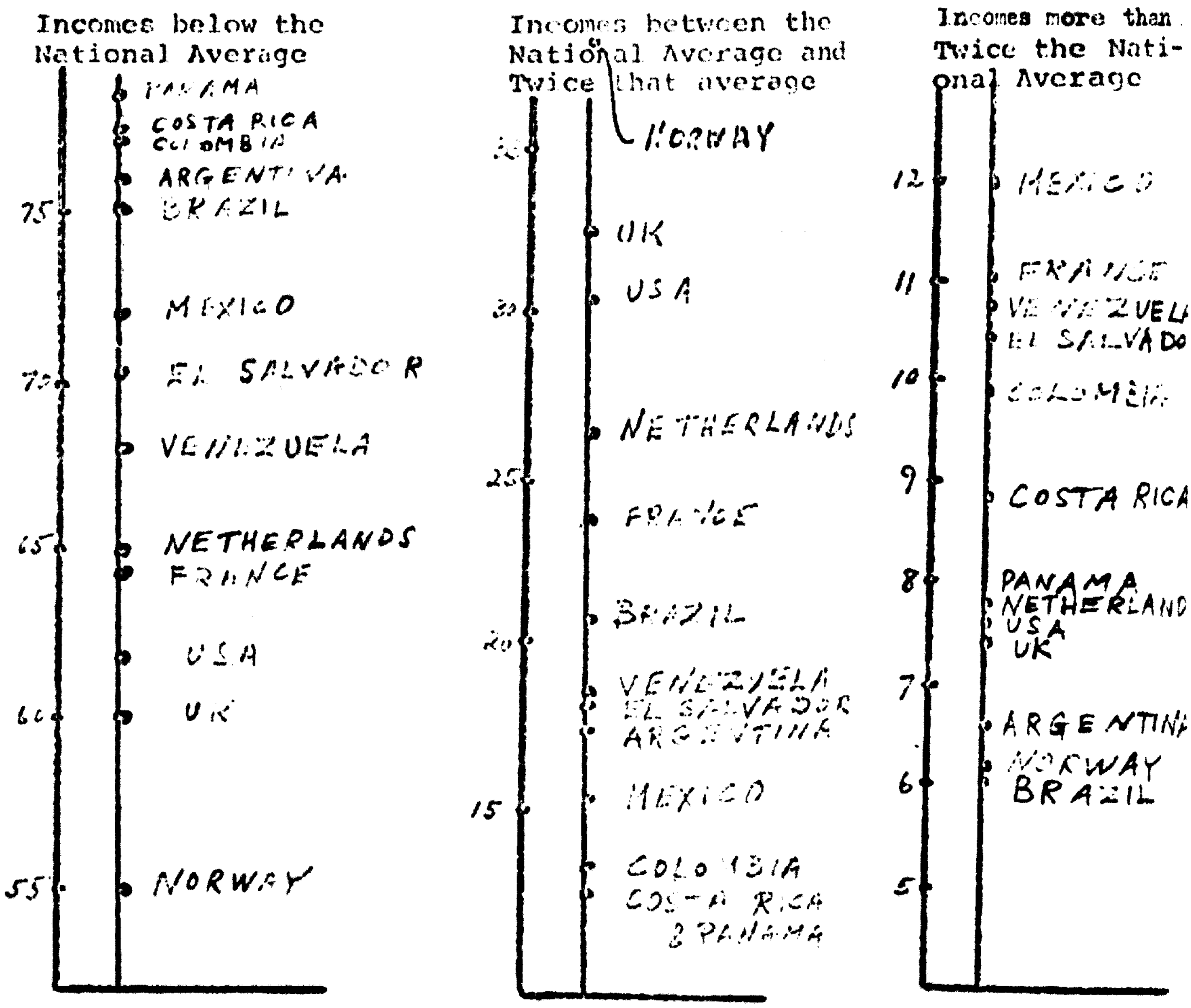
Inequality may stimulate savings by the upper income classes. In some cases these retained funds are invested at home, and this provides a base for industrial growth. Frequently, however, funds saved by the upper classes leak out of the country and end up in foreign banks or foreign investments. To the extent that this is true, the developing country must import foreign capital for real investment purposes.

The poor masses are at or near the margin of subsistence, and cannot save appreciable amounts. Inequality, therefore, cannot be relied upon to generate funds for capital financing and expansion.

There have been notable exceptions to this situation. Japan is a case in point. During the period of industrialization, before the country received advanced nation status, there was a high rate of saving and this is thought to have been stimulated by the inequality of income distribution. The poor were able to save something, together with the rich, and the latter preferred to invest at home rather than abroad. Consequently, Japan's industrialization progress was largely financed internally. The usual case is not like this.

Table 6

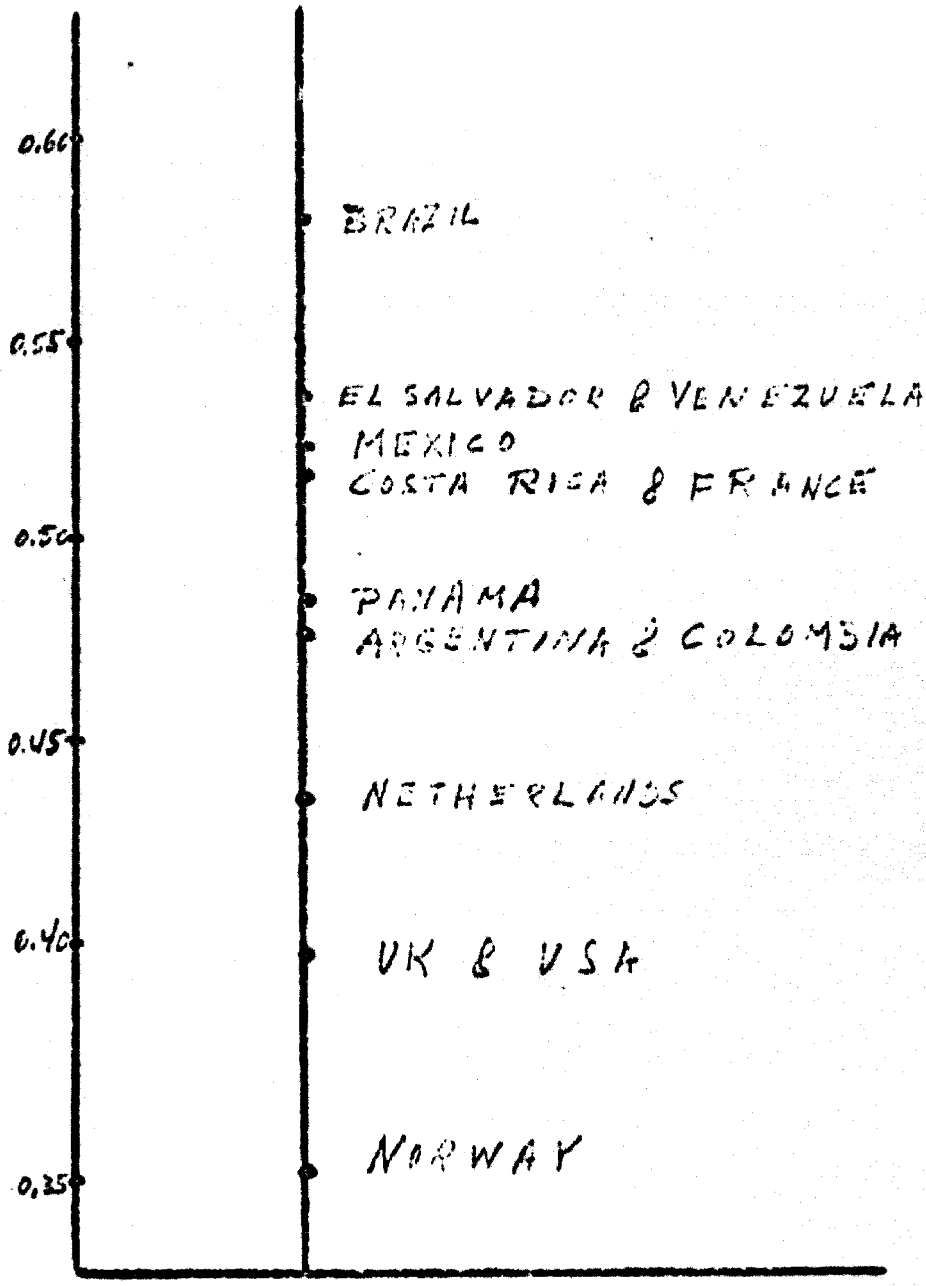
Percentage of Population in Income Groups Expressed in Terms of National Average



Source: U.N., Income Distribution in Latin America, (CEMLA), New York, 1971, p, 11.

Table 7

Coefficients of Concentration[a]



[a] based on the formula

$$\gamma = 1 - \sum_{i=1}^{n} f_i \frac{(g_{i-1} - g_i)}{10,000}$$

g = cumulative percentage of income received

n = number of income groups

f_i = % of population in each income group

g_i = % of income received

Apart from the effect on means of financing capital expansion, income distribution is, in itself, an interesting phenomenon, especially in relation to its effect on saving or consumption. In the advanced, industrial countries, we often find that disparities are not large enough to matter very much. The opposite situation prevails in the developing country. Disparities are so large, that it is to be expected that changes in inequality will have a significant and measurable effect on the saving/spending decision of individuals. The LDC model should not be without measures of income inequality. Such measures may appear in many forms--as a descriptive statistic of the size distribution of income, as a set of percentages for the factorial composition of national income, or as a demographic measure of the urban/rural ratio.

