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A SIMULATION MODEL FOR ECONOMIC PLANNING: A PAKISTAN EXAMPLE

by

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I. Introduction

For purposes of economic planning, the primary function of any model is to provide a systematic procedure for quantifying the effects of alternative economic policies. Given a specified development plan, a simulation model will derive the implied time path for each of the relevant measures of economic activity. If the model accurately describes the economy, the simulation results will provide the policy-makers with the information necessary for choosing among the alternative plans. Unlike an optimizing model, the simulation model does not itself choose among the alternatives - that task is left to the planners.

Section II below provides a description of the general simulation model being used and section III then presents some illustrative results obtained by applying the model to Pakistan The simulation results show first how the model can be adjusted to conform quite closely to the actual behavior of the economy. After it is calibrated, the model is used to compare several alternative economic policies for the period 1965-69. Finally, the model is used to trace out the implications of alternative rates of import substitution. Particular attention is paid to

the relationships among savings rates, trade deficits, and rates of growth of output.

It should be emphasized that the results presented here are primarily designed to illustrate some of the uses to which the model can be put. While the results should be relevant to the actual Pakistan situation, they must be interpreted with a good deal of caution. This is particularly true since the input data was not compiled as carefully as would be advisable in an actual planning application.

II. Structure of the Model

Empirical implementation of a simulation model, of course, requires that each behavioral relationship be adapted specifically to the particular country. However, in most cases, it should not be necessary to make major changes in the logical structure of the model. The basic economic characteristics of many developing economies are sufficiently similar that they can be described within the same general framework. The model presented below is designed to provide this sort of general, analytical framework. To facilitate adaptation to specific empirical conditions, the relationships in the model

have been made as flexible as possible. Usually the adaptation can be accomplished simply by changing the values of the relevant parameters. Unfortunately, relationships which satisfy the requirement of flexibility also tend to be rather complicated.

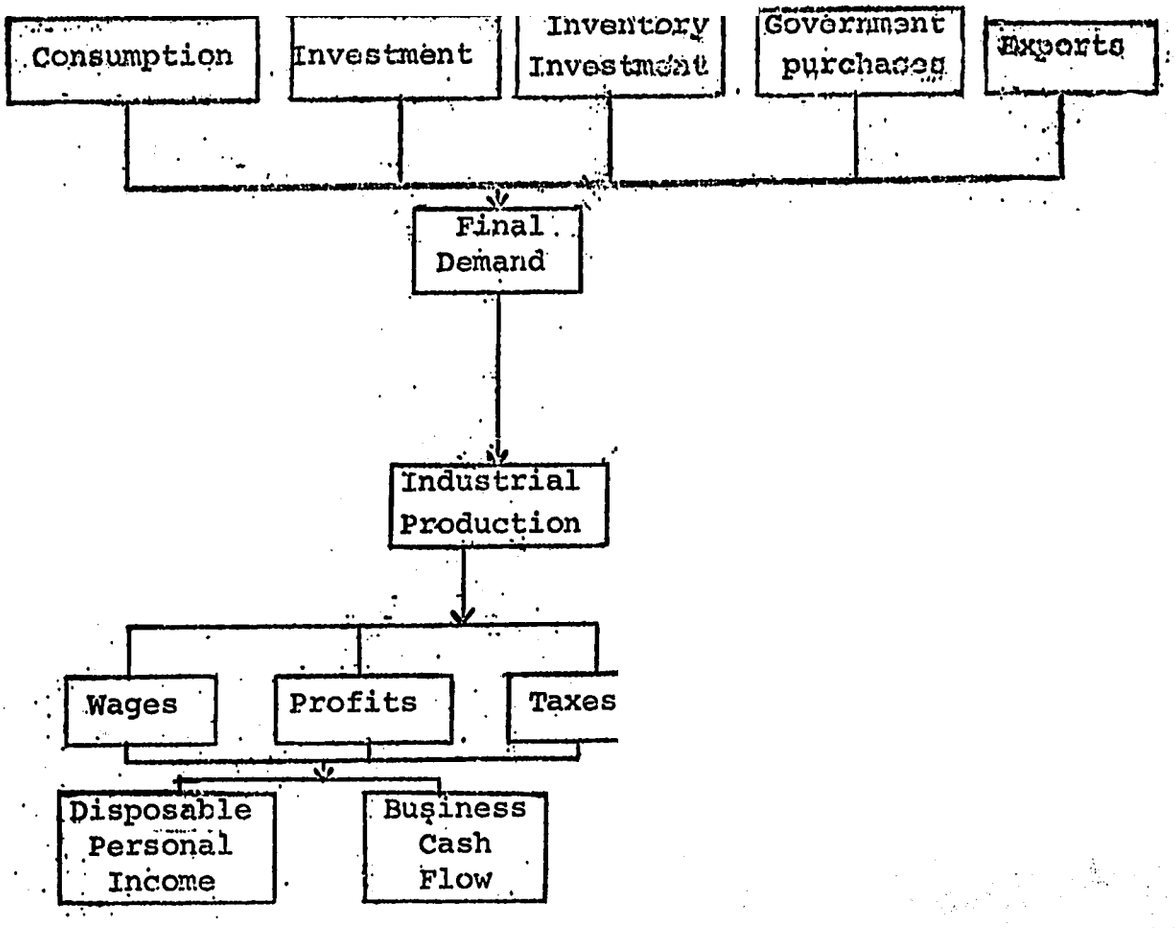
In its operational form, the simulation model handles an enormous number of variables and is extremely complex. Indee one of the principal dangers of a simulation model is that it can overwhelm an unwary user with masses of detailed information. But this is a danger that is easily avoided. The detail of the model should not be allowed to obscure its relatively straightforward economic logic. The basic structure of the model can be outlined in just a few sentences as below or shown in a simple flow diagram as in Figure 1.

The computations performed by the model can be divided into three major blocks: those dealing with (1) final demand, (2) industrial production, and (3) income. Final demand is composed of personal consumption expenditures, fixed investment, inventory investment, government purchases, and exports. Within each of these categories, demand is estimated on the

basis of individual commodities. That is, if the output of the economy is classified into ten commodity groups, final demand will be estimated separately for each of those groups. These estimates are largely based on exogenous variables, such as government policy variables, or on the outputs and incomes of the preceding time period.

Given the final demand for each commodity, the model next uses an input-output table to compute the industrial production required to meet those demands. Finally, the third block of computations determines the distribution of income associated with the estimated levels of industrial production. Wage payments are related to industry outputs; profits are derived from estimates of revenues and costs; and taxes are related either to output, to wages, or to profits, depending on the type of the tax. From the above, it is possible to estimate disposable personal income and the cash flow to businesses. These items, together with the output figures and the exogenous variables, provide the information required to carry the simulation into the next time period. At this point, the computation procedure simply repeats itself.

Figure 1


Consumption
Investment
Inventory Investment
Government purchases
Exports
Final Demand
Industrial Production
Wages
Profits
Taxes
Disposable Personal Income
Business Cash Flow

