

A Dynamic Multi-Sectoral Programming Model for Korea*

Boum Jong Choe**

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I. Introduction

Planning effort in Korea during the formative years of the First and Second Five Year Plans was primarily concerned with determining the sectoral input requirements necessary to achieve the target GNP growth rates each year. The target GNP growth rates and the level of other aggregate variables were projected using a simple macroeconomic planning model under the alternative assumptions about the exogenous variables. In translating these aggregates into sectoral outputs and inputs, the criteria adopted were merely that the primary and the social overhead sectors should be emphasized in the First Five Year Plan and the light manufacturing industries in the Second Five Year Plan. The Plans showed no explicit interest in choosing the least cost combination of the sectoral outputs and inputs, nor were they concerned with the problem of optimal aggregate saving and investment decisions.

The Third Five Year Plan (1972-76), however, tried to incorporate this neglected aspect to the possible extent. As the Plan stands now, the net influence seems unclear. The problem of optimal resource allocation for the

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**The author is a full-time instructor of economics, College of Commerce, Seoul National University.

Korean economy has been investigated by several authors. Westphal (1970) formulated a dynamic multi-sectoral programming model to investigate the optimal choice between steel and petrochemical complexes under increasing returns to scale. Kendrick and Taylor (1969) experimented with a dynamic nonlinear planning model for Korea. Beginning with Bruno's (1966) study on Israel, linear programming has been extensively applied to development planning problems. His model is basically static, and Bruno, Fraenkel, and Dougherty (1968) extended it to a dynamic problem. There are, of course, a number of studies that followed this line of approach. The model that I present here also fall in this category. Our present model, however, is more dynamic in the sense that it covers more years (or periods) compared with the Westphal's study, whose optimal solutions run over only three years.

The model has ten sectors and extends over ten years and five periods with a period consisting of 2 years. The terminal year is 1976 which is also the terminal year of the Third Five Year Plan. The model has 153 activities numbered by the sectors and periods. Some features of the model have been adopted from that of Bruno, Fraenkel, and Dougherty applied to Israel. The special features of the Korean economy made it necessary to modify their model in many significant areas. I used a ten sector aggregated version of the 1966 input-output table for Korea, which is still the most recent one available. It differs in many significant ways from the one for 1963 on which Westphal's results are based. This is primarily due to the substantial structural changes of the Korean economy during the period. Although the Korean economy is expected to undergo another round of significant structural changes for the coming decade, no adjustment to the coefficients has been attempted.

Static linear programming models are beginning to be utilized in actual plan formulation in several underdeveloped countries. However, the dynamic versions are still in the experimental stage. Usefulness of a dynamic model

rests on its ability to indicate very general optimal growth possibilities under the alternative assumptions about the policy parameters and exogenous variables. In the present exercise I confined my interest to this area. Any improvement in the model formulation in the sense of more correctly representing the structure of the economy or allowing for more flexibility may be expected to make some difference, but as far as it makes only marginal improvements it may not be able to claim substantial superiority. Given the innumerable limitations of the present model, we may still expect to obtain reasonably good results for our purpose if the data are sufficiently reliable. The input-output coefficients, being measured in money terms, are likely to represent distorted market economy and the only available incremental capacity-output coefficients appear to be rather underestimated.

As it turns out, although my expectations remain not fully satisfied after a number of experiments, some seemingly useful results were obtained in the sense that the model seems to behave roughly in the desired direction and the results therefrom are not likely to diverge greatly from what the economy is actually heading to.

II. The Model

It will be useful to indicate some special features of the model at the outset. These may be considered as a way of representing the economic structure of Korea.

- (a) The terminal capital stock is included in the objective function and is given an arbitrary weight in relation to the aggregate consumption.
- (b) Import substitution is allowed only for the competitive imports as of 1966 and is represented by decreases of the competitive import activities from the previous years.
- (c) The noncompetitive imports of machinery are assumed to be complemen-

tary with rather than substitutable for the domestically produced investment goods.

- (d) Exports are assumed to grow at the exogenously specified rates.
- (e) It is assumed that the economy can borrow the exogenously specified amount of capital from abroad. The model allows for the temporal choice of the capital inflow.
- (f) Lastly but not leastly, an important assumption is that the usual ideal conditions hold in the economy, meaning that the prices in the base year represent the social marginal costs.

Implications of these assumptions will be discussed subsequently in connection with each specification of the model. An algebraic statement of the model is presented below with the explanation of the symbols used. The sectoral classification can be found in Table 1.