4. <u>Money Supply and Deficits or Surpluses</u>: The monetary mechanism in the developing country is quite different from the usual system of industrial countries. Money and credit markets are strategic for financing industrialization; therefore it is worthwhile examining the special factors determining money supply or other credit market variables for the developing country.

If money supply gets out of hand, we may find price increases following the lines of the orthodox quantity theory of money.

This need not happen, however. Some developing economies have price and monetary stability; some do not.

Money markets are less well developed in the emerging nations. Many credit instruments are not used; interest rates often turn out to be quite high (between 15 and 20 percent); and it may seem hopeless to try to model this sector of the economy in the same way that we do it for advanced nations of Western Europe, North America, or Japan.

When there is an internal deficit in developing countries, the treasury must borrow to cover this discrepancy. Bonds issued to the banking system then provide a monetary base, from which expansion of the money supply grows. The public usually does not want domestic government securities or cannot afford to buy them; so they end up with the banking system, probably the central bank, and this is expansionary financing of the deficit. Similarly, an external deficit in trade can be covered by foreign capital inflow. These foreign funds then become part of the base for monetary expansion.

In industrial countries with sophisticated money markets, the central bank authorities can offset the external deficit, with its flow of foreign exchange into the country, by engaging in open market operations. These procedures are not generally feasible in developing countries. The very mechanism of real economic growth thus generates monetary expansion and subsequent inflation.

Reserve requirements and interest rate policies may be other tools at the hands of monetary authorities with which they can tr to control money supply. With high nominal interest rates, alrea and with high reserve ratios in many cases (60%), there remains practically no leeway for the authorities.

In the case of the Mexican Model, to be discussed below, there has been an attempt to build a sectoral model of the money market that can be used together with a model of the real sector. This is an experimental study, but appears to be very promising. In studies of the Indian money market, many of the conventional relationships of the advanced countries' money markets seem to hold, but on the supply side of money creation the mechanism seems to be different.

5. <u>Lack of an Organized Capital Market</u>: In many respects; this special aspect of the developing economy is covered by the previous comments concerning money supply. One direct and immedia consequence of this aspect of economic structure is that the equations of money supply and the whole credit market sector will be different from those customarily dealt with in the case of industr economy model building. Equations of the Mexican credit market wi be presented in a later section, and it will be possible to see th implications of this difference in structure.

Two other features of fact that organized capital markets in the industrial economy sense do not exist are the size and relevan of interest rates and the determinants of industrial investments.

It is not uncommon to find high nominal interest rates accompanying high inflation rates in the developing economy. In fact, interest rates might even be quite high in the presence of moderate inflation. Economic calculation and its statistical modeling in the advanced industrial sectors of the world take place at interest or time discount rates ranging from 3 to 12 percent per annum, depending on the historical time period and the country being considered. This is a fairly wide spread, but is an order of magnitude below the rates often quoted for developing countries. Rates ranging upwards from 15-20 percent are not unusual. To some extent these high nominal rates compensate for inflation so that the real rate may not be far out of line with real rates in industrial countries. But, to a large extent, these high rates reflect capital shortages and conventional activities of money lenders that have been perpetuated over long periods of time.

In the sense that these extraordinarily high rates of interest represent virtual unavailability of capital on conventional terms in well organized money markets, investment decisions probably follow a calculus that differs from the currently fashionable "neo-classical" type now used in models of industrial economies. Investment in developing countries is consequently best geared to some version of the accelerator theory, possibly with an allowance for capital accumulation, and modified by credit availability. The modification for credit availability may take the form of introducing a variable representing internal funds (domestic gross savings) and external funds (capital flows - grants or loans from abroad).

6. <u>Economic Dualism</u>: The Meaning of "Dualism" for the developing economy is that one-sector models are clearly inadequate. Dualism in this context is taken to mean that there is an advanced or modern sector and a backward or traditional sector in most developing countries. This does not imply a two-sector model as the ideal specification for the developing economy because it may be important to subdivide both the advanced and backward sectors into smaller subdivisions and have a multisector model. This approach will be examined, again in the Mexican context, to show how many input-output sectors, can in fact, be introduced into a typical model of the developing countries.

In a crude sense, and as a first approximation, the idea of dualism may be taken to mean

urban and rural or

agricultural and industrial.

On closer examination, though, we may find that the agricultural sector can be quite advanced in economic technique and organizati At the same time, we may find many backwards elements in the manufacturing sector, such as "cottage industries". Certain industries, however, can only be modern and technologically advanced. The more careful treatment of dualism will mean for our purposes that the economic model of the developing countries must be multi sectoral, that distinctions must be made between modern and traditional methods between and within sectors, and that studies of industrialization will focus on the growth prospects for the modern sector and its interrelationship with the traditional sectors.

In some countries, feeding of the domestic population is an overriding economic problem. The solution of this problem centers in the more traditional agricultural sector. In order for industrialization to go forward there has to be a solution to the food problem, either through enhancement of domestic agricultural productivity, through trade, or through aid.

7. Population Pressures: A reason why provision of adequate food is a basic problem of primary importance for many developing countries is that they enjoy a birth rate that keeps a population pressure on available food supplies. Population pressures may develop in other directions, as well. Associated with the growth in total output (food and nonfood) there may be a growth in population that holds down the overall per capita growth rate.

Population growth rates in developing countries have been more than twice as high as those in industrial market economies. The Socialist countries are at an intermediate position. The pertinent comparisons can be seen in Table 8.

In model building for developing economies, it is not so much the fact that population growth is a serious problem and that many countries have not learned to cope with the problem; it is that population must be given endogenous treatment within the model. Many, if not most, economic models treat population as an exogenous variable that is to be left to the expertise of demographers. This is narrow minded and over specialized.

Table 8

Population Level and Rates of Growth 1963-1969

Area:	Total, 1969 (in thousands)	Average Rate of Growth (1963-69) (in %)
World	3,561,000	2.0
Developed market economy countries	749,000	1.1
Developing countries and territories	1,685,000	2.7
Socialist countries	1,127,000	1.6

Population does have many unique noneconomic aspects, but it is a genuine endogenous variable that has much bearing on economic performance and is greatly affected by economic performance. Birth rate, death rate, net emigration, internal distribution, and other important demographic characteristics must be built directly into the models to be constructed for the developing countries. Short run population movements may have a large degree of exogeneity, but medium and longer run movements that are so important for the study of industrialization should be modeled in a formal sense from the beginning.

8. Population Migration from Rural to Urban Sectors: It was just remarked that not only population size but its distribution is significant for the economics of industrial development. Also, in the discussion of "dualism" it was noted that the urban/rural dichotomy was a gross representation of what was meant. The shift of population from rural to urban sectors that we see going on over the entire world must be explained and fully incorporated into the models of developing countries.

This demographic shift will be associated with income distribution, which has been singled out as a primary consideration for developing country models, and also with technical efficiency in agriculture. As agriculture becomes more efficient, rising output can be achieved with smaller labor requirements either absolutely or relatively, at the same time that increasing opportunities in the industrial/urban sector are becoming available. In these circumstances, there should be a shift of population from rural to urban centers in relation to relative earnings and job opportunities in the two sectors. This demographic shift has been observed in advanced industrial economies--some already at a stage of industrial maturity and some in the developmental stage. In the latter category, Japan stands as a prime example of a country where this kind of demographic shift occurs, after World War II, before the country achieved nation status.

The statistics in Table 9 indicate that urbanization is taking place all over the world, but the greatest percentage growth rates in the urban fraction is taking place in the developing world.

9. Foreign capital imports: The developing nations, in the process of industrializing, will have debtor status. There have been historical cases in which countries developed industrially through the medium of domestic savings, but these are exceptional, and it is to be expected that the normal course of industrialization in the near future will be through the medium of foreign investment.

On average, foreign savings represented about 12-13 percent of gross domestic capital formation in developing countries in the 1950's and 1960's (see Table 10). Many individual countries had extremely high fractions with foreign saving accounting for more than one-quarter of domestic capital formation. On the whole, these countries were putting a great deal into capital. The investment proportion of GDP came to more than 15 percent.

Foreign capital may flow into developing countries in different forms. Some of it will be direct investment by multinational corporations. This may be, by law or custom, in joint ventures or wholly owned foreign enterprises. Some foreign capital will come as aid, or as loans from developed country governments, or as loans by internationalorganizations. A major consequence of the necessity of this capital flow, regardless of the specific composition among sources, is that a considerable debt or equity servicing will be required on a regular annual basis. One immediate observation is that the central aggregate output measure in developing country models will be GDP and not GNP. The two differ by net factor payments abroad.

Table 9

Degree of Urbanization

	% Urban Population 1950	1960	% Growth Rate (50-60)
World	28	33	18
More developed major areas	52	59	13
Europe	53	58	9
Northern America	61	70	15
Soviet Union	39	49	26
Oceania	56	64	14
Less developed major areas	18	23	28
East Asia	15	23	53
South Asia	16	18	13
Latin America	41	49	20
Africa	14	18	29

Source: Growth of world urban and rural population, 1920-2000, United Nations, pg. 12, Table 1.