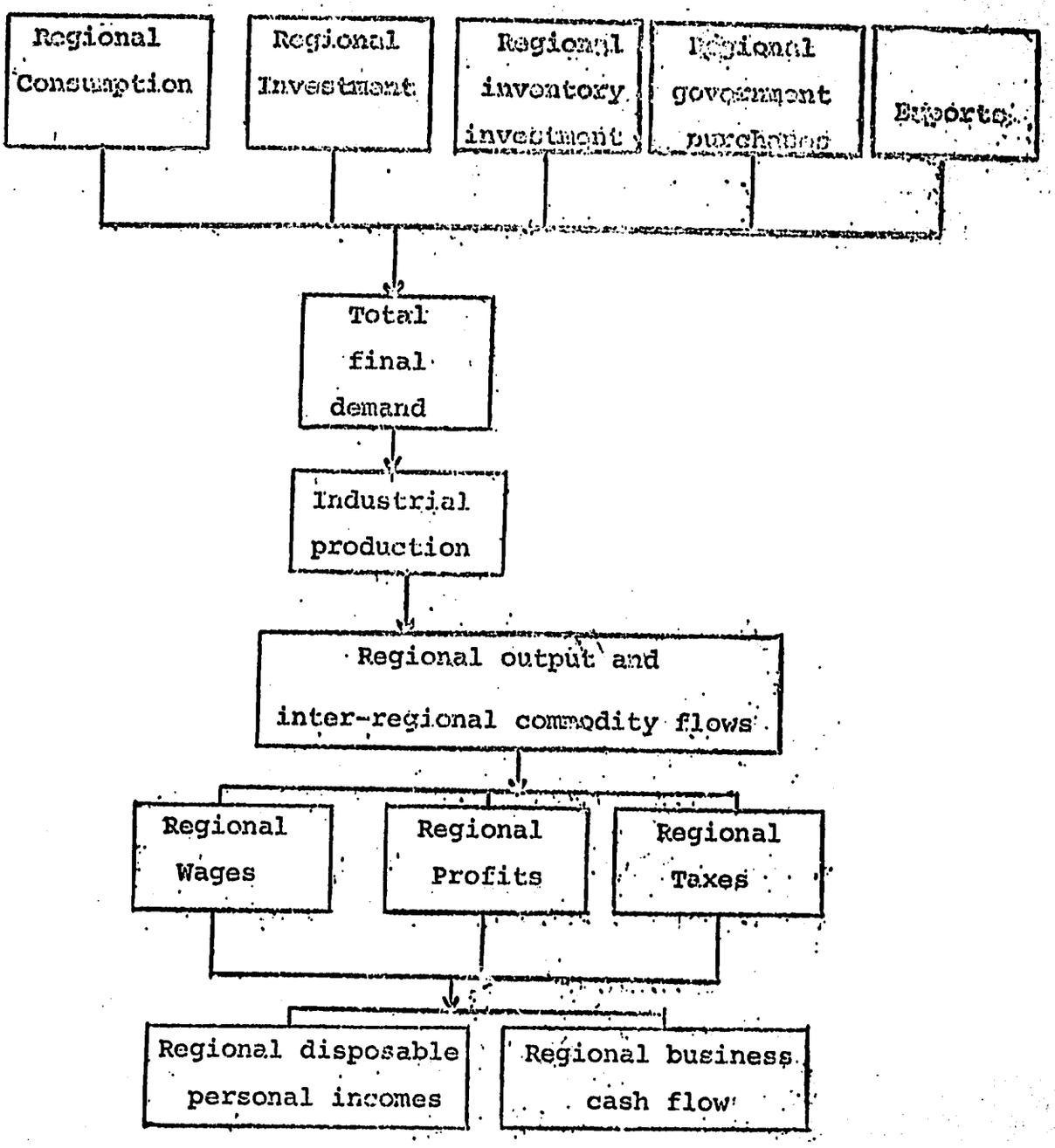
The picture of the model given by this highly condensed outline is obviously far from complete. The outline does, nontheless, provide a broad overview that can give some order to the more detailed discussion to follow. Through all its convolutions and variations, the model will retain this same logical structure. There is, however, one feature of the model that will require some modification of this structure.

Most of the relationships in the actual simulation model are specified on a regional, rather than a national, basis. Disaggregation into geographic regions is, of course, necessary if the results of the model are going to be used for transport planning. The regional measures are, in addition, often of direct interest to the economic planners. In a number of countries, the problems of regional development are just as pressing and difficult as are the problems of national development. The price that must be paid for obtaining regional information from the model is a sharp increase in the number of variables which must be manipulated; also the need to estimate regional output and inter-regional commodity flows adds a fourth major block of computations to the model.

With the introduction of regional variables, the structure of the model appears as shown in Figure 2. The components of domestic final demand are now computed on a regional basis. Since exports go only to the outside world, they do not need to be disaggregated regionally. Total final demand for each commodity is obtained by summing the regional demands. As before, the input-output table is used to translate final demand into industrial production. Since there is virtually no hope of empirically estimating regional input-output tables, industrial production is here estimated an a national basis.

The next block of operations, and this new block is the only change in the basic structure of the model, allocates the national industrial output to the various regions within the country. The flows of individual commodities from each region to all other regions are also computed at this point. Having determined these flows, the model proceeds as before to compute incomes. These incomes, which are now computed regionally, again serve as inputs for the estimation of final demand in the next time period.

Figure 2


Regional Consumption
Regional Investment
Regional inventory investment
Regional government purchases
Exports
Total final demand
Industrial production
Regional output and inter-regional commodity flows
Regional Wages
Regional Profits
Regional Taxes
Regional disposable personal incomes
Regional business cash flow

The Basic Simulation Model

Within the framework just outlined, this section will describe the individual functions used in the basic simulation model. To keep the discussion reasonably comprehensible, many of the details, particularly those concerning computational procedures, have been omitted. In the notation used below, the letters I, J and L refer to the Ith, J^{th}, and L^{th} industry or commodity. The letters appear in parentheses following the variable to which they pertain. In a similar fashion, the letters M and N will be used to refer to regions. Thus C(I,M) is the consumption demand for the Ith commodity in region M. Unless indicated otherwise, summations run over all commodities or all regions. Non-subscripted variables are measured in the tth, or current time period; variables measured in the previous time period will appear with a (t-1) subscript. Though the time periods can, in principle, be of any length, they are here treated as years.

Final Demand

Consumption.

Total personal consumption in current prices, CEXP, is assumed to be determined solely on the basis of the income received in the previous period, Y_{t-1}.

$$CEXP(M) = ALPHA * Y(M)_{t-1} \qquad (2.1)$$

The parameter ALPHA is the average propensity to consume out of lagged income. It should be observed that ALPHA, like all other parameters in the model, is exogenously determined but is not necessarily constant over time. If there is reason to think that there is some secular trend in the propensity to consume, ALPHA can be varied in accordance with that trend. In fact, any parameter or any exogenous variable can be changed at the start of each time period. This capability gives the model much more flexibility then the relatively simple form of some of the functions would at first indicate.

The consumption of an individual commodity, measured in constant prices, is related to total current dollar expenditures and to the price of the commodity. Similar relationships are

used to determine the demand for imported consumer goods, CIMP.

$$C(I,M) = CEXP(M) * APC(I) / P(I,M) \qquad (2.2)$$

$$CIMP(I,M) = CEXP(M) * API(I) / PIMPRT(I,M) \qquad (2.3)$$

Throughout this section, it is assumed that commodity prices are either held constant at the base period levels or are specified exogenously. Since the sum of demands for individual commodities must equal total expenditures, the parameters in these functions must satisfy the following condition:

$$\sum_{I} [APC(I) + API(I)] = 1.0$$

Fixed Investment

The investment function has something for everybody; it contains five separate factors which may play a role in determining the amount of gross fixed investment. Of course, in any particular application, some or most of these terms may be eliminated.

$$RINVST(I,M) = ACCEL(I) * [ROUTPT(I,M)_{t-1} - RPCAP(I,M)_{t-1}] \left[\frac{1}{CME(I)}\right]$$

$$+ CONST(I) * RETAIN(I,M)_{t-1} + EXOG(I) * ROUTPT(I,M)_{t-1}$$

$$+ WTINVS(I) * RINVST(I,M)_{t-1} + XINVST(I,M) \qquad (2.4)$$

The first term in this function reflects a flexible accelerator or capital stock adjustment process. It is assumed that firms will act to keep their capacity in line with their output. If, in the preceding period, output exceeded capacity, that will tend to increase the industry's investment expenditures. As used here, capacity refers to a target or desired level of output and not to any absolute production limit. Therefore, it is quite possible for an industry to produce an output in excess of its capacity, though this will usually involve some increase in average production costs. $\frac{1}{CME}$ is the amount of investment required to support an increase in capacity of one unit. This factor multiplied times the gap between output and capacity gives the amount of investment required to close that gap in a single time period. But, firms may choose to close the gap more gradually; ACCEL is the fraction of the gap which

is made up within one year.

The second term simply says that a larger cash flow, retained earnings plus depreciation, is likely to encourage greater investment. The third and fourth terms are basically inertial factors. So long as the economy in general and the industry in particular continue to expand, investment can be expected to grow along with output. Hence, the inclusion of lagged output, $ROUTPT_{t-1}$. Also, some industries are very sluggish about changing their investment behavior. For these industries, investment expenditures in any given year will be closely related to investment in the preceding year, $RINVST_{t-1}$.

The last term, XINVST, is investment that is exogenously determined. Government investment is, or may be, one example of this type of investment. The channeling of funds into the establishment of new industries is a particularly relevant instance. In some cases, investment by foreigners may also need to be specified exogenously. Finally, if the other terms in the investment function are eliminated, XINVST can be used to set investment equal to the levels appearing in a pre-specified development plan.

Demand for Investment Goods

It should be recalled that in this first block of operations the model is primarily concerned with the estimation of final demand. But equation (2.4) only computes the investment outlays by each industry; it does not compute the final demand for particular investment goods generated by those outlays. To estimate investment demands, it is assumed that investment expenditures can be allocated among investment goods according to predetermined proportions. Each industry has an exogenously specified set of coefficients, B(I,J), which measure the demand for investment good I generated by one dollar of investment expenditures by industry J. The total investment demand for domestic good I is simply the sum of the demands generated by the individual industries.

$$\text{RIDEM}(I,M) = \sum_{J} B(I,J) * \text{RINVST}(J,M) \qquad (2.5)$$

In addition, the investment outlays will usually generate a substantial demand for imported goods. Imports of investment goods are estimated through the use of an analogous set of coefficients.

$$RINIMP(I,M) = \sum_{J} BIMP(I,J) * RINVST(J,M) \qquad (2.6)$$

To keep demands equal to expenditures, the B and BIMP coefficien must satisfy the condition that

$$\sum_{I} [B(I,J) + BIMP(I,J)] = 1.0$$

Inventory Investment

It is assumed that, for each industry, there is a desired ratio between stocks of inventories and the level of output. If inventories during the preceding period were not sufficient to achieve this ratio, firms will add to inventories during the current period. Letting RIF denote the target inventory-output ratio, inventory investment is given as

$$RINVC(I,M) = RIF(I) * ROUTPT(I,M) - RINV(I,M)_{t-1} \qquad (2.7)$$

Inventories are regarded as consisting of final products and are held by the producer. Stocks of raw materials held by producers present no particular problems since they can be treated as incipient final products. Thus, the inventory investment by Industry I is also a final demand for commodity I.