ALGEBRAIC STATEMENT OF THE MODEL

Objective function

$$(1) \text{ Max. } \sum_{t=1}^5 \frac{C_t}{(1+\rho)^{t-1}} + \lambda \sum_{j \in J} \frac{K_{j5}}{(1+\rho)^4}$$

Output determination

$$(2) \sum_{j \in J} a_{ij} X_j + C_i + I_i + E_i + G_i = X_i + CM_i, \quad i \in I$$

Consumer demand

$$(3) C_i = \beta_i C$$

$$(4) C = \sum_{i \in I} C_i$$

Savings constraint

$$(5) \frac{C_t - C_{t-1} + G_t - G_{t-1}}{V_t - V_{t-1}} \geq 1 - \varphi$$

Investments

$$(6) I_s = 0.1 \sum_{i \in I} b_{si} X_i \quad s \in (I - J)$$

$$(7) \sum_{i \in I} b_{ji} X_i \leq K_j \quad j \in J$$

$$(8) K_{jt} = K_{jt-1}(1 - \mu_j) + \alpha(I_{jt} + NCM_{6t}) \quad j \in J$$

$$(9) NCM_6 = \gamma \sum_{j \in J} I_j$$

$$(10) I = \sum_{i \in I} I_i + NCM_6$$

Exports

$$(11) 0 \leq E_{pt} - E_{pt-i} \leq \Psi_p E_{pt-1} \quad p \in P$$

$$(12) E = \sum_{p \in P} E_p$$

Imports

$$(13) M = \sum_{i \in I} m_i X_i + \sum_{i \in I} CM_i + NCM_6$$

$$(14) CM_{qt} \leq CM_{qt-1} \quad q \in Q$$

Foreign exchange constraint

$$(15) \sum_{i=1}^5 \frac{[\sum_{i \in I} u_i^e E_i]_t}{(1+\eta)^{t-1}} + \sum_{i=1}^5 \frac{CF_t}{(1+\eta)^{t-1}} + \sum_{i=1}^5 \frac{AT_t}{(1+\eta)^{t-1}} \geq \sum_{i=1}^5 \frac{[\sum_{i \in I} u_i^m M_i]_t}{(1+\eta)^{t-1}}$$

$$(16) \alpha \sum_{i=1}^5 CF_i (1+\eta)^{5-i} \leq D_5 - D_0 (1+\eta)^5$$

GNP definition

$$(17) V = C + G + I + E + M$$

Subscripts

t : denotes time periods from 1 to 5. It is not used in relationships not involving intertemporal aspects.

I : the set of all sectors. An element of I is denoted by i .

J : the set of capital goods producing sectors. An element of J is denoted by j . J consists of sectors 6 and 7.

P : the set of export goods producing sectors. An element of P is denoted by p . P consists of all sectors except sector 8.

Q : the set of sectors for which competitive imports existed in the base year. An element of Q is denoted by q . Q consists of all sectors except sectors 7 and 8.

List of Variables and Parameters

Endogenous variables

- V : aggregate GNP
- C : aggregate private consumption
- C_i : consumption of the i -th sector output
- I : aggregate investment
- I_i : investment from the i -th sector output
- E : aggregate export
- E_i : export from the i -th sector output
- M : aggregate import
- CM_i : competitive import of the i -th sector
- NCM_6 : noncompetitive import of machinery used in investment
- X_i : gross output of the i -th sector
- K_j : capital stock from the j -th sector output
- CF : foreign capital inflow

Exogenous variables

- G : aggregate public consumption
- G_i : public consumption of the i -th sector output
- A : unilateral transfers of foreign capital
- D : total debt to the rest of the world

Parameters

- a_{ij} : input-output coefficient matrix
- b_{ij} : incremental capacity-output coefficient matrix
- ρ : consumption and capital discount rate
- η : foreign exchange discount rate
- β_i : marginal propensity to consume the i -th sector output
- φ : maximum marginal propensity to save
- μ_j : depreciation rate of the capital stock of the j -th sector
- α : conversion factor
- γ : proportion of the noncompetitive import of machinery needed for the total investment of machines and construction
- ϕ_p : maximum export growth rate of the p -th sector
- u_i^e : effective foreign exchange rate applicable to the i -th sector export
- u_i^m : effective foreign exchange rate applicable to the i -th sector import
- λ : relative weight on capital stock
- m_i : noncompetitive import coefficients

Table 1. Sectoral Classification

Sector	1	agriculture, forestry, fishery
	2	mining
	3	light manufacturing
	4	basic, intermediate, and finished chemicals
	5	metal products
	6	machinery and transport equipments
	7	construction and earthen products
	8	electricity
	9	transportation, storage, and communication
	10	service, etc.