Table 10

Foreign Savings and Gross Domestic Capital
Formation, 1953-55 and 1962-64 for Selected Countries

Country	Gross Domestic Capital Formulation as a % of Gross Domestic Product		Foreign Savings as % of Gross Domestic Capital Formation	
	1953-1955	1962-64	1953-55	1962-64
Trinidad and Tobago	22	28	16	31
Tunisia	..	22	..	55
Thailand	16	20	15	9
China	16	20	38	10
Colombia	17	19	8	19
Jamaica	15	19	53	17
Rhodesia and Nysaland	29	19	24	1
U.A.R.	..	18	..	23
Venezuela	..	18	..	-24
Burma	21	18	-7	1
Fed. of Malaya	11	18	-81	-10
Ghana	15	17	13	25
Mauritius	14	17	-41	-30
Panama	11	17	38	51
India[b]	8	13	4	24
Ecuador	15	17	12	18
Rep. of Korea	13	16	57	62
Bolivia	..	16	..	43
Paraguay	14	16	9	11
Sudan	10	16	-1	21
Costa Rica	18	15	18	35

Table 10 Cont.

Uruguay	15	15	19	10
Mexico	14	15	4	11
Jordan	..	14	..	145
Philippines	8	14	29	-5
Ceylon	10	14	-36	16
Honduras	15	14	8	12
Iran	..	14	..	7
Iraq	16	14	-33	-10
Chile	8	13	1	19
Morocco	..	12	..	11
Tanganyika	..	11	..	-9
El Salvador	..	11	..	2
Guatemala	9	11	1	26
Republic of Vietnam	..	10	..	141
Average, all Developing Countries [a]	15	16	12	13

a including estimates of countries not shown based on 1960 prices and exchanges rates.

b rates based on net domestic capital formation.

Source: U.N., World Economic Survey, 1962, Table I-II, p. 39.

The existence of capital flows into the developing countries means that their money supplies will be directly dependent on international capital movements and, to a large extent as argued above, outside the influence of domestic monetary policy. Another consequence that will be reflected in model structure will be the relationship between domestic investment outlays and net capital transfers from abroad. This reinforces the decision not to adhere strictly to standard neoclassical specifications of investment functions but to allow a direct exogenous influence from foreign capital decisions. These decisions will be partly profit-maximizing by multinational firms or individual investors and partly political or diplomatic, under the influence of overseas governments and international organizations.

10. Import substitution: Imports of foreign capital by developing countries will take the form of food (in some cases), other consumer goods, materials, fuel, and capital goods. Capital goods imports will be the physical counterpart of the financial capital flows discussed under point 9. These goods will be largely machines and equipment that cannot yet be produced locally. Either they cannot be produced efficiently, or they cannot be produced at all. There is no realistic possibility of import substitution in this case, just as there will probably be no possibility for the case of many materials or fuel. Some of these, of course, will be found available domestically, as in oil-producing states of the Middle East, Africa, and Latin America.

Import substitution can, however, occur in the case of consumer goods and to a certain extent in the case of foods. In the usual equations for imports, we expect to find a positive net correlation between imports and domestic activity.

$$M = M(X, P_m, P, r, d, R)$$

$$\frac{\partial M}{\partial X} > 0$$

where

M = imports

X = GDP or a component of it, or income

P_m = import price

P = domestic price

r = exchange rate

d = duty indicator

R = foreign exchange reserves

If a policy of import substitution is being followed, however, we should find a negative net correlation

$$\frac{\partial M}{\partial X} < 0$$

As domestic production increases, a flow of goods that can substitute for imports becomes available, and the negative correlation results.

A similar result occurs for food. If the domestic harvest is good there is less need for imports. The higher is domestic output of agricultural commodities, the lower is the flow of food imports. The activity variable on the right hand side of import equations must be quite specific. In the case of food imports, it should be agricultural production. In the case of other consumer goods, it should be industrial or manufacturing output in specific lines of activity.

In order to implement a policy of import substitution, there may be direct controls on imports; there may be preferential schedules of exchange rates and duties; or there may be subsidies to domestic industry. If policy works through exchange rates and duties, these variables should be included explicitly in the import equations.

11. Political instability: Small samples and less precise data may be responsible for error in the estimation of models of developing countries, but a major contributing factor will be lack of stability in the underlying patterns of behavior. Many causes are responsible for the lack of regularity, but a substantial influence must surely come from comparative political instability. It is very difficult to quantify and measure political variables in economic models of developing countries, yet it must be fully recognized that they are present.

Some first attempts have been made in connection with models of Brazil[1] to introduce relative strength of political parties in an economic equations system. This is more interesting as an academic experiment than as a firm possibility for a working model. A much simpler and more superficial approach has been to introduce political "dummy variables" in an economic model. Thus,

[1] See Marzouk, S.H., Bibliography.

the investment equation of the Mexican Model contains the variable

DUM10 = 1.0 in 1952-53, 1958-59, 1961-63, 1964-65, 0.0 otherwise

This variable assumes the values of 1.0 principally, but not exclusively because of changes in political regimes, every six years, and exerts temporary retarding influence on private fixed investment. It is a political event that disturbs economic behavior, but it has been so regular that we can try to take account of it in sample estimation. In post-sample applications to 1970-71 it was correctly inserted into the estimated equations and produced, with foresight, good econometric results. In a rudimentary way, therefore, political effects can be taken into account.

Pure political instability, as distinct from political regularity would not help in estimation or simulation of developing country models. It would make for greater error variance and less certainty for parameter estimation and extrapolation error. This is a limitation that must be kept clearly in mind by model builders dealing with developing economies.

This list of special characteristics of developing country models is undoubtedly not exhaustive, but it covers the major issues that have a common thread across many developing economies. In building models for these cases, we should keep these points firmly in mind to see that they are properly reflected in the system ultimately emerging. There are enough important issues detailed in this listing to render the developing country model distinct from a mere imitation of the typical industrial country model. It is definitely not a case of following blindly the specifications that work for US, Canada, Japan, UK, Netherlands, Germany, and the like--simply collecting new data series and estimating new values of coefficients. It is a case of constructing models from first principles that bring out clearly these specific aspects of developing economies.

II. Examples of Models for Developing Countries

An illustration of the main points made in the preceding section will be drawn from research on model building for Mexico--a project that has been in progress for more than seven years and developed to a point where the model is used regularly for economic analysis, forecasting, and policy formation. The complete model is to be published elsewhere [NBER], therefore it will be treated only in outline form in this discussion.

Outline of the Mexican Econometric Model

I. Generation of Aggregate Demand

1. Domestic demand (private/public consumption, private/public investment, inventory change).
2. Foreign demand
   a. Exports (cotton, coffee, sugar, nonferrous metals, manufactures, tourism, border transactions).
   b. Imports (capital goods, raw materials, fuel, tourism, factor payments).

II. Generation of output

1. Primary production
2. Secondary production
3. Tertiary production
4. Capacity output (primary and secondary/tertiary)

III. Demographic processes

1. Urgan labor force participation rate
2. Rural labor force participation rate
3. Urbanization

IV. Income formation

1. Wage rate
2. Wage income
3. National income

V. Price formation

VI. Taxation

1. Federal income taxes
2. Federal export taxes
3. Federal import taxes
4. Federal sales taxes
5. Other federal taxes
6. Federal non-tax income
7. Non-federal (state and local) taxes

Statistical equations for all these outlined sectors or variables together with identities make up a complete model of 143 equations. A data bank for all the variables by years since 1950 is regularly up-dated. An efficient computer program exists for simulating this model for decades (by years) or other lengthy periods.

There are many ways by which this model relates to the discussion in section I.

1. Conditions of supply. Production equations in primary, secondary, and tertiary sectors are stated explicitly in the model. The industrial sector is concentrated in the secondary category but many branches of industry concerned with the

infrastructure are in the tertiary sector (electric power, transport, communications, etc.). In addition to equations of production in which output is regressed on components of final demand, there are capacity output equations that relate potential production to available capital, the latter being determined by cumulating net investment totals. Capacity production is estimated separately for agriculture, on the one hand, and a combination of secondary and tertiary industry on the other. The reason for combining the latter two is that separate investment data were not available for each.

2. Exports of basic materials. Mexico's leading exports are individually modeled, as functions of price and market demand conditions. There are separate equations for cotton, coffee, sugar, lead, copper, zinc, manufactures, tourism, and labor (Braceros). Many of these equations depend directly on US demand conditions, as Mexican export activity is mainly with the U.S.. Market conditions in countries that compete directly with Mexico in world supply of these particular exports are also included.

3. Inequality of income. In the present version of the Mexican model, the role of income distribution does not appear explicitly. In some trial equations, factor share distribution has been used. In this form, consumer spending is linearly related, with separate coefficients, to wage and to nonwage (profit type) income. The marginal propensity to consume out of wage income is approximatley unity, and out of nonwage income approximately 3/4. These coefficients are not unlike those estimated for a model of Peru, but in that case, the nonwage

coefficient was as low as [illegible] the factor share function is carried another step [illegible] to nonwage income and la[illegible] stock, we have added influence from (factorial) income distribution. This equation looks reasonably good but fits the Mexican data less closely than a generalized accelerator function, and the latter is presently used in the working model. Thus, income distribution shows signs of imputance but does not play an essential role in the present versions of the model.

4. Money supply: In a later sector the full structure of a monetary sector for the Mexican economy will be spelled out. It will be seen, however, that money supply is a direct function of, among other things, the domestic deficit and the net foreign balance.

5. Domestic capital markets. This aspect of economic structure will also be clarified and elaborated in the subsequent section on the model of the Mexican money market. It should be mentioned now, however, that tightly considered interest rate changes do not affect capital spending decisions in the Mexican as in many industrial country models. Private investment follows a strictly physical (flexible) accelerator pattern while public investment depends on public fiscal variables and the flow of credit funds to the public sector.

As the monetary sector becomes more developed and as better monetary-real linkages are constructed, it is expected that the flow of financial funds made available by the monetary sector will become the dominant variables in the capital formation [illegible]. It will, therefore, be demonstrated that it is, [illegible], possible to model the monetary sector in a developing country but that it may take on a different structural form.