Total Final Demand

The remaining elements of final demand, government purchases and exports, are exogenously determined. As noted above, the rest of the world is treated as a single external region so export demands are not disaggregated regionally. The total final demand for each commodity is equal to domestic demands, summed over all regions, plus foreign demand.

$$Q(I) + \sum_{M} [C(I,M) + RIDEM(I,M) + RINVC(I,M) + GOV(I,M)] + EXP(I) \qquad (2.8)$$

Exports are estimated outside the model because of the need for detailed analysis of specific world markets and of domestic production capabilities. To maintain consistency, the investment function should include any additional investment required for export production. In the case of some commodities, particularly raw materials, it may be more accurate to assume that the country is able to export all that can be produced in excess of domestic needs. Rather than make exports

an endogenous variable, which would greatly complicate the model, this situation can be handled simply by specifying several alternative levels for exports. The simulation results can then be examined to see which alternative seems most feasible on the basis of its associated output levels and capacity utilization rates.

Industrial Production

Given final demand, an input-output table is used to compute the total production of each industry. By definition, total production is equal to the production of intermediate goods plus the production of final products.

$$TOUTPT(I) = \sum_{J} [A(I,J) * TOUTPT(J)] + Q(I) \qquad (2.9)$$

A(I,J) is the amount of good I required in the production of one unit of good J. The input-output table is the matrix, A, comprised of the A(I,J) coefficients. Equation (2.9) can be rewritten to give total output as a function of final demand.

$$TOUTPT(I) = \sum_{J} IA^{-1} (I,J) * Q(J) \qquad (2.10)$$

IA^{-1} (I,J) denotes the elements of the inverse of the matrix obtained by subtracting the A matrix from the identity matrix.

The input-output coefficients are based on the country's production methods and are exogenously specified. Generally, these coefficients will change over time as a result of changes in the underlying technology. If input-output tables are available for two different years, the past rates of change in the coefficients can be used to project future tables. Where direct technological information exists, this too can be used to modify the relevant coefficients.

Regional Disaggregation

Since the simulation results presented later will not involve any regional disaggregation, the details of this aspect of the model can be omitted. Basically, the computations in this section allocate the total industrial output to the appropriate regional production centers and then determine the flows of goods between the various regions. Output is allocated on the basis of relative profitability and productive capacity. Production tends to shift toward those regions which are more efficient or more advantageously situated and which are expanding

their productive capacity relatively rapidly. The pattern of commodity flows is determined using a gravity model and will be altered in response to changes in relative costs of production and transport. Once the flows have been computed, the model proceeds to derive the distribution of income.

Distribution of Income

Wages.

Labor income in an industry is determined by the level of output and by the labor cost per unit of output. Unit labor cost is defined as the wage rate (dollars paid per man-hour) divided by labor productivity (output produced per man-hour). It is assumed that unit labor costs are constant for all levels of production below capacity. When output is pushed above capacity, the industry will be forced to pay higher wages or to hire less efficient workers. In either case, the marginal wage cost will rise. For production levels in excess of capacity, the marginal wage cost is given by the following relationship.

$$\text{WMARG}(I,M) = \text{WAGER}(I,M)\ (1.0 + \text{WOVER}(I,M) \left(\frac{\text{ROUTPT}(I,M)}{\text{RPCAP}(I,M)}\right) - 1.0] \quad (2.11)$$

WAGER, an exogenous variable, is the basic unit labor cost, i.e., the cost that is applicable for outputs less than capacity. The parameter WOVER is the elasticity of the marginal wage cost with respect to overcapacity production. Thus, if output exceeds capacity by 2 percent and WOVER is 3, the marginal wage cost will exceed WAGER by 6 percent. When production is less than capacity, the marginal wage cost is simply WAGER. The industry's total wage bill is the integral, over the relevant output range, of the marginal wage cost. When output is below capacity, the relationship for computing total wage payments reduces to the following:

$$\text{WAGES}(I,M) = \text{WAGER}(I,M) * \text{ROUTPT}(I,M) \qquad (2.12)$$

Profits and Retained Earnings

The value of an industry's sales is computed by multiplying the shipments to each region by the price in that region. Since the selling price includes any sales taxes, the industry's revenue is equal to sales minus indirect taxes.

$$\text{REVENU}(I,M) = \sum_{N} \text{FLOW}(M,N,I) * [\text{P}(I,N) - \text{TAX}(I,N)] \qquad (2.13)$$

FLOW (M,N,I) is the flow of good I from region M to region N.

Production costs include, in addition to labor costs, the cost of materials. Payments for domestically produced goods can be computed using the input-output coefficients, but firms also require some imported inputs. Letting AIMP(I,J) denote the amount of import I required to produce one unit of good J, total production costs are

$$\text{RPCST}(I,M) = \text{ROUTPT}(I,M) \sum_{J} \text{A}(J,I) * \text{P}(J,M) + \text{AIMP}(J,I) * \text{PIMPRT}(J,M) + \text{WAGES}(I,M) \qquad (2.14)$$

Profits, which are defined as all non-wage income and which include depreciation, are equal to revenue minus production costs.

$$\text{PRFIT}(I,M) = \text{REVENU}(I,M) - \text{RPCST}(I,M) \qquad (2.15)$$

If the country imposes taxes on profits, these too should be deducted. After this is done, the profit variable measures the cash flow available to the industry for reinvestment or for distribution to individuals. Assuming that BETA is the proportion of earnings that is distributed, retained earnings (includ...

depreciation) are

$$RETAIN(I,M) = PRFIT(I,M) \left[1.0 - BETA(I)\right] \tag{2.16}$$

Disposable Personal Income

Personal income in a given region equals the labor income from all industries in the region plus the distributed earnings received by persons in the region. Most of the distributed earnings could be more accurately described as the income of owner-operated enterprises. Assuming this to be the case, distributed errnings are received only from firms located within the region.

$$Y(M) = \sum_{I} WAGES(I,M) + BETA(I) * PRFIT(I,M) \tag{2.17}$$

Disposable personal income is obtained by deducting personal income taxes.

$$DPI(M) = \left[1.0 - PTAX\right] Y(M) \tag{2.18}$$

Aggregate Results

The detailed economic quantities discussed above can be combined to produce aggregate measures of economic activity which are particularly useful in providing a summary description of the pace of economic development. Real gross national product (GNP) is obtained by summing final demands and then deducting all imports of intermediate goods.

$$GNP = \sum_{I} Q(I) - \sum_{I} \sum_{J} AIMP(I,J) * TOUTPT(J) \qquad (2.19)$$

Aggregate real consumption and investment are the sums of the regional variables.

$$CONSUMPTION = \sum_{I} \sum_{M} \left[C(I,M) + CIMP(I,M)\right] \qquad (2.20)$$

$$INVESTMENT = \sum_{I} \sum_{M} RINVST(I,M) \qquad (2.21)$$

The final aggregate measure, and one which usually plays a major role in development planning, is the balance of trade.

The value of exports is

$$VALEXP = \sum_{I} EXP(I) * P(I,NREGON) \tag{2.22}$$

where P(I,NREGON) is the price of good I on the world markets. Goods are imported to satisfy the demands of consumers, government, investors, and producers. Thus, total imports into region M of good I are

$$IMP(I,M) = CIMP(I,M) + GOVIM(I,M) + RINIMP(I,M)$$
$$+ \sum_{J} [AIMP(I,J) * ROUTPT(J,M)] \tag{2.23}$$

The total value of imports is

$$VALIMP = \sum_{I} \sum_{M} VALIMP(I,M) * PIMPRT(I,M) \tag{2.24}$$

and the balance of trade is

$$BALANC = VALEXP - VALIMP \tag{2.25}$$

Extensions of the Model

The basic simulation model, as described above, provides a complete set of relations that can be used for simulation experiments. The model has, however, been modified to permit the inclusion of several additional features. The three major changes that have been made expand the scope of the model to include (1) price and wage inflation, (2) import quotas, and (3) detailed analysis of the transport sector. Only the first of these modifications will be described here since that is the only one that is used in the results presented below.

Prices

In the basic model, prices were assumed either to be held constant or to be specified exogenously. But in a number of developing countries, inflation is so rapid and so pervasive that it is itself one of the major concerns of the policy makers. In these instances, it is unreasonable to assume that prices can be treated as predetermined variables. The pace and incidence of inflation will be significantly affected by the pattern of economic development.