(A) Objective Function

The maximand of the linear programming problem is the weighted sum of the discounted aggregate consumption in each period and the capital stock in the terminal year. The goods are valued at their base year prices and then aggregated. This process is justifiable under the assumption (f), which is grossly an unrealistic one. But there is practically no way of escaping from this problem. Shadow prices of a programming solution may be suggested as a substitute but they should also assume an initial set of prices to be computed in the first place.

It has been shown that maximization of aggregate consumption generally leads to a different development strategy from maximization of GNP.⁽¹⁾ Investments decline sharply from the second period on in many cases of the Adelman and Sparrow experiments when consumption is maximized. Then the question arises: why maximize only consumption? A.K. Sen showed that in evaluating an investment project its effect on savings should enter the maximand as well as its effect on consumption when the economy's savings rate is sub-optimal.⁽²⁾ Moreover a proper weight should be placed on savings

(1) I. Adelman and F. Sparrow, "Experiments with Linear and Piece-wise Linear Dynamic Programming Models," in *Theory and Design of Economic Development*, Johns Hopkins Univ. Press, 1966, p.307.

(2) A.K. Sen, *Choice of Techniques*, Oxford; Oxford Univ. Press, 1960, in the introductory chapter.

in relation to consumption. It is in this connection that the terminal capital stock is included in the objective function. The ex post equality of savings and investment may suggest that investments rather than capital stock should be used. But it can be easily shown that the capital stock term can be expressed in terms of initial capital stock and investments in each period with appropriate allowance for depreciation by substituting equation (8) into (1). The initial capital stock term is a constant and can be ignored. One of the purposes of having capital stock in the objective function explicitly is to ensure significant positive investments in each period in the system. However, this does not solve the problem of allocation of investment goods among sectors. Capacity of certain sectors may unduely expand at the expense of other sectors. This problem has usually been solved by introducing terminal capital stock constraints for each sector. In the model this problem has been left out and it is hoped that the model itself would behave nicely in this respect.

The linear form of the objective function raises a host of problems. The implication is a constant marginal rate of substitution between consumption in different periods regardless of its growth rate. This results in the so-called “flip-flop” phenomenon in a model with linear objective function characterized by a constant discount rate and with an upper bound to the growth rate. If the discount rate is less than the maximum growth rate consumption is optimally delayed to the terminal period and vice versa. The choice of a discount rate is, therefore, very important to the behavior of the model. Essentially, a non-linear formulation of the objective function should be introduced to overcome this difficulty, but this is beyond the scope of the present attempt.

(B) Output Determination and Treatment of Import Substitution

Equation(2) states the balance of supply and demand of goods and services. Equality of the relationship does not allow any excess supply in the system.

This may be too restrictive an assumption but it is useful in indicating the maximum possible growth. An additional implication of this equation is that import substitution is possible only for the competitive imports. Competitive import is subjected to decrease over time by inequality (14), signifying non-negative import substitution. Perhaps a comment on the Korean economic situation is in order to justify this stringent formulation.

Tremendous emphasis on export expansion following the initiation of the First Five Year Plan brought about unprecedented increases in exports, i.e., from 40 to 320 million dollars during the period from 1961 to 1967. But imports as well increased from 316 to 996 million during the same period. The balance of payments gap in the current account almost doubled. What is striking is the fact that competitive imports were 60% of total imports throughout the years. This means import substitution has been neglected in policy making and planning. All this seems to have led to a situation in which more dollars can be saved by substituting for imports than can be earned by promoting exports at the same cost. Korea's limited natural resource base and high costs involved prevent substitution of noncompetitive imports for the near future.

(C) Consumption and Saving

Total consumption is divided among the goods in fixed proportions according to equation (3). The implication of this formulation has been discussed well in the literature. It assumes either that relative prices do not change over time or that increases in demand are just enough to compensate decreases in prices so that total expenditure on a particular good remains unchanged. Equation (4) is a definitional identity. The marginal propensity to save, φ , in the inequality (5) is assumed to increase over time. Though this assumption may be unwarranted in the long run, over the planning horizon of ten years we may take this for granted in view of the very recent past trend of the

propensity in Korea.