In a model construct of the Indian Money Market, Thampy Mammen finds evidence for a more conventional financial system in a developing country.[1] The Indian case represents a briefly developed money and banking system with much English influence. Although, there is little evidence of feedback from interest rates and other financial variables to the real sector, there is good evidence of standard portfolio decision behavior in the holding of financial assets. It is remarkable that the Indian Model simulates well for dynamic movements of a spectrum of interest rates in the neighborhood of rates (2.0-7.0 %) observable in the money markets of most of the advanced industrial nations.

6. Dualism. The distinction between large scale and small scale enterprise is not found in the Mexican model, but the distinction between the primary sector on the one hand and secondary and tertiary sectors on the other plays an important role. Both the final demand equations for output and the capacity production equations are split between these sectors. This is the major aspect of dualism in the system. In the later section on input-output structure, the sector subdivisions are carried much further

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1. See Bibliography and the summary article Thampy Mammen, "Indian Money Market: An Econometric Study", International Economic Review, 14 (February, 1973), 49-68.

to 15 separate sectors in this model. Dualism between the traditional and modern [illegible] does come into display.

7. Population. Aggregate population is definitely a variable in the Mexican model; consumption is estimated per capita and labor force participation rates figure importantly in determining labor supply, but population is not treated endogenously in the model. In principle, birth, death, and net migration rates can be explained but this has not yet been done, except for special consideration of bracero earnings. In later developments, both the total and distribution of population among subgroups will be estimated through an expanded set of demographic equations.

8. Urban/rural distribution. One special aspect of population is treated in some detail in the model, namely, the distribution of labor force between the urban and rural sectors. There are separate equations for the urban/rural population distribution, urban labor force participation, and rural labor force participation. Total capacity, idle capacity, and productivity in the two sectors account for the shifts of population and work force from rural to urban centers.

9. Foreign investment. Imports of capital goods depend in part, on accumulations of foreign reserves. These may be earned through exports or from foreign capital inflows. On the other hand, foreign investment must be serviced; therefore equations are developed for payments of interest and dividends abroad--both public and private.

10. [illegible]. [illegible] concept to isolate statistically, but the equation for capital goods imports contains a term for domestic manufacturing output with a negative coefficient attached. As domestic manufacturing output rises ceteris paribus, imports of machinery and equipment decline. This is evidence of import substitution, but it is not widespread in the Mexican case. It is only in this one equations that we observe this phenomenon. It is thought to be more relevant in models of other Latin American economies.

11. Political instability. Mexico is not unstable, as are governments in other Latin American countries. We do find significant impact of political developments in Mexico, especially in the presence of a political "dummy" variable in the private investment equation to signify the tendency of new governments to depress investment especially in the beginning transition year of each new term.

All the special aspects of developing country models are not present in the Mexican case, but many are. It is evident that the model of Mexican development is specially designed to fit the situation of the country and is far from being a copy of the type of model that is appropriate for advanced industrial economies.

The Mexican Model has been simulated over the period 1971-76 and in some cases until 1980, under different assumptions about public policy. For the purposes of studying industrial development, it is instructive to look at the assumptions of two contrasting public policies.

Table 11

Assumptions for Policy Simulations

(growth rates)

	Deflationary Case	Expansionary Case
Government investment	7.5%	9.9%
Federal enterprise investment	6.8	9.9
Public works (highways)	5.0	7.0
Government consumption	7.0	8.7
Bank credit to federal government	7.0	15.0
External debt	7.0	10.0

The public expenditures are largely concerned with infrastructure investment that will promote industrialization. The monetary measures indicate the degree to which financing of industrialization will be supported by the domestic banking system and by the importation of capital from abroad. In the expansionary simulation, industrial output (mining, construction, manufacturing, and electricity) is expected to grow by almost 50 percent, 1971-76. Correspondingly, in the deflationary case, industrial output should grow by less than 40 percent over the same period. The more rapid pace of industrialization adds a full point to the estimated rate of inflation. This is tolerable but not necessarily desirable.

The main point to be demonstrated is that many such simulations can be constructed for realistic policy analysis, each showing the consequences of alternative proposals for industrial development, each proposal having several different dimensions.

III. Highlights of a Financial Model for a Developing Economy: The Case of Mexico

An important link in the chain of events leading to industrialization is the financing of capital formation. This is essential if investment in industry is to be carried on at the high rates needed for strong growth--overall between 5 and 10 percent per annum in real terms. It is a fascinating exploration to determine if financial modeling is possible in the LDC.

Here, we do not attempt to explain the whole model of the financial behavior of Mexico; instead this is an attempt to give highlights of the most important features of the financial sector in developing economies generally, through the medium of the particular case of Mexico.

One of the first aspects that has to be considered in modeling the financial sector of LDC's is that capital markets are not very well developed in such economies, this means that the market is not integrated as it is in the developed economies of Northern America or Western Europe. Thus if the monetary authorities want to influence the levels of aggregate investment expenditure, the changes needed in the rate of interest, given that their effects will not be readily transmitted to the proper place, due to lack of integration of capital markets, may be too extreme for practical consideration. It is rather by working on the availability of credit that the Central Bank can hope to affect the level of capital spending and thus achieve a desired rate of growth, which may be safely assumed to rank high among the goals of developing economies.

It is by making credit available or scarce to different sectors of the economy that monetary authorities can affect the level and composition of the national product. Later, we shall demonstrate how this was incorporated into the model of the Mexican economy through the specification of the investment equation.

How can the economic authorities affect the availability of credit to the private sector? The discussion of this second aspect is closely related to the problem of money supply. Before answering the question, we must look into a third aspect, namely, the problem of money supply.

It has been usual in theoretical models, to treat money supply as an exogenous variable, determined by decision of monetary authorities. However, this is a gross oversimplification of the many complexities involved, especially in the case of developing economics.

In most developing economics, the external sector plays a substantial role throughout the system but has particularly great significance for the stock of money.

If we assume that there are no or limited open market operations and that a 100% reserve ratio is required on demand deposits, changes in the balance of payments situation will affect the supply of money. An excess of inflows over outflows is going to increase the stock of money, and there is very little the monetary authorities can do about it.

A second influence on the stock of money to consider is the Government deficit. This is especially important for two reasons, which also stem from the peculiar character of developing economies. First, developing economies, unlike industrialized nations are more concerned with achieving a rapid rate of growth. This usually implies that the public sector has to take action in building the infrastructure and increasing its expenditure, both of which have to be financed somehow. Second, we find that in LDC's--as is the case in Mexico--that corresponding to a given increase in gross domestic product, the increase in tax revenue is relatively low. This is a consequence of the fiscal tax system which is not as progressive as in DC's. What this implies is that the tax revenue will not be a sufficient source of funds for financing internal deficits.

These two characteristics of developing countries leave open two ways of financing the Government deficit. The Central Bank can simply increase the stock of money by giving direct credit to Government or they can force the Banking system to finance part of such deficit. In the case of Mexico both ways have been used. The Central Bank offers the financial institutions the possibilities of holding their required reserves partly in cash and partly in low yielding Government securities. So it is able to pass on part of the financing of Government to other financial institutions, thus avoiding the excessive inflationary pressures that would be created by financing the whole deficit by issuing money. The Central Bank, however, still has to finance part of the deficit itself. We discussed above that credit availability is an important determinant of private spending. Thus if the Central Bank attempts to get "too much" funds from the financial system for public use it may be endangering the potential growth of private investment and in that way, jeopardizing the goal of rapid economic growth.

This siphoning of funds away from the private sector, however, is to a certain extent counteracted by the borrowing of the financial institutions from the Central Bank: thus we have to consider a third influence or determinant of money supply. That is, the commercial bank's borrowing from the Central Bank. This additional source of funds will permit banks to increase their reserves and thus increase their lending, which will in turn permit new deposits to be made and so on, with a net effect on the stock of money.

Let us now go back to the question of how the policy makers affect the avilability of credit. In Mexico, this is done by manipulating the reserve requirement ratio. The Central Bank can vary this ratio for different types of institutions and for different types of deposits. This gives the banks the alternative of holding low interest government securities which are preferable to holding cash as reserves.

With these observations we are now ready to specify the equations that will capture the determination of the money stock, credit availability and the influence of financial flows on the real sector in Mexico, namely on private investment.

Money Supply:

$$MSC = \underset{(2.497)}{0.822}\ FAEC + \underset{(2.074)}{1.221}\ FTBDEX - \underset{(-10.129)}{1.319}\ DGC + \underset{(2.123)}{2.891}$$

R^2 = .985 S.E. = 1.64 D.W. = 2.07

WHERE:

MSC = Money Supply (defined as currency + demand deposits)
FAEC = Foreign reserves of the system
FTBDEX = Commercial banks credit expansion
DGC = Government deficit (defined as revenues - expenditures)

The equation was fitted to annual series for the period 1950-1970. The only deviation from the specification in the discussion above was to use credit of commercial banks as a proxy for their borrowing from the Central Bank, since these data were not available. The result looks quite satisfactory (the numbers in parentheses are "t" statistics). Historically the foreign reserves and government deficit have been the most significant variables in this relationship.