In the long run and in an economy characterized by reasonably competitive markets, prices will be determined primarily by costs. Of course, even under these conditions, it is possible for the government to cause inflation by excessive increases in the money supply. Since the model does not include a financial sector, price increases due to general monetary inflation will have to be assumed to proceed at an exogenously determined rate. Apart from this inflation, the price of a commodity will be increased only in response to an increase in average costs. Therefore, when output does not exceed capacity, the pricing function is the following:

$$\Delta P(I,M) = PASSA(I)*\Delta SCA(I,M) + PASSD(I)*\Delta TAX(I,M) + PASSE * P(I,M)_{t-1} \qquad (2.26)$$

PASSA is the proportion of the increase in production costs that is passed on in prices; PASSD is the proportion of an increase in indirect taxes that is passed on; and PASSE is the rate of general inflation. Since prices are measured at the point where the good is sold, the relevant cost variable

is the average cost of supplying the good to that region. The average supply cost, SCA, is a weighted average of the regional production costs where the weights used are the proportions of total supply coming from each producing region.

When output exceeds capacity, the pricing function is expanded to include demand factors as well as costs. Also, marginal cost will now be different from average cost and may have a different impact on prices. The parameter PASSB measures the proportion of an increase in marginal costs that would be passed on if the industry were operating precisely at full capacity. It is assumed that as output is pushed above capacity, firms will tend to increase the proportion of costs that are passed on. Alternatively, as output increases, firms will expand their profit margin by increasing the mark-up over costs. To reflect this type of behavior, the cost term in the pricing function is given the following form.

$$\Delta PCOST(I,M) = \left[1.0+PASSF(I)*\left(\frac{\sum_M ROUTPT(I,\ldots)_{t-1}}{\sum_M RPCAP(I,M)_{t-1}} -1.0\right)\right]\left[PASSA(I)\Delta SCA(I,M)\right.$$

$$\left. + PASSB(I)\left\{\Delta SCM(I,M) - \Delta SCA(I,M)\right\}\right] \qquad (2.27)$$

Since an increase in long-run average costs will produce an equal change in marginal costs, ΔSCA is subtracted from ΔSCM to eliminate any double counting. The parameter PASSF determines the sensitivity of mark-ups with respect to overcapacity production. If output exceeds capacity by 1 percent and PASSF is 2, then the mark-up will increase by 2 percent.

When demand is very strong, producers may raise prices even in the absence of an increase in costs. Therefore, the pricing function in the final firm also includes a term relating prices directly to the rate of capacity utilization.

$$\Delta P(I,M) = \Delta PCOST(I,M) + PASSD(I) * \Delta TAX(I,M) + PASSE(I)$$

$$* P(I,M)_{t-1} + PASSG(I) \frac{\sum_M ROUTPT(I,M)_{t-1}}{\sum_M RPCAP(I,M)_{t-1}} P(I,M)_{t-1} \quad (2.28)$$

In some cases, it may be useful to perform the simulations in terms of relative prices rather than absolute prices. This is easily done by dividing all prices by some aggregate price index such as the GNP deflator. The advantage of relative prices is that they avoid the almost insurmountable difficulties involved

in making meaningful projections of general monetary inflation. Also, relative prices are all that are relevant to questions concerning the allocation of resources. Though absolute prices are useful, particularly in the area of foreign trade, most of their advantages are retained and many of their headaches avoided through the use of relative prices.

III. The Simulation Results

Data from Pakistan are used to illustrate some of the uses to which the model can be put. The period covered is from 1960 to 1969. Observed data are used for 1960-64 and projections or forecasts are used for 1965-69. Almost all of the information is derived either from a paper by Tims or from the Third Five-Year Plan of the government of Pakistan.[1/] The Tims paper is particularly useful in that it provides estimates of input-output tables for the years 1960, 1964, and 1969. All data pertains to East and West Pakistan combined.

1/ Tims, Wouter, "Growth Model for the Pakistan Economy", Planning Commission, Karachi, 1965. Government of Pakistan: The Third Five-Year Plan, 1965.

To keep the examples reasonably simple, the data are consolidated to the point where the economy contains only four industrial sectors. The industries are agriculuure, consumer goods and services, investment and intermediate goods, and transport. The goods available in the economy also fall into the same four categories. Since the present discussion will focus only on the aggregate results, no attempt was made to provide a realistic regional breakdown of the data.

It should be observed that the model is in no sense an optimizing model. It has no criterion function to maximize or minimize. All the model can do is simulate or predict the behavior of the economy under a set of specified conditions. If the problem is to evaluate several alternative development plans, the model can trace out over time the economic implications of each of the different plans. Insofar as these predictions are accurate, they should prove useful to the decision makers who must eventually choose the "most desirable" plan. Naturally, before the model can be used to examine alternative policies it must be shown that the behavior of the model is similar to the behavior of the actual economy.

The Calibration Runs

To calibrate the model, simulations were run for the five-year period 1960-1964 - the most recent period for which actual data are readily available. Insofar as possible, the parameter estimates were derived directly from the available empirical material. Where direct measurement was not possible, the parameters were adjusted iteratively until the results conformed reasonably well to the actual behavior of the economy.

The actual data and the results of the basic simulation run (run 1) are shown in Table 1. The table gives information for the first and last years of the period (1960 and 1964) and cumulative values for the entire period. In all cases, the discrepancies between the actual and the predicted values are extremely small. This, of course, does not prove that the model as set up here is a perfectly accurate representation of the Pakistan economy. However, the similarity is certainly sufficient for purposes of the present example.

To permit longer simulation runs and to compare the model's results with the projections in the Third Plan, run 1 is extended to cover the period to 1969. This extension is done in such a

way that the results can be construed as a type of "null hypothesis". Exogenous variables and parameters are extrapolated in a "reasonable" but somewhat conservative manner. For the most part this means continuing, but not accelerating, trends observed during the first five-year period. The results, as given by run 2 in Table 2, can be interpreted as the outcome that could be expected if the pattern of economic change observed in 1960-1964 were to be continued through 1965-1969.

Alternative Savings and Investment Policies

When one compares run 2 with the projected data, it is apparent that the null hypothesis implies somewhat slower growth than that anticipated in the Third Plan.[1/] To show that this difference is not due simply to the smaller amount of investment in the null hypothesis, another run (run 3) is made in which investment is exogonously specified to be equal to the levels given in the Third Plan. Though run 3 shows somewhat more growth than run 2, it is still appreciably below the projected amount.

1/ Actually the projected data are derived from a number of government sources in addition to the Plan. Hopefully an over-all consistency with the Plan has been maintained.

All other policy variables under direct government control, such as government expenditures and taxes, have the same values in the simulation runs as in the projected data. Therefore, it is the indirect rather than the direct impact of the developmen program that accounts for the difference in growth rates. For example, the Third Plan assumes a marked acceleration in the rate of structural change in the Pakistan economy. The extent of this change is much greater than that observed in the 1960-64 period and is also greater than that incorporated in simulation runs 2 and 3.

One of the principal assumptions underlying the projected data is that the average rate of consumer savings will increase quite sharply during the Third Plan. In terms of the parameters of the model, this implies that the average propensity to consume, ALPHA, will fall from .922 in 1964 to .889 in 1969. Run 2, on the other hand, assumes a decline of only half that amount with the propensity to consume equal to .906 in 1969.

If the propensity to consume is set at the levels implied by the Plan, and no other changes are made, the result is a sharp decline in economic growth. Run 4, which except for the

reduction in ALPHA is the same as run 2, shows the effect of the increased saving. This outcome is simply a straightforward example of a Keynesian depression due to insufficient demand. An increase in domestic saving, unless it is offset by an increase in investment, is not conducive to rapid growth. Unfortunately, there is nothing in the real world, not to mention in the model, to guarantee that funds released from consumption will go into productive investments. These funds can just as readily end up in gold hoards or in bank accounts in Switzerland.

The Third Plan, however, goes on to argue that the additional savings are necessary to finance expansion in industries that can produce import substitutes. In the present model almost all import substitution would have to occur in the investment and intermediate goods industry. If Pakistan were able to achieve the maximum feasible amount of import substitution, the import coefficients for investment goods should be reduced by about 25%.[1/] This is more than twice as much import substitution as was assumed in the previous simulation runs and is more than four times as much as was observed in the 1960-64 period. As such,

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1/ These coefficients are the elements of the BIMP Matrix.

25% would seem to be an upper limit estimate of the amount of import substitution that can reasonably be expected.

Simulation run 5 incorporates both changes described above: the increase in the saving rate and the 25% reduction in the import coefficients. All measures of economic activity in run 5 show an increase over those in run 4 but they are still not quite as high as those in the null hypothesis, run 2. The increase in output in run 5 is, however, accompanied by a decrease in the cumulative trade deficit. Thus, import substitution has more than offset the additional import demand generated by the higher output.[1/] The import substitution in run 5 channels a greater proportion of the investment demand into domestic markets but this has only minor secondary effects on the aggregate level of investment. Run 5's cumulative investment of Rs. 71.8 billion is Rs. 800 million higher than the investment in run 4 but it is still Rs. 3.0 billion lower than the projected amount.