(D) Investments

Inventory investments of non-capital goods producing sectors have been taken to be 10% of the amount required for the output. This is a very simplifying generalization but it will not affect our results in any significant way. Relationships (7) and (8) state the capital stock constraints and stock accumulations. The conversion factor α represents the fact that a period consists of two years. It is assumed that all the investments in the current period contribute to the capital stock formations. If we assume that a comparable amount of investments continue to be inherited from the previous period, this may be a good approximation to reality. Equality (9) states the assumption (c) above. Equation (10) is another definitional identity.

(E) Exports and Imports

Inequality (11) states the assumption (d) above. This formulation has the merit of allowing for the economies of scale in the export industries. The prospect of further expansion of exports tends to be rather optimistic among Korean experts. But it seems quite clear that exports can not grow as fast as before and a projection of the past trend into the future cannot work for a variety of reasons. Most important of all is the fact that exports started off from a sub-standard low level and the upper bounds are beginning to be felt recently in a number of sectors. For these reasons ϕ_p 's have been substantially lowered from the trend value but still are higher than other underdeveloped countries. Equations (12) and (13) are the definitions of aggregate export and import respectively. The first term on the right hand side of the equality (13) is the sum of noncompetitive imports needed for the output.

(F) Foreign Exchange Constraint

Formulations (15) and (16) reflect the assumption (e) above. Intertemporal

choice of borrowing is allowed by stating the foreign exchange constraint for the whole period with a limit on the terminal debt. The effective exchange rates placed on the exports and imports by sector reflect the distortions resulting from export subsidies and import duties and other quantitative restrictions. Exports and imports together with foreign exchange availabilities are measured in domestic currency and thus u^e is larger than u^i when import duties are heavier than export subsidies. Data on these parameters are not available and a combination of guesswork and indirect inference was used to arrive at the figures. Since foreign capital inflow is merely increasing the total foreign exchange availability, it can be used for the import of both investment and consumption goods. Terminal debt constraint will always be exhausted because no cost is incurred in terms of the objective function. This unfortunate situation can be avoided by placing a fixed charge per unit increase of the terminal debt. Another method is to find the implications of varying the terminal debt level and offering a choice between them. In the present paper the latter approach has been tried. The international commercial loan rate, i.e., 6%, is used for η . Again α is used to specify the debt accumulation correctly.

III. The Data

The ten sector input-output table for 1966 was computed at the purchaser's prices. The commercial margin relegated to the supply side of the table had to be subtracted from appropriate entry on the demand side under the assumption that margins are uniform in every trades. Although the assumption is very crude it did not make much difference to each entry because of the relatively small amount of the commercial margins. The capital-output coefficients had to be adjusted upward from their inexplicably low levels. It should honestly be admitted that the **B** matrix used may well be an inaccurate rep-

resentation of the reality. The Planning Board is now in the final stage of compiling such a table and use of this table is expected to improve the results to a great extent. Most of the other coefficients have also been derived from the 1966 table. The parameter values and the level of exogenously given variables are presented in Table 2. These were used for the typical optimal solution.

The government consumption is assumed to grow by 7% per year. The base year official exchange rate of 280 won per dollar was used throughout.

Table 2 Parameters and Exogenous Variables

Periods	1	2	3	4	5				
φ	.25	.28	.30	.33	.35				
A(in mil. \$)	70	60	50	40	30				
D(in mil. \$)					2,500				
Sectors	1	2	3	4	5	6	7	9	10
ψ_p	.30	.05	.25	.30	.25	.30	.25	.10	.05
u_i^e	1/350	1/370	1/470	1/500	1/400	1/350	1/425	1/400	1/295
u_i^m	1/522	1/600	1/602	1/521	1/419	1/356	1/320	1/280	1/290

IV. The Optimum Solutions

The experiments with the model by using different parameters and exogenous variables produced some useful results that shed some light on the behavior of the economy. It would be senseless, however, to attempt to use these kind of results in the actual planning. We will discuss the process of arriving at the typical optimum solution and its variations under slightly different specifications of the exogenous variables.