Credit Available to the Private Sector:

$$FTOTP = \underset{(48.778)}{0.738}\ FTCT - \underset{(-3.869)}{52.192}\ PGFTCT + \underset{(3.102)}{2.660}\ RD - \underset{(-2.343)}{21.9303}$$

R^2 = .99 S.E. = 1.595 D.W. = 2.08

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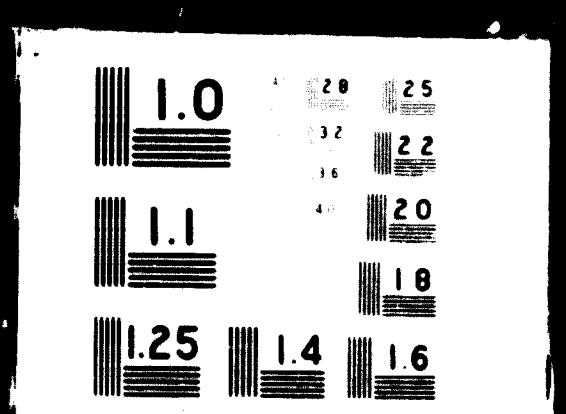

WHERE:

FTOTP = Credit given to the private sector by the financial system

FTCT - Total amount of resources captured by the system

PGFTCT = Financing to Government as a percentage of the total amount of resources captured by the system

RD = Interest rate

The rationale of this equation is that banks' capacity to lend is determined by the amount of deposits they receive from the public, however the banks can choose between lending to the private sector or holding other types of assets like government securities or just cash. To reflect this choice an interest rate variable was used. It is the rate charged on commercial loans and gives the only lending rate available. The rate on government securities was not included. However, it has been fairly stable over the sample period so that no real harm is done by excluding it. The variable PGFTCT which is the financing to government as a percent of the total amount of deposits is used to capture the effect of drawing funds from the private sector to be used by the public sector. The regression results show that all variables included are significant and the equation seems to explain the sample years well.

Private Investment:

This equation is presented to show how the availability of credit influences private spending behavior.

We assume that desired private investment is a function of real variables. However actual investment is going to depend on the amount of funds available. That is:

$I^d = f_1$ (real variables)

$I_a = \lambda I^d$

$\lambda = f_2$ (funds)

thus: $I_a = f_3$ (funds, real variables)

WHERE:

I^d = Desired investment

Ia = Actual investment

λ = Proportion of desired investment actually undertaken

A linear function was fit to the data. The real variables included were: the change in gross domestic product with lags up to 3 periods, and a dummy variable to account for the expectations of the private sector every six years associated with the change of public administration.

We are not going to duscuss the rationale for the real variables included. This is done elsewhere[1]. As regards the funds available, two sources are identified:

(1) Own funds,

(2) Funds borrowed from the financial system.

These two are lumped together to avoid problems of multicollinearity. The regression results were:

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[1] L.R. Klein, Abel Beltran del Rio. "Macroeconometric Model Building in Latin America: the Mexican Case", The Role of the Computer in Economic and Social Research in Latin America, Ed., R. and N. Ruggles, (New York: N.B.E.R., 1973).

$$IPR = \underset{(3.917)}{0.049}\ FNDVPR - \underset{(-2.394)}{0.775}\ DUMPO + \underset{(3.479)}{0.360}\ DGDPR_{t-1}$$

$$+ \underset{(2.866)}{0.304}\ DGDPR_{t-2} + \underset{(3.268)}{1.517}$$

R^2 = .95 S.E. = 0.635 D.W. = 1.90

WHERE:

IPR = Real gross private investment

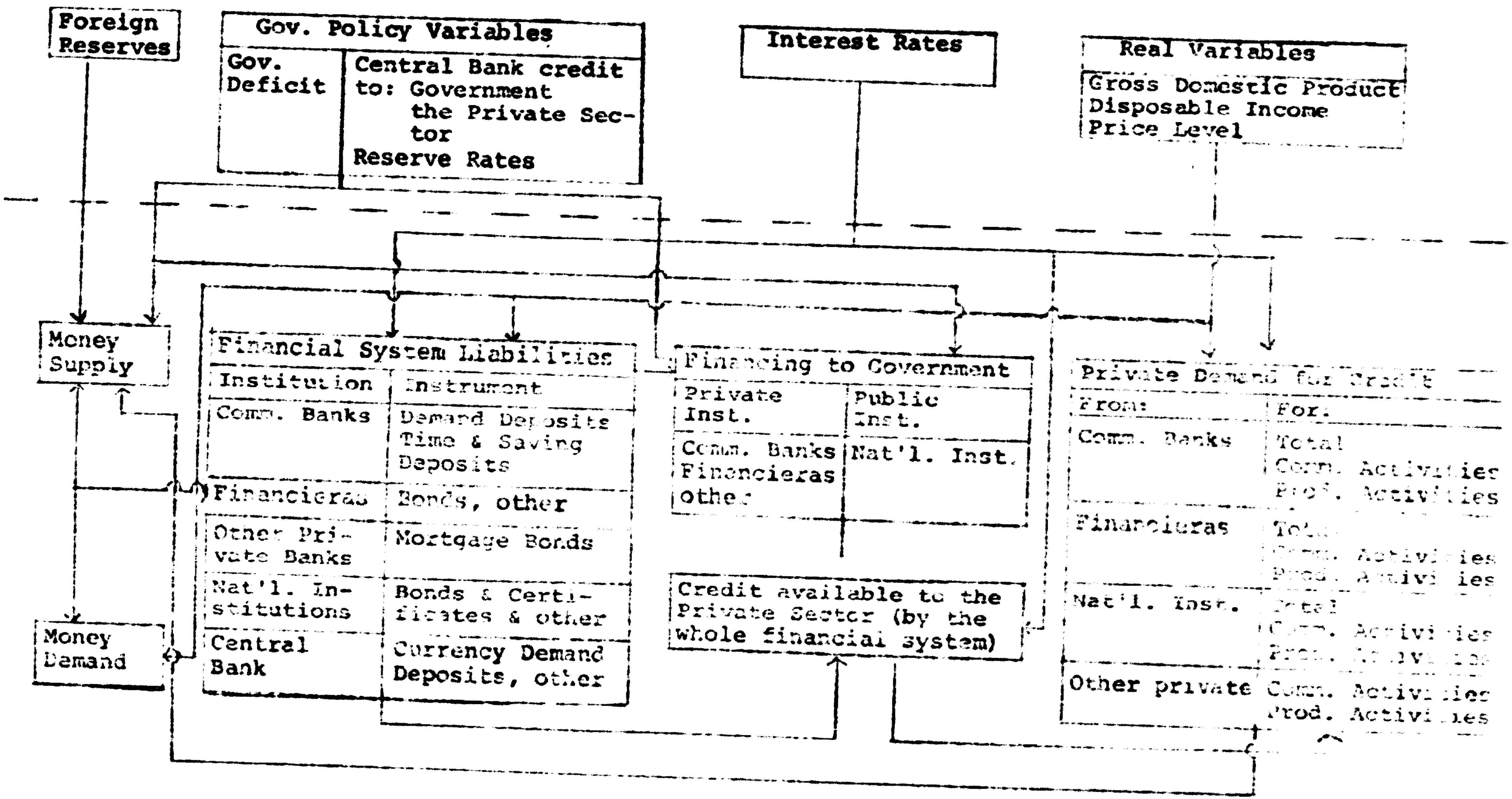
DUMPO = Political dummy

FNDVPR = Credit to the private sector (excludes credit given to commercial activities) + nonwage income + depreciation, the sum deflated by the input GNP deflator

$DGDPR_{t-i}$ = Change in real gross domestic product at time t-i, i = 1, 2.

This completes the highlights of the financial model. The full model includes also equations to explain the financing given to government, total amount of deposits captured by institutions and type of instruments, demand for credit, and price level but these will not be discussed here. However a condensed flow chart is given in Figure (3).

The main points to be emphasized are (1) that financial sectors can be modeled in developing countries, (2) that they have their own distinctive structure based on the institutional organization of money markets, (3) and that financial flows modeled as above can be linked to real capital formation in the rest of the developing economy.



CONDENSED FLOW CHART OF MEXICAN FINANCIAL SECTOR MODEL

Figure 2

IV. Input-Output Analysis Linked to Macroeconometric Models for the Developing Country

In previous sections we have dealt with the broad macro problems of modeling the developing economy as a whole and the financial sector to be linked to the capital formation process. Now we come to the heart of the analysis of industrial development by considering the insertion in the system of an input-output table to show the interindustry flows of goods. That input-output systems exist and are used in the analysis of development of the LDC is well known and definitely established in many separate studies. The new dimension that we investigate here is the possibility of integrating it with the macro model and using both together in the analysis of industrial development. Again we continue with examples drawn from the Mexican case.

The work done in connecting the Wharton-DIEMEX Aggregative forecasting model to a 15 sector I-O table [1] follows the original ideas developed in the Brookings econometric model[2] and on the work of R. Preston.[3]

In Figure (3) we have a chart showing the relationships that exist between interindustry accounting and national income accounting both from the expenditure side and the income side.

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[1] J.A. Ramirez, "Prediccion Industrial Utilizando El Metodo de Insumo-Producto conectado al Modelo V", Mimeo, DIEMEX-WEFA (Nov. 1972).

[2] F.M. Fisher, L.R. Klein and Y. Shinkai, "Price and output Aggregation in the Brookings Econometric Model," The Brookings Quarterly Econometric Model of the United States, Eds., J.S. Duesenberry, G. Fromm, L.R. Klein and E. Kuh (Chicago: Rand McNally & Co., 1965).

[3] R.S. Preston, The Wharton Annual and Industry Forecasting Model (Philadelphia, Economic Research Unit, Dept. of Economics, Wharton School, University of Pennsylvania, 1972). Studies in Quantitative Economics, No. 7, 14-20.

Before going into the details of how the linkage can be done, let us make explicit the identities involved in Figure (3).