1/ With exports exogenously specified at the same levels in all runs, changes in the trade deficit are due solely to changes in imports.

Run 6 maintains the same high savings rate and rapid import substitution that were used in run 5, but investments are exogenously specified to be equal to the projected amounts. If run 2 can be viewed as the null hypothesis, it might not be too inappropriate to term run 6 the "official" hypothesis. Insofar as possible, run 6 incorporates the major behavioral assumptions that can be derived from the available government documents. The input-output tables, the capital-output ratios, the composition of consumer and investment demand, the level of government expenditure, and of exports are taken from those sources. The rates of saving and of import substitution are those implied by the Third Plan. It is even assumed that the planners can, by some means, maintain investment at exactly the levels specified in the Plan. As run 6 shows, these assumptions are not sufficient to generate the high growth rate and the low trade deficit given by the projected data. Compared to the projected data, run 6 shows a cumulative GNP that is Rs. 6.8 billion lower and a trade deficit that is Rs. 1.8 billion higher than planned. The projected growth rate of GNP between 1964 and

1969 is 6.6% while that implied by run 6 is only 5.8%. Furthermore, unless there is a tremendous increase in capital-output ratios, particularly in the investment goods industry, the amount of investment specified in the Plan seems to generate considerable excess capacity. In 1969 agriculture would be operating at or slightly above full capacity; the consumer goods industry would be producing at nearly full capacity; but the investment goods industry would be operating at rates well below capacity. If this rather unbalanced situation were actually to occur, it would leave the economy in a very precarious position at the start of the Fourth Plan. All in all, it is difficult to see how the projections in the Third Plan can be derived in a logically consistent fashion from the premises contained therein.

Investment vs. Consumption Oriented Alternatives

The last two simulation runs in Table 2 are based on development strategies that might be considered as alternatives to the official plan. The first alternative, run 7, maintains something of the spirit of the Third Plan by continuing to emphasize expansion of the investment goods industry to promote import substitution. In run 7 producers in addition tend to retain and

reinvest a greater proportion of their profits. This causes investment to exceed, by a considerable amount, the investment in any of the previous runs or in the projected data. Run 7 also assigns somewhat greater importance to the consumer sector than is given to it in the Plan. The average propensity to consume is here assumed to decline only as much as in the null hypothesis, i.e., about half as much as in the official hypothesis.

When these changes are made, the model generates a growth in GNP almost equal to that given in the projected data. But achieving this growth requires increases over the Plan levels of Rs. 5.3 billion in investment and of Rs. 3.9 billion in the trade deficit. These results are, in a sense, the model's estimate of what it would cost to achieve the planned growth rate (6.6%) using a development strategy similar to the one proposed in the Third Plan.

Run 8 examines the possibility of using a development strategy that places more emphasis on consumer goods and less on investment goods. In this run, from 1964 on, the average propensity to consume out of personal income is held constant

at the 1964 level of .922. Also, by increasing the accelerator coefficient, investment is made more responsive to excess capacity. The rate of import substitution is the same as in the null hypothesis; less than half as much as in runs 6 and 7.

The growth achieved in run 8 is approximately the same as the planned amount, but the investment required is almost Rs. 6 billion less than in run 7 - a run which generated the same growth rate but which emphasized expansion of the investment goods industry. Despite the lower rate of import substitution assumed in run 8, there is a reduction, compared to run 7, of Rs. 1.0 billion in the trade deficit. There are several factors that account for this change. An expansion of the investment goods industry requires a much greater proportion of imported goods than does an expansion of the consumer goods industry. In addition to the investment requirements, it takes more imports of intermediate goods to produce capital goods than to produce consumer goods. Thus, the change in development strategy causes a shift in the composition of demand which more than offsets the differences in the rate of import substitution.

Perhaps the most significant aspect of run 8 is the level of consumption it generates. Personal consumption is Rs. 5 billio higher than in run 7 and Rs. 7 billion higher than the projected amount. Consumer expenditures between 1964 and 1969 grow at a rate of 6.6% as compared to rates of 5.7% in run 7 and 5.3% in the projected data. Per capita consumption could increase by Rs. 67 or 21% rather than by the planned amount of Rs. 43 or 13%.

There are of course a great many other alternatives that could be proposed and analyzed. For the present purposes, however, the simulation results discussed above should suffice to illustrate one way in which the model can be used. Though the model cannot choose between alternatives, it is able to provide the information necessary for making a rational decision. In the examples given here, there are at least two general conclusions that could be drawn from the simulation results. First, given the assumptions of the Third Plan, the projections for gross national product and for the balance of trade deficit seem very optimistic. Second, the strategy of emphasizing the expansion of import substitutes and other investment goods seem to entail rather heavy costs, particularly in terms of foregone consumption.

One advantage of using the simulation model is that it allows the planning agency to estimate this cost. Naturally any conclusions based on the results presented here are necessarily very tentative because of the crudeness of the data employed.

Import Substitution

In the preceding section, the model was used to compare specific, well-defined development plans. This section will show how a simulation model can be used in formulating such a plan. Basically, the model is used to provide quantitative estimates of the sets of feasible alternatives. This is done by making continuous, small changes in parameters and then tracing out the implications of each set of assumptions. Since each simulation run is very inexpensive, it is possible to consider literally hundreds of alternatives with this approach.

For purposes of illustration, the problem of import substitution is considered here. In Pakistan, as in most developing countries, the shortage of foreign exchange is a factor constraining the pace of economic advance. One method for loosening this constraint is to expand the domestic production of goods currently being imported. But the expansion in production

requires capital investment and that, in turn, requires imported goods. These changes in the pattern of output and investment will affect the rate of growth of national income and that too will alter the demand for imports. Finally, if real resources are to be diverted to investments in industries producing import substitutes, the resources available for current consumption must be reduced. Therefore, a plan involving rapid import substitution must also incorporate a high marginal savings rate.

A number of simulation runs were made to determine the relationships among rates of import substitution, gross national product, marginal savings rates, and trade deficits. Each 10-year simulation run was based on the "null hypothesis" (run 2) described above. Except for the changes specified below, all parameters and exogenous variables were given the same values as in that run.

Starting from this base, it was assumed that import substitution proceeded at various rates ranging from 10 percent to 45 percent over the 10-year period. Roughly speaking, a 25 percent rate of import substitution implies that, for a given level of GNP, imports in the tenth year will be 25 percent less

than they were in the null hypothesis. It was assumed that the import substitution affected the pattern of investment and intermediate demands but did not alter consumers' behavior patterns. Thus, 25 percent import substitution would appear in the model as a 25 percent reduction in the BIMP and AIMP coefficients during the tenth year. To derive the corresponding reduction in earlier years, it was assumed that the import substitution proceeded at an even pace. The coefficients pertaining to domestic demands, the A and B coefficients, were increased by off-setting amounts. The reduction in intermediate demand for imports was assumed to increase the domestic intermediate demands for both consumer goods and investment goods. Reduced investment demand for imports increased the domestic demand for investment goods only.

For each assumed rate of import substitution, a large number of runs were made using different values for the average propensity to consume, ALPHA. The changes in ALPHA of course produced changes in the distribution of output between consumption and investment. This also influenced the economy's growth rate and the size of the trade deficit.

Trade-Offs Among Marginal Savings Rates, Trade Deficits, and GNP

The results of the simulation runs are summarized graphically in Figures 3 and 4. Figure 3 shows the derived relationship, at various levels of GNP, between the marginal savings rate and the trade deficit. GNP and the trade deficit are measured in year 10 while the marginal savings rate (MSR) is measured over the 10-year period. For any given level of GNP, the higher marginal savings rates are always associated with higher rates of import substitution. For example, with GNP equal to Rs. 60 billion, an MSR of 19.5 corresponds to 25 percent import substitution while an MSR of 23.9 corresponds to 45 percent import substitution.

The slopes of the curves in Figure 3 can be used to compute the change in the savings rate that is necessary to generate a specified reduction in the trade deficit while holding GNP constant. Though each curve is approximately linear, the curves become much flatter at lower levels of output. When GNP is Rs. 66 billion, an increase in the MSR of 3.75 percentage points reduces the trade deficit by Rs. 1.0 billion. But, when GNP is only Rs. 56 billion, the MSR must increase by 6.0 percentage points to cut the deficit by Rs. 1.0 billion.

Figure 4 presents the same body of information in a slightly different format. This graph gives the relationship between the MSR and GNP, given the size of the trade deficit. Presenting the data in this form would be particularly useful if a specific goal has been, or is likely to be, set for the trade deficit. The graph shows how the economy can produce a higher GNP, without increasing the trade deficit, if it can increase the MSR and the rate of import substitution.