The linear programming tableau can be formed by solving the system of equations and thus eliminating some of the endogenous variables, simplifying the problem. GNP, capital stock, and noncompetitive imports are eliminated from the set of activities. The one period version of the tableau is given in

Table 3. One Period Tableau of the Model

Activities	X_i	C	I_0	I_T	E_p	CM_q	CF_t	Sign	R.H.S.
Constraints									
Commodity Balance	$1-A-\sum_j b_{ji}$	1	-1	-1	-1	+1		=	G_i
Savings Constraint	$-\frac{1}{m_i} \sum_j b_{ji}$	$\frac{\varphi}{1-\varphi}$	1	1	1	1		\leq	$\frac{(G_t-G_{t-1})}{1-\varphi}$
Capital Stock Constraint	b_{ji}		$-\alpha(1+\gamma)$	$-\alpha\gamma$				\leq	$K_{j0}(1-\mu_j)$
Export Constraint					$1/\Psi_p$			\leq	E_0
Competitive Import Constraint						I		\leq	CM_{t-1}
Foreign Exchange Constraint	$u_i^m \cdot m_i$		$u_i^m \cdot \gamma$	$u_i^m \cdot \gamma$	u_i^e	u_i^m	+1	\leq	A_t

Table 3.

(A) The Typical Optimum Solution

The first sensible optimum solution was obtained without any weights on investments in relation to consumption and without any bounds on competitive imports. The general result was:

- (i) Consumption increased from the first to the second period but decreased rather sharply thereafter.
- (ii) Investments were made in the first period on a large scale and practically disappeared thereafter except for occasional appearances on a negligible scale.
- (iii) The machinery and chemical sector produced nill during the first half of the periods and the required amounts were imported.

Thus, a weight of 2 was placed on investments and competitive import bounds had to be introduced. In the above experiment the number of activities was larger than that of the constraints, so a number of activities were set equal to zero. Even if the number of activities were less than that

of constraints, we are likely to have some zero domestic outputs if there is no bounds on competitive imports when imports are cheaper than domestic production. To make the system generate a positive set of domestic production it is thus necessary to introduce the competitive import bounds. If the imports are actually not cheaper than domestic production as in my earlier conjecture, we would have zero competitive imports throughout, which is again undesirable. Thus it is better to have bounds on imports and assume cheaper imports as far as the behavior of the model is concerned.

Under this alternative set of specifications, it was possible to obtain a reasonable set of optimum solution summarized in Table 4. Figure 1 shows the changes of the key variables over time. Consumption shows a steady increasing trend except for a slight setback in the terminal year. The shadow prices of exports increase very rapidly and much of the agricultural goods and services are exported, reducing domestic consumption. Investments from the machinery and construction sectors output show no sign of uniform trend. Aggregate investment sometimes decreases, although the savings rate is assumed to increase over time. It is not that the savings constraint is redundant. Contrarily, the shadow price of the savings constraint is fairly high throughout except the last period. It seems to be due to the foreign exchange constraint that limits the output level combined with the savings constraint, making it relatively unprofitable to expand the capital stock to a larger extent. Still, it may well be that the capital-output ratio is lower than it actually is. Although the savings rate has initially been set at a substantially high level, the high shadow price of the savings constraint vis-a-vis foreign exchange seems to indicate clearly that the economic growth of Korea is bound essentially by these two factors.

The pattern of trade raises some problem. First of all, the pattern deviates from what is normally expected or what has been going on in the recent

Table 4. The Typical Optimal Solution

		In billion won									
Sectors Periods	1	2	3	4	5	6	7	8	9	10	
(A) Outputs											
1	463	41	329	112	80	174	77	20	83	414	
2	512	48	363	134	80	129	143	22	91	452	
3	544	50	379	139	89	160	122	23	97	478	
4	631	61	430	173	90	94	223	25	110	535	
5	655	55	414	153	100	202	85	26	113	538	
(B) Exports											
1	11	8				6	5		10	26	
2	18	8				8	8		12	28	
3	31	9	1			14	13		15	31	
4	53	10					20		18	34	
5	90	11				42	32		22	38	
(C) Competitive Imports											
1			15	31	16						
2			15	31	16						
3			15	31	16						
4			15	31	16						
5			15	31	16	47					
(D) Investments											
1						111	54				
2						66	115				
3						85	88				
4						87	179				
5						90	29				
(E) GNP and Consumption											
	GNP					Consumption					
1	958					790					
2	1,053					852					
3	1,106					881					
4	1,269					977					
5	1,247					955					

past. The solution indicates that the economy should export primary products and services and import light manufactured goods, chemicals, and metal products. And this pattern do not change substantially over time. Korean exports in the last few years were concentrated on light manufactured goods