Looking at the table across rows, the following holds:

(1) $\sum_{j=1}^{n} X_{ij} + \sum_{k=1}^{m} F_{ik} = X_i \qquad i = 1,\ldots,n$

that is, the sum of industry i's sales to each of n industries (including itself) (X_{ij}'s) plus the sum of its deliveries to each category of final demand (F_{ik}): consumption, capital formation, etc., will be equal to the gross output of industry i.

If we look, instead, at columns, we have the following:

(2) $\sum_{i=1}^{n} X_{ij} + \sum_{k=1}^{w} Y_{kj} = X_j \qquad j = 1,\ldots, n$

that is, the sum of industry j's purchases from all n industries plus the sum of payments to the w factors of productions will equal the total inputs used by industry j (X_j's).

Also we see that the row totals equal column totals:

(3) $\sum_{i=1}^{n} X_i = \sum_{j=1}^{n} X_j =$ GROSS OUTPUT

Looking at the deliveries made by each industry to each of the m final demands we have:

(4) $\sum_{i=1}^{n} F_{ij} = G_j =$ Total final demand j, $j = 1,\ldots,m$

and looking at factor payments,

(5) $\sum_{j=1}^{n} Y_{ij} = Y_i =$ Total payment to factor i, $i = 1,\ldots,w$

Also we know that total spending = total income.

(6) $\sum_{j=1}^{m} G_j = \sum_{i=1}^{w} Y_i = GNP$

For each industry we have the following identities:

(7) $\sum_{k=1}^{m} F_{ik} = F_i =$ Total deliveries by industry i to final demand. $i = 1,\ldots,n$

(8) $\sum_{i=1}^{w} Y_{ij} = Y_j =$ Total payments to factors of production or value added by industry j. $j = 1,\ldots,n$

If we substitute (7) in (1) for each industry or sector we have:

(9) $\sum_{j=1}^{n} X_{ij} + F_i = X_i \qquad i = 1,\ldots,n$

Let us assume that:

(10) $\dfrac{X_{ij}}{X_j} = a_{ij}$

That is that the output of industry j is proportional to its inputs from industry i. Then, (9) can be rewritten as:

(11) $\sum_{j=1}^{n} a_{ij} X_j + F_i = X_i \qquad i = 1,\ldots,n$

or in matrix form as:

$$\begin{bmatrix} a_{11} \ldots a_{1j} \ldots a_{1n} \\ \vdots \\ a_{n1} \ldots a_{nj} \ldots a_{nn} \end{bmatrix} \begin{bmatrix} X_1 \\ \vdots \\ X_j \\ \vdots \\ X_n \end{bmatrix} + \begin{bmatrix} F_1 \\ \vdots \\ F_j \\ \vdots \\ F_n \end{bmatrix} = \begin{bmatrix} X_1 \\ \vdots \\ X_j \\ \vdots \\ X_n \end{bmatrix}$$

or compactly as:

(12) $AX + F = X \quad \text{or} \quad X = (I - A)^{-1} F$

If we know W, we can predict what the gross output vector should be in order to support the given final demand deliveries in vector F.

We can now look into the details of the linkage of the I-O accounting to a macroeconometric model, following the case of Mexico.

There are three kinds of problems that arise when we attempt to go from national income accounting (which is the basis for macroeconometric models) and interindustry transactions accounting. First, we do not have time series observations on final demand deliveries by each industry, what we have are the GNP final demand components, i.e., consumption, capital formation, etc., However for the year for which a direct requirement matrix is available we can obtain this information. By making the assumptions of proportionality and constancy made before, we can transform GNP components into final demand deliveries by industry. That is:

(13) $$\frac{F_{ij}}{G_j} = h_{ij} \qquad i = 1,\ldots,n \quad j = 1,\ldots,m$$

More compactly:

(14) $$F = HG$$

Where F = nx1 vector of final demand deliveries by industries

H = nxm matrix of industrial or sectoral distribution of final demand categories coefficients. (This is obtained for the year that an I-O table is constructed.)

G = mx1 vector of final demand by spending categories.

The second problem we face is the following: In national accounts we deal with value added concepts (Y's); whereas in input-output accounting we deal with gross output concepts. The difference between the two are intermediate transactions.

We can easily establish a relation between the two concepts.

Value added = Gross output - Purchases of intermediate goods

Using our symbols:

(15) $Y_j = X_j - a_{1j}X_j - a_{2j}X_j - \ldots\ldots, - a_{nj}X_j$

or

(16) $Y_j = (1 - \sum_{i=1}^{n} a_{ij}) X_j \qquad j = 1, \ldots\ldots, n$

Let $1 - \sum_{i=1}^{n} a_{ij} = b_{jj}$

Then (16) can be expressed in matrix form as,

(17) $Y = BX$

Where B is a diagonal matrix with its diagonal elements b_{jj} defined as before and off diagonal elements equal to zero.

Substituting (12) and (14) into (17) we have:

(18) $Y = \left[B \; (I - A)^{-1} \; H \right] G$

Let $B(I - A)^{-1} H = C$. This is a matrix with as many rows as sectors in the direct requirement (A) matrix and as many columns as GNP spending component categories. For the Mexican case we have 15 sectors and 6 final spending categories.

Writing out (18) we have:

(19)
$$Y_1 = c_{11}G_1 + c_{12}G_2 + \dots + c_{1m}G_m$$
$$\vdots$$
$$Y_n = c_{n1}G_1 + c_{n2}G_2 + \dots + c_{nm}G_m$$

However, the C matrix, given the properties of the A and H matrices has the property that $\sum_{i=1}^{n} C_{ij} = 1$.[5]

This property implies that:

(20)
$$\sum_{i=1}^{n} Y_i = \sum_{i=1}^{m} G_i = GNP$$

Thus, given the technical coefficients matrix A and the matrix of industrial distribution of final demands H we can establish a link between final demand spending categories (G's) and output originating or value added by sector (Y's). A link that takes into account the structure of industrial interdependence in the economy.

A third problem, however, remains. We have implicitly assumed that the A and H matrices are constant over time. Yet, this is not so in actual life. Technology and tastes change. It is only reasonable to expect the a_{ij} and h_{ij} to change over time even though such changes may be slow and gradual. This

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[5]See R.S. Preston, op. cit., pp. 16-18.

coupled with the fact that such matrices are constructed only every 10 years or so, if at all, will cause our projections made from given A and H matrices to have an error element attached to them.

There are several ways in which we could handle the problem. One could be to try to model each of the elements of the C matrix. However this is not practical given the present availability of data especially data referring to interindustry transactions.

A second and more practical way is as follows: Using time series data for the G sector and given the C matrix a series of $\hat{Y}$ vectors can be estimated from (18), that is:

(21) $$\hat{Y}_{t+i} = C\,G_{t+i} \qquad i = 1,\ldots,T$$

These $\hat{Y}_{t+i}$ can then be compared with the actual Y vectors for the same period, and a series of residual vectors can be constructed.

(22) $$Y_{t+i} - \hat{Y}_{t+i} = U_{t+i} \qquad i = 1,\ldots,T$$

The factors that make for changes in C are the same that give rise to the observed errors U_{t+i}; thus we can attempt to model these errors. There are n equations to be estimated, which is considerably smaller than the number of equations we would have had we tried to model each of the elements of the C matrix. In this case our projections will be made according to the following formula:

(23) $\hat{\hat{Y}}_F = \hat{Y}_F + \hat{U}_F$

Where $\hat{Y}_F$ will be based on the projections of the G sector that come from the macro model according to (21); $\hat{U}_F$ will be the projections of the errors based on the model that is developed for the errors observed in the past.

How can we model the vector U? There are different ways in which this can be done. One way, following the approach of Fisher, Klein and Shinkai[6] is to use autoregressive models. R. Preston[7] uses two such models.

(i) $U_{it} = f\ (U_{it-1}, t) + e_{it} \qquad i = 1,\ldots,n$

(ii) $U_{it} = f\ (U_{it-1}, U_{i,t-2}, t) + e_{it} \qquad i = 1,\ldots,n$

However, if we want to preserve identity (20) the same regressor must be used for each error equation. Otherwise a method to allocate a final discrepancy must be used.

In the case of Mexico a slightly different model was used. After obtaining the observed errors for the period 1951-1971. Principal components were obtained for the 15 sectors' errors. It was observed that the first three principal components accounted for 94.1% of the overall variance of the original series. The following model was then used:

$$U_{it} = f\ (PC1_{t-1}, PC2_{t-1}, PC3_{t-1}) + e_{it} \qquad i = 1,\ldots,n$$

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[6] F.M. Fisher, L.R. Klein, and Y. Shinkai, op. cit.

[7] R.S. Preston, op. cit., 19-20.

WHERE:

$PC1_{t-1}$ = First principal component lagged one period

$PC2_{t-1}$ = Second principal component lagged one period

$PC3_{t-1}$ = Third principal component lagged one period

The merits of this approach are twofold. On one hand the identity of total value added and total final demand (20) is preserved given that the same regressors (the first three components) are used for each of the 15 error equations; on the other hand the use of one-period lags facilitates greatly the extrapolation of the errors.

The next step in closing the circle is to replace in the Mexican Forecasting Model the original separate equations for value added by sector by the new equations that flow from the I-O framework. This is in the process of being done. Since the macro model has only 3 sectors (primary, secondary and tertiary) the input-output equations have to be aggregated from 15 to three. This equation will then feedback into labor requirement equations, wage and price equations and indirectly into demand equations. In this feedback relationship it will not be possible to solve the macro model without the I-O model and vice versa. At present the two systems are being used in a limited way, without feedback from the I-O to the macro model.