Impact on the Investment and Intermediate Goods Industry

For some purposes, the summary information contained in Figures 3 and 4 may be all that is required. In general, however, the more detailed data produced by the model will be needed to evaluate the desirability and/or feasibility of the various alternatives. To make this more concrete, three specific programs will be selected from those used to derive Figures 3 and 4. The first plan (P_1) incorporates 25 percent import substitution and produces a GNP of Rs. 60 billion and a trade deficit of Rs. 3.5 billion. The second plan (P_2) also has 25 percent import substitution but grows somewhat more rapidly to achieve a GNP of Rs. 65 billion and a trade deficit of Rs. 4.5 billion. The third

alternative (P_3) involves 45 percent import substitution and generates a GNP of Rs. 65 billion and a trade deficit of Rs. 3.5 billion.

To compare these alternatives, the simulation model can be used to provide industry detail and to trace out the time path for variables of interest. As Figure 5 shows, the time path for GNP provides very little additional information since all three plans produce very smooth growth. The trade deficit, however, moves very differently in each of the plans (Figure 6). The deficit in P_2 is not only much larger than in the other plans but grows steadily and is still increasing in year 10. P_3, on the other hand, holds the trade deficit constant after year 7. The comparison between P_1 and P_3 is particularly interesting. P_1 ends up with virtually the same deficit as P_3, but it does so by having the deficit increase more rapidly in the early years, and then decline after year 7. As a result, the cumulative deficit over the 10-year period is appreciably larger for P_1 than for P_3. On the other hand, it could be argued that the growth path established by P_1 is more likely to lead to future reductions in the deficit than that generated by P_3. If this possibility is of interest, it should be investigated through simulation runs covering longer periods.

Even when a development plan produces a level of aggregate output that is perfectly reasonable, it may impose unrealistic demands on certain individual industries. This is particularly true when the plan involves significant structural changes such as those associated with rapid import substitution. Clearly, with the three plans being examined here, the investment goods industry is the one most likely to be overtaxed. Figures 7 and 8 show the movements in that industry's output and investment. As would be expected, P_3, with 45 percent import substitution, puts the greatest strain on the industry. Any available technological information and individual expertise should be used to determine whether the implied very rapid growth in output is, in fact, feasible. Insofar as possible, any necessary modifications or constraints should be incorporated directly into the model.

The problem concerning investment is whether the industry is capable of absorbing the enormous additions to capital involved in the second and third alternatives. Naturally, this question is closely related to the previous one concerning the maximum feasible output levels. The virtue of the simulation

technique is not that it always provides answers to these questions, but that it provides sufficient information that these problems can be recognized and faced up to. If, in the end, it is decided that all of the alternatives are feasible, the simulation results provide the planner with the quantitative information necessary for choosing among them.

Table 1

Actual data and the simulation run for 1960-1964

(millions of rupees)

	Agriculture		Consumer goods		Investment goods		Transport		GNP	Investment	Consumption	Trade defici
	X	I	X	I	X	I	X	I				
ctual 960	20019	1062	27211	1126	7131	834	2100	583	36063	3605	31379	2154
un 1 960	19862	1062	27239	1126	7169	834	2105	583	35942	3605	31350	2240
ctual 964	23316	1750	34377	2690	13198	2185	2926	950	45060	7575	36051	3919
un 1 964	23410	1775	34461	2700	13288	2153	3030	1042	45229	7670	36214	3967
ctual umulative	107780	6879	153325	9270	49560	7049	12470	3954	202806	27152	168575	14850
un 1 umulative	108029	6959	153496	9318	50186	6976	12724	3994	202138	27247	168303	14909

X is output

I is investment

TABLE 2

Simulations of the Pakistan Economy, 1960-1969

Cumulative Totals (billions of rupees)

	Agriculture		Consumer Goods		Investment Goods		Transport					
	X	I	X	I	X	I	X	I	GNP	Invest-ment	Consump-tion	Trade deficit
Projected data 1960-1969	245.0	17.5	368.0	26.2	139 0	20.9	30 0	10.3	479.2	74.8	381.1	36.5
Run 2 "Null" hypothesis	244.8	17.9	365.5	25.2	135.1	10.2	31 6	10.2	472.8	72.6	382.8	38.6
Run 3 Predetermined investment	244.7	17 5	365.5	26.6	135.8	20 9	31.7	10.3	473.0	74.8	382.4	40.2
Run 4 Increased saving	242.5	17.4	361.8	24 7	133.2	18.9	31 2	10 0	468.0	71.0	378.6	37.6
Run 5 Increased saving high import substitution	243.3	17.6	362.9	24.8	135.1	19.3	31.4	10.1	470.2	71 8	379.4	37.2
Run 6 "Official" hypothesis	243.9	17.5	363.7	26 2	137.7	20.9	31.7	10.3	472.4	74.8	379.7	38.3
Run 7 Emphasis on investment goods	246.7	20.0	367.5	27.3	142.8	21.9	32.4	10.9	479.3	80 1	383.4	40.4
Run 8 Emphasis on consumer goods	248.0	20.1	370.3	26.0	138.3	17 4	32.1	10.7	479.5	74.3	388.4	39.4

Figure 3

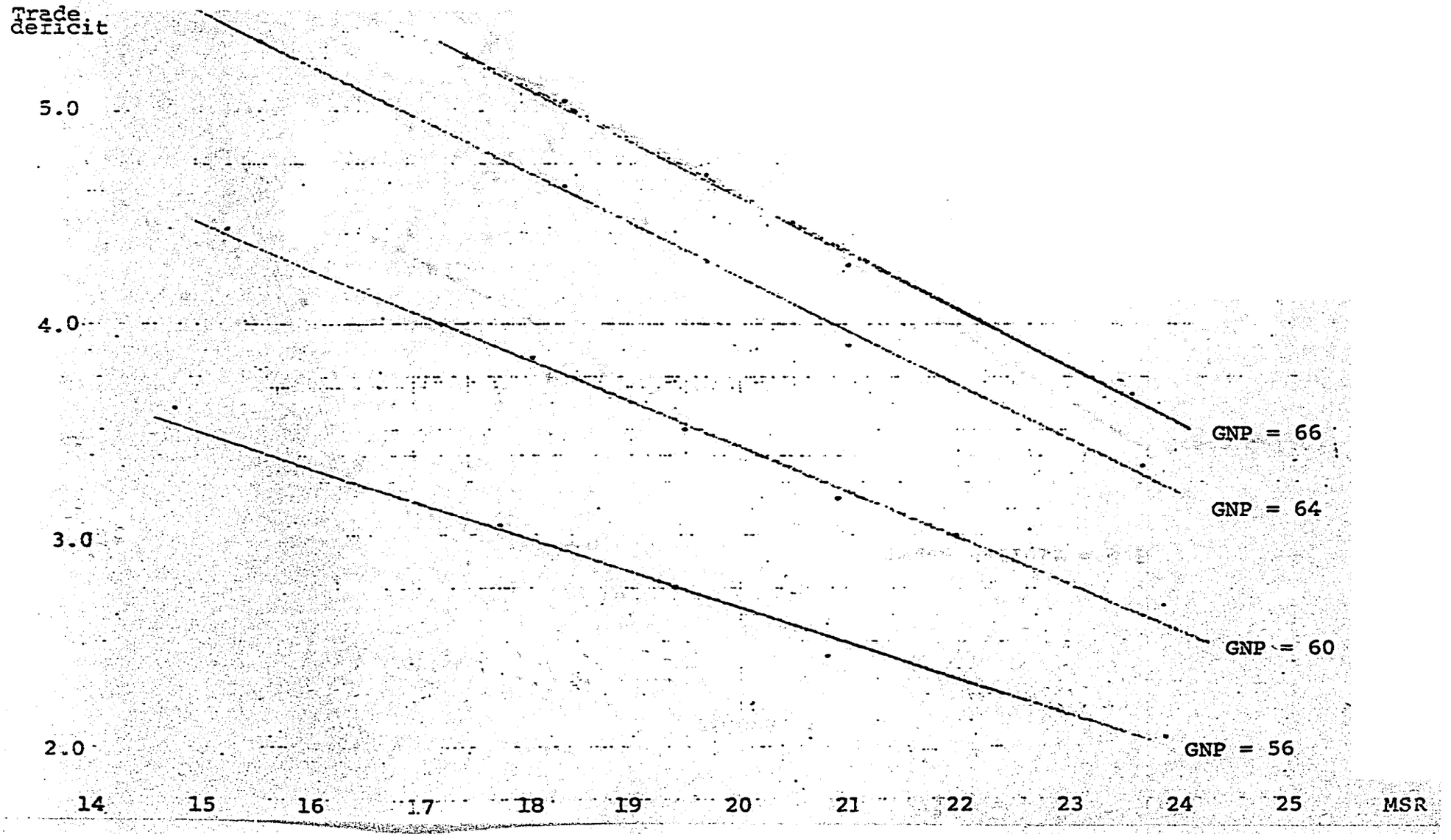
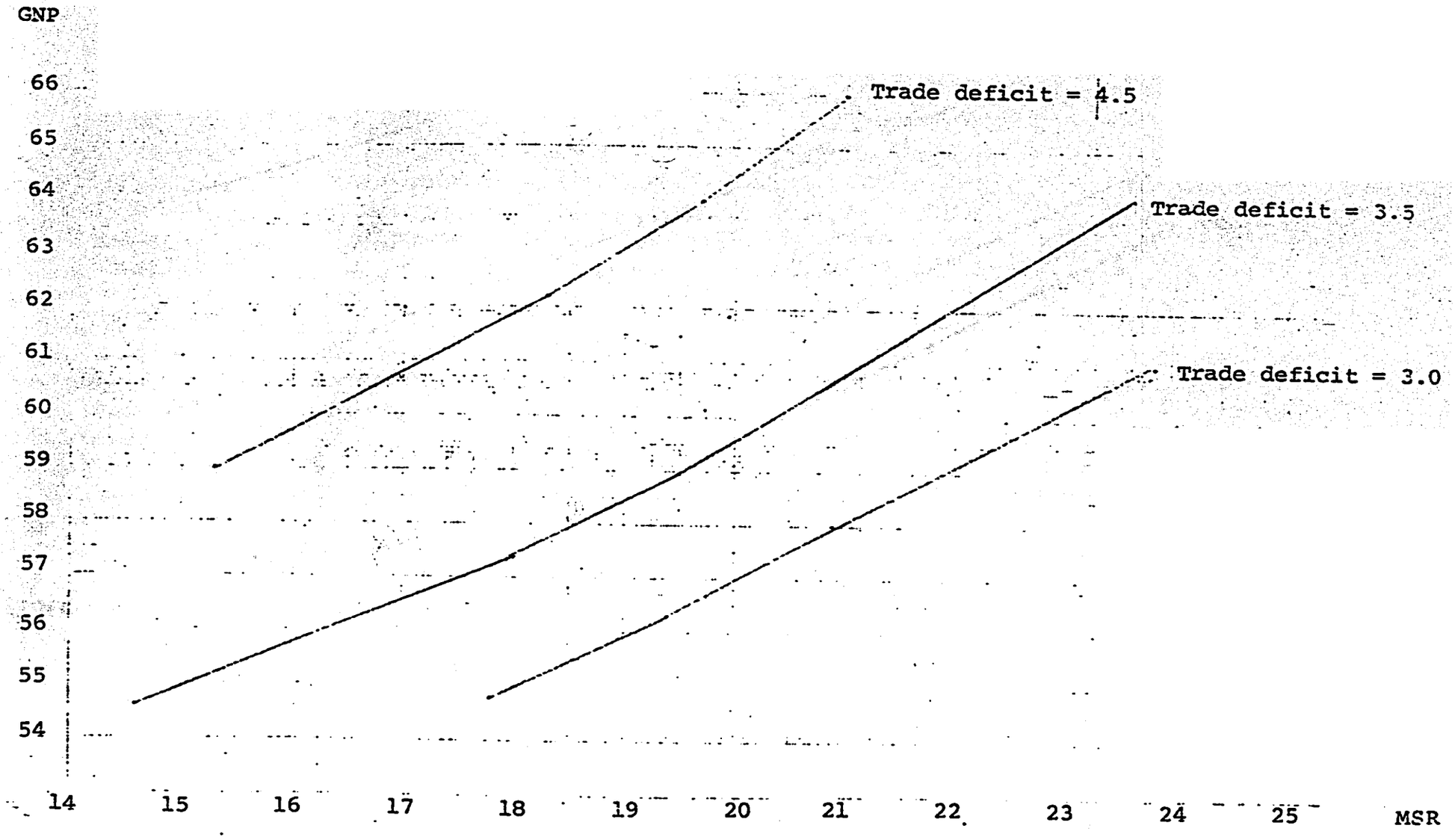