Some experiments were conducted using the forecasting macro model and the interindustry model. A forecast for the years 1972-1980 was made, then a disturbed forecast was computed for the same years, the change being a sustained increase of 1 billion pesos in real government expenditures. This was done by adding a constant to the equation for government investment. In the final result, there is both original and induced government investment.

From each of the two simulations, we obtained a different $\hat{G}$ vector. These were then fed into the input-output model, obtaining a <u>control</u> and a <u>disturbed</u> $\hat{Y}$ vector according to (23). With these two vectors we were able to calculate a table of multipliers for each sector and in total.

These multipliers were calculated as ratios of two changes. In the numerator we used the change in $\hat{Y}$ computed from the two sets of $\hat{Y}$ vectors (disturbed $\hat{Y}$ - control $\hat{Y}$). In the denominator the change in government consumption <u>plus</u> the change in that part of capital formation that corresponded to government investment.[8] In this way a table of multipliers by sectors and in total was calculated (see Table (12)).

This experiment can be helpful in detecting possible industrial bottlenecks in the economy. It shows the expansion required in each industry to support a given fiscal stimulus. For example, Sector 1, which is agriculture, should be producing 20.8 additional billions of constant pesos by 1980 as a result of the original and induced increments to spending. If we look at past performance

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8 In the I-O model, private and public investment are lumped into a single item, namely capital formation. The weights used to separate them were those found in the simulations of the macro-model, in which we have separate equations for each.

of Sector 1 we see that for the period 1960-1973 it grew at an average rate of 3.10%.[9] Yet, to get the 29.8% increase that sector will have to grow for the period 1972-1989 at an average rate of 6.7%, more than double the past rate. This may indicate that additional measures should be taken in that sector in order to achieve that growth.

Other examples could be prepared on industrial response to investment stimuli, but that is not the purpose of this section. We merely wanted to show how an interindustry model can be effectively linked to a macro model of a developing economy. The data, methodology, facilities and statistical regularities are available to make this kind of industrial research possible.

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9 See Abel B. del Rio, "Descriptive survey of the Mexican Economy", Chapter 3 of the Ph.D. Dissertation presented to the Faculty of Economics of the Wharton School, Univ. of Pennsylvania, 1973 (Wharton EFA, April, 1973).

[illegible] INCREASE IN REAL [illegible] EXPENDITURES
MEXICAN FORECASTING MODEL CONNECTED TO THE 1960 I-O TABLE

	1972	1973	1974	1975	1976	1977	1978	1979	1980
SECTOR 1------------- (AGRICULTURE)	0.0930	0.1501	0.1905	0.2385	0.2798	0.3199	0.3480	0.3710	0.[illegible]37
SECTOR 2------------- (MINING)	0.0155	0.0182	0.0210	0.0242	0.0273	0.0299	0.0311	0.0315	0.0324
SECTOR 3------------- (OIL & RELAT. PROD.)	0.0290	0.0410	0.0495	0.0598	0.0687	0.0772	0.0829	0.0874	0.0939
SECTOR 4------------- (FOOD & BEVERAGES)	0.0310	0.0555	0.0733	0.0941	0.1127	0.1307	0.1438	0.1552	0.1711
SECTOR 5------------- (TEXTILE & APPAREL)	0.0169	0.0331	0.0427	0.0542	0.0638	0.0733	0.0801	0.0858	0.[illegible]
SECTOR 6------------- (LUMBER & FURNITURE)	0.0192	0.0244	0.0282	0.0329	0.0370	0.0408	0.0432	0.0448	0.[illegible]
SECTOR 7------------- (CHEMICALS & RUBBER)	0.0171	0.0256	0.0311	0.0379	0.0437	0.0493	0.0531	0.0561	0.[illegible]
SECTOR 8------------- (N. FERREOUS PROD.)	0.0221	0.0235	0.0250	0.0270	0.0290	0.0304	0.0310	0.[illegible]	0.[illegible]
SECTOR 9------------- (BASIC METAL IND.)	0.0280	0.0311	0.0338	0.0371	0.0401	0.0426	0.0437	0.0440	0.[illegible]
SECTOR10------------- (FABR. METAL PRODS.)	0.0539	0.0620	0.0686	0.0767	0.0861	0.0905	0.0939	0.0956	0.[illegible]
SECTOR11------------- (CONSTRUCTION)	0.1597	0.1598	0.1658	0.1735	0.1834	0.1889	0.1892	0.1861	0.1856
SECTOR12------------- (ELECTRICITY)	0.0113	0.0144	0.0168	0.0194	0.0223	0.0247	0.0263	0.0275	0.[illegible]
SECTOR13------------- (COMMERCE)	0.2657	0.3628	0.4389	0.5289	0.6118	0.6888	0.7427	0.7872	0.[illegible]
SECTOR14------------- (TRANSPORT)	0.0272	0.0332	0.0415	0.0513	0.0603	0.0688	0.0749	0.0802	0.0877
SECTOR15------------- (SERVICES)	0.0937	0.1447	0.1836	0.2291	0.2707	0.3101	0.3385	0.3628	[illegible]
TOTAL I0-------------	0.8804	1.1790	1.4102	1.6850	1.9348	2.1659	2.3225	2.4461	2.[illegible]

MATRIX "A"

	1	2	3	4	5	6	7	8	9	10
SECTOR 1	0.06310	0.00320	0.00010	0.27330	0.08420	0.09300	0.06260	0.00040	[illegible]	[illegible]
SECTOR 2	0.0	0.23360	0.01340	0.00080	0.00030	0.00140	0.01060	0.04310	0.09700	[illegible]
SECTOR 3	0.01930	0.03570	0.30710	0.01510	0.01430	0.01730	0.01440	0.08420	0.05850	[illegible]
SECTOR 4	0.05160	0.00280	0.00110	0.15590	0.00420	0.00590	0.71490	0.00200	0.00450	[illegible]
SECTOR 5	0.01620	0.00280	0.00160	0.00320	[illegible]	0.00680	0.01070	0.00470	0.00530	[illegible]
SECTOR 6	0.00380	0.00810	0.00770	0.01490	0.00770	0.18520	[illegible]	0.03440	0.00220	[illegible]
SECTOR 7	0.02300	0.02300	0.00560	0.00450	0.05100	0.02390	0.11590	0.01940	0.03720	[illegible]
SECTOR 8	0.00010	0.00280	0.00070	0.01060	0.00060	0.00230	0.00640	0.07120	0.01440	[illegible]
SECTOR 9	0.00150	0.01580	0.01240	0.00490	0.00450	0.00700	0.00750	0.01310	[illegible]	[illegible]
SECTOR10	0.00700	0.01160	[illegible]	0.01080	[illegible]	0.00910	0.01080	[illegible]	0.01220	[illegible]
SECTOR11	0.00440	0.00560	0.00270	0.00150	0.00290	0.00290	[illegible]	[illegible]	[illegible]	[illegible]
SECTOR12	0.00230	0.02460	0.00040	0.00540	0.00460	0.01110	0.00050	0.02570	0.01320	[illegible]
SECTOR13	0.03730	0.03870	0.02020	0.04930	0.11780	0.08620	0.09300	0.09550	0.06700	[illegible]
SECTOR14	0.0	0.00210	0.00140	0.00190	[illegible]	0.00370	0.00340	0.00320	0.00150	[illegible]
SECTOR15	0.00490	0.03520	0.02370	[illegible]	0.02600	0.04300	0.03950	[illegible]	[illegible]	[illegible]