Trade deficit
5.0
4.0
3.0
2.0
14
15
16
17
18
19
20
21
22
23
24
25
MSR
GNP = 66
GNP = 64
GNP = 60
GNP = 56

Figure 4


GNP
66
65
64
63
62
61
60
59
58
57
56
55
54
Trade deficit = 4.5
Trade deficit = 3.5
Trade deficit = 3.0
14
15
16
17
18
19
20
21
22
23
24
25
MSR

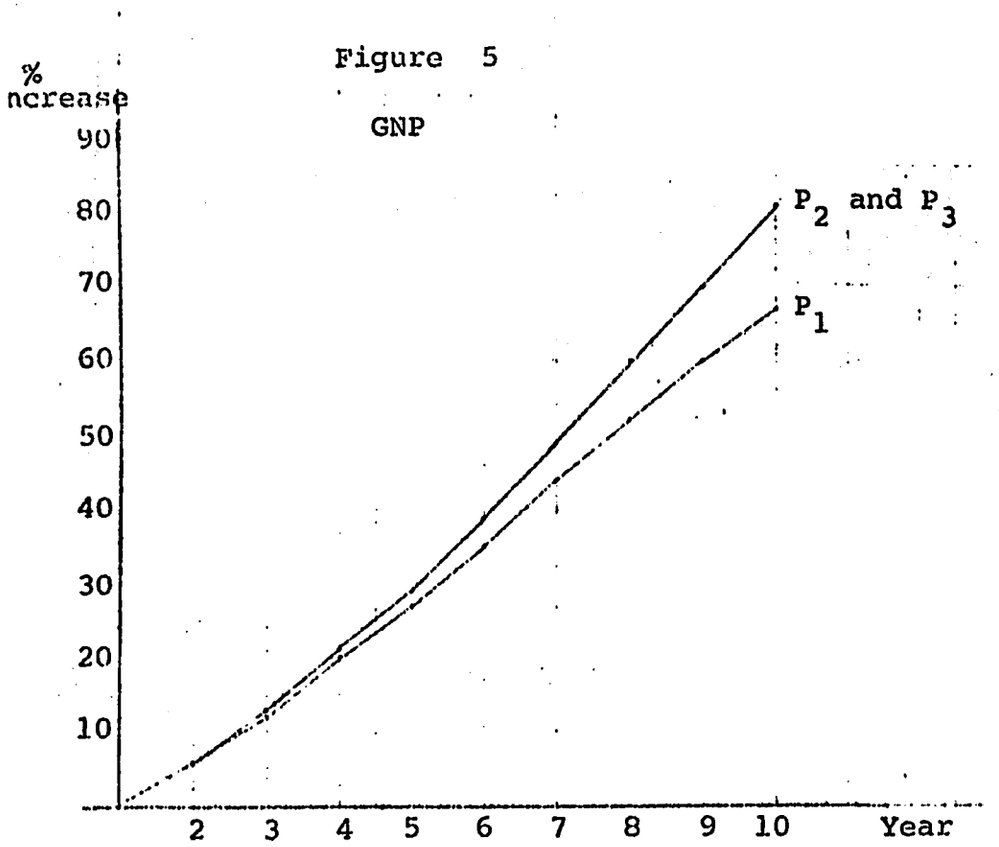


Figure 5
GNP
% ncrease
90
80
70
60
50
40
30
20
10
P2 and P3
P1
2
3
4
5
6
7
8
9
10
Year

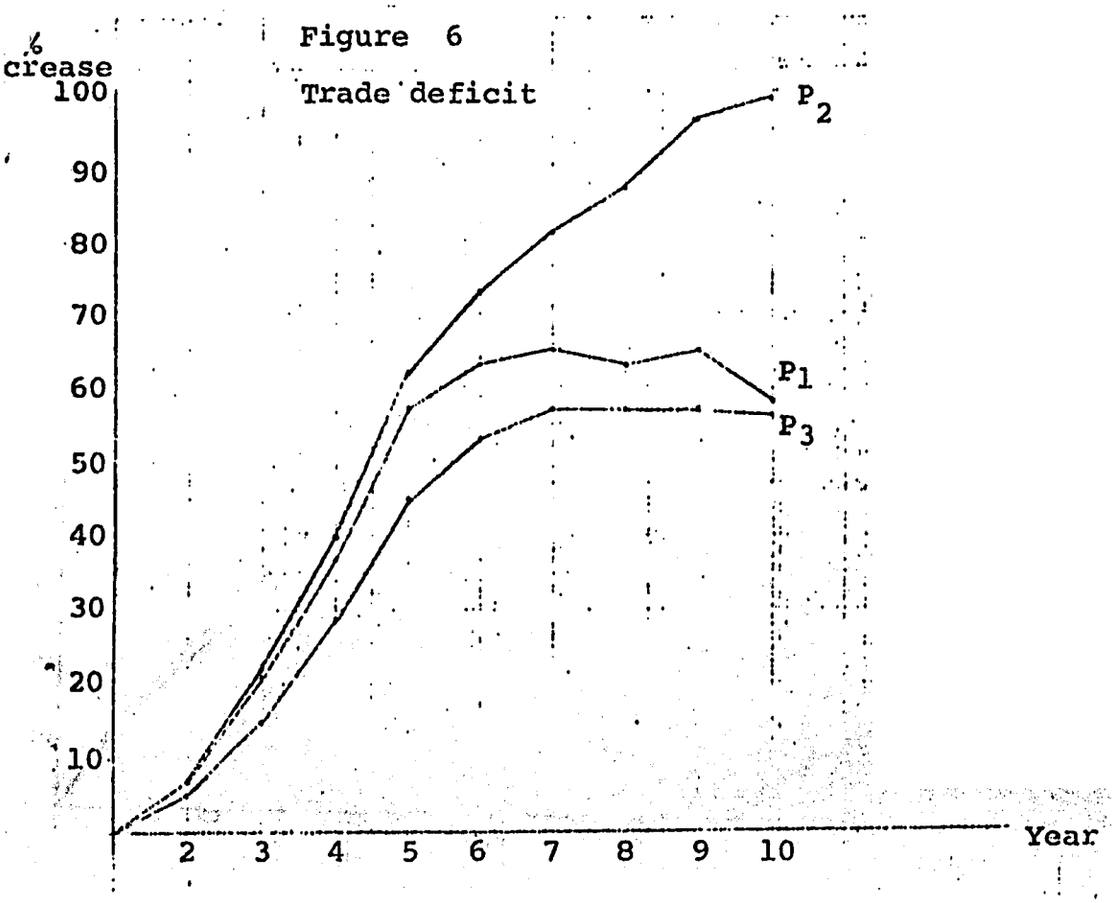


Figure 6
Trade deficit
% crease
100
90
80
70
60
50
40
30
20
10
P2
P1
P3
2
3
4
5
6
7
8
9
10
Year

Figure 7

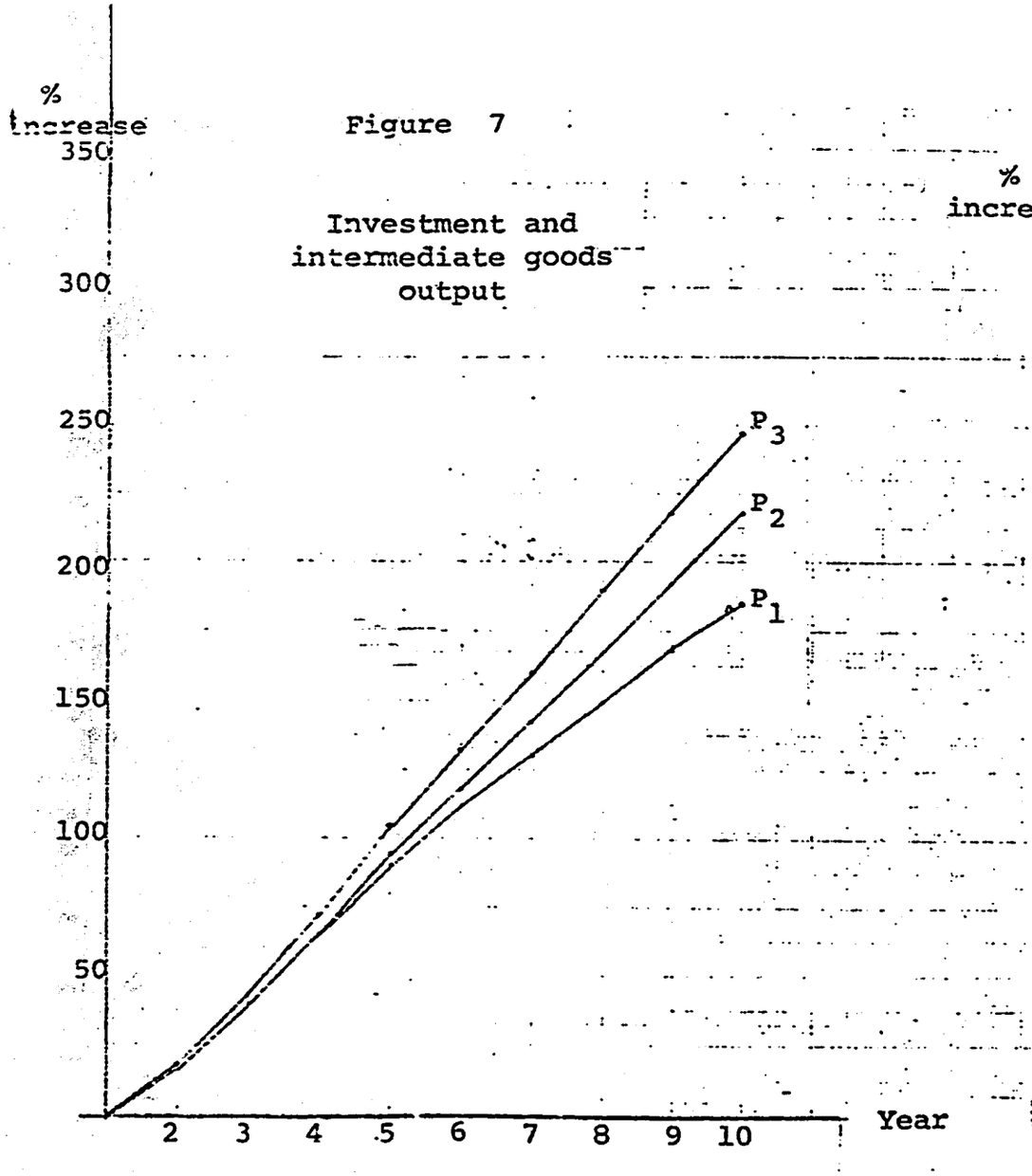
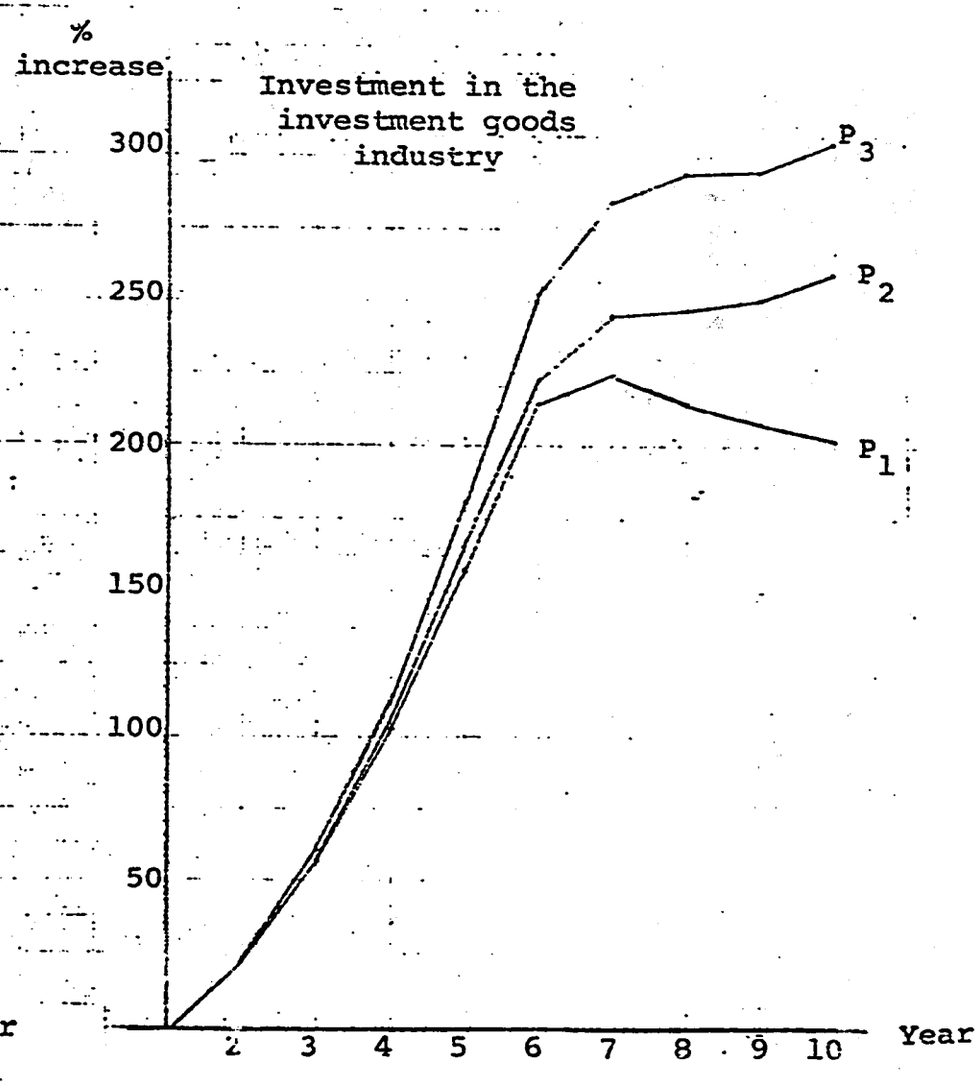



Figure 8