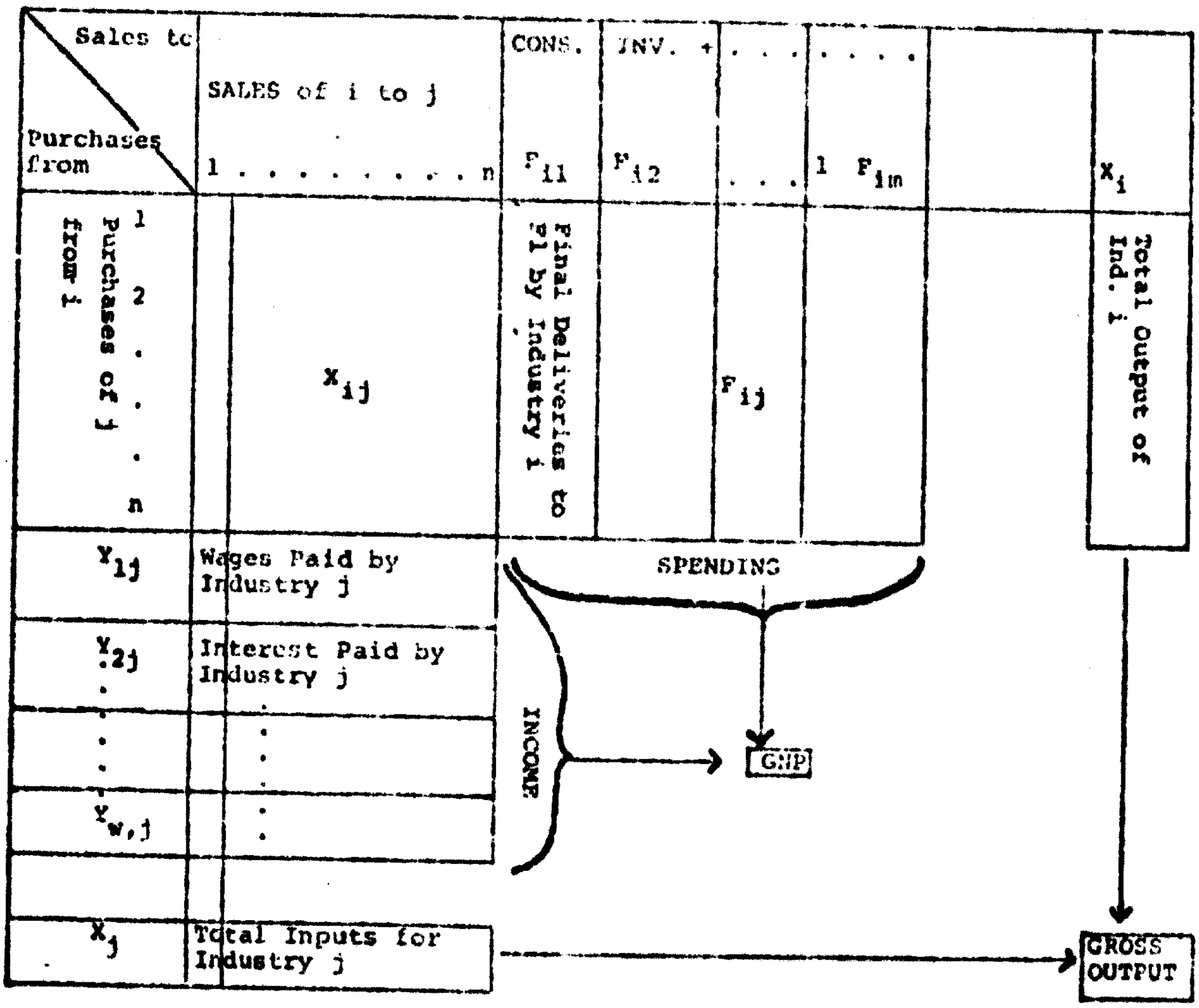
	11	12	13	14	15
SECTOR 1	0.00020	0.0	0.00010	0.0	0.00060
SECTOR 2	0.01550	0.00720	0.00050	0.00090	0.00020
SECTOR 3	0.00890	0.09200	0.00300	0.12710	0.00390
SECTOR 4	0.00290	0.00090	0.00100	0.00350	0.00350
SECTOR 5	0.00270	0.00230	0.00170	0.00150	0.00270
SECTOR 6	0.14460	0.00590	0.00500	0.00600	0.01150
SECTOR 7	0.01370	0.00500	0.00150	0.02780	0.01030
SECTOR 8	0.10250	0.00050	0.00040	0.00020	0.00060
SECTOR 9	0.08370	0.00590	0.00250	0.00340	0.00480
SECTOR10	0.06220	0.02360	[illegible]	0.01200	0.01490
SECTOR11	0.00430	0.01550	0.00160	0.00900	0.01180
SECTOR12	0.00350	0.03630	0.00470	0.00370	0.00500
SECTOR13	0.11910	0.06220	0.00650	0.02700	0.04130
SECTOR14	0.00140	0.00540	0.05490	0.00300	0.00420
SECTOR15	0.02500	0.01950	0.03010	0.03020	0.10780

I-O

Figure 3.

RELATIONSHIP BETWEEN INTERINDUSTRY TRANSACTIONS,

FINAL DEMAND AND FACTOR PAYMENTS.



V. Individual Models for Industries

The input-output method is basic for studying related inter-industrial economic activities, but by the very scope of such systems they are likely to be limited. They are limited in terms of sector detail both from the side of basic data collection and ability to analyze large systems simultaneously. In our example in the previous section, we worked with only 15 sectors. This is large in terms of macro model analysis but small from the point of view of input-output analysis. As an example, the 15-sector case shows the methodology and its potential. It is as large a system as can be strongly linked to a macro model of a developing country, given the usual data limitations that are encountered in this area of research.

Input-output analysis is limited in yet another way. It gives uniform economic and statistical treatment to each sector in terms of a few economic magnitudes. It enables us to project total output and possibly some components of factor increases and final demand. It does not, however, provide an in-depth view of each separate industry. For that view, it is probably better to construct <u>satellite</u> models for individual industries. These can be quite detailed for any single case.

The idea of a satellite model is that it studies the relationships within an industry and its linkages to the national economy through the macro model allowing influences of the latter on the industry being studied, without feedback in the national economy model. Such models have been studied extensively for industrial economies.[1] It is the purpose of this section to show how such systems may be specified, estimated, and simulated for the developing country, again using Mexico for a case study.

A sound way to approach the building of a satellite industry model is to try to build equations that will be capable of generating the main entries, in a complete system, in the accounting statements of the firms that make up the industry. This means that the model should be able to estimate the components of the accounting identity.

Profits = Revenues - Costs.

To estimate total revenues, some classes of demand and market prices for the industry's output will have to be estimated. Similarly, types of cost must be estimated. Retained earnings, after paying dividends and taxes from profits will give the change in net worth in the total balance sheet for the industry. We also have the identities,

$$\text{Assets} = \text{Liabilities} + \text{Net Worth}$$

$$(\text{Net Worth})_t = (\text{Net Worth})_{t-1} + \text{Retained Earnings}$$

It will, therefore, be necessary to estimate the holdings of assets and liabilities, by type, for the industry. At least some asset holdings such as fixed capital and inventories are

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1 See Essays in Industrial Econometrics, I, II, III, Ed. L.R. Klein, (Philadelphia: Economic Research Unit, University of Pennsylvania, 1969, 1969, 1971).

important for studying investment in the economy as a whole.

The first step is the more necessary, namely, to estimate revenues, costs, and the industry's profits. Attention will be centered on this aspect of model building in this section.

Revenues for the industry will be determined by the demand for their products and the prices that these products command in the marketplace. Costs can be directly estimated from a total cost function or from a system of factor demand functions, factor prices, production function, and some miscellaneous cost items.

Links to the national economy will come about because national income will undoubtedly affect demand for the industry's output and general price movements will have a bearing on the industry's price movements. These are linkages without feedback that connect satellite models to national macro models.

Factor input demand will depend on industry output and factor costs. The latter, in turn, will probably depend on national wage, interest, and materials prices movements. This provides another linkage, also without feedback from the industry to the nation. The model, then, will show how national economic trends will work out in the form of specific industry trends.

In the Mexican case, studied on a proprietary basis, a beverage industry model specifies that demand depends on real price, real income, and some natural factors (rainfall and temperature) that affect "tastes".

$$X = f_1 (Y, Y_{-1}, \frac{pX}{pG}, (\frac{pX}{pG})_{-1}, T, R) + e_1$$

X = output for the industry
Y = national disposable personal income
pX = price (index) of X
pG = price (index) of GNP
T = temperature
R = rainfall

The demand equation is specified for a single product being consumed in the domestic market. Multiple products could be handled by using a whole series of appropriate demand functions. Also export sales would depend on foreign demand conditions such as foreign incomes and competing prices.

Next, we have an equation for industry price, pX:

$$pX = f_2 (TC/X, (TC/X)_{-1})$$

TC/X = unit cost (Total cost divided by output).

This equation is based on the assumption that prices are, with a lag, marked up on unit cost. The production function has the form:

$$X = f_3 (L, K, t).$$

It may be normalized with output (X) a function of factor inputs or with labor requirements (L) a function of output (X) and capital (K). In any event, this equation will enable one to estimate total employment for a given level of output. The level of output, in turn, will be obtained from the demand functions.

In order to estimate costs for the profit calculation, labor input must be valued at prevailing wage rates (wL). Wage equations, as a function of national wage and labor market conditions, together with industry-specific variables, can be constructed. Similarly, capital costs can be calculated by using interest and depreciation rates in the expression:

$$(r + d)K.$$

Costs of materials, maintenance and other current inputs could also be evaluated in separate equations.

A way of simplifying and condensing the whole model, however, is to estimate directly a total cost function that is consistent with the technology expressed in the production function. Generally speaking, a cost function derived in the usual way in economic theory of the firm, will take the form:

$$C = f_4 (X, w, r, C_m, C_o, t)$$

C = cost in current prices
X = output in constant prices
w = nominal wage rate
r = money interest rate
C_m = nominal unit cost of materials
C_0 = nominal unit cost of "other" inputs.

If the production function is log-linear, the associated cost function should also be log-linear.

If for a given output level, determined by demand conditions, the production function provides estimates of labor requirements, there is need for a separate equation to estimate capital requirements. This is known as an investment function in the terminology of macroeconomic models. What is needed in the present instance is an estimate of an industry investment function.

$$\Delta K = f_5 (X, r, d, K_{-1})$$

This is a flexible accelerator version of the function in which output, beginning capital stock, and unit capital costs are the main variables. It would also be possible to introduce financial constraints from retained earnings and the supply of credit to the industry from the financial sector. The last-mentioned variable would be related to the financial market model, as discussed in a previous section.

Finally, the system would be closed with the estimation of equations for wage rate (discussed above) and other unit input costs for capital and materials. To a large extent these variables would be estimated as functions of national economy variables which serve as the links in the chain of influences from the overall models to the sector satellite models for individual industries.

In this outline sketch of the design of an industry model, it has not been possible to give complete numerical results because of the proprietary nature of such systems, yet it can be asserted that satellite solutions of industry or other sector models can be obtained by using the output of simulations from national models as input values for the industry models. In the

Mexican case, and certainly in many others for developing countries, there are enough data now to construct the whole sequence of models that are necessary for the study of industrial development. In particular the overall macro and financial sector models can be designed to yield the kind of output that would be needed to operate industry models. Moreover, there is enough statistical regularity in industry data series to provide a basis for the estimation and simulation of the satellite model.

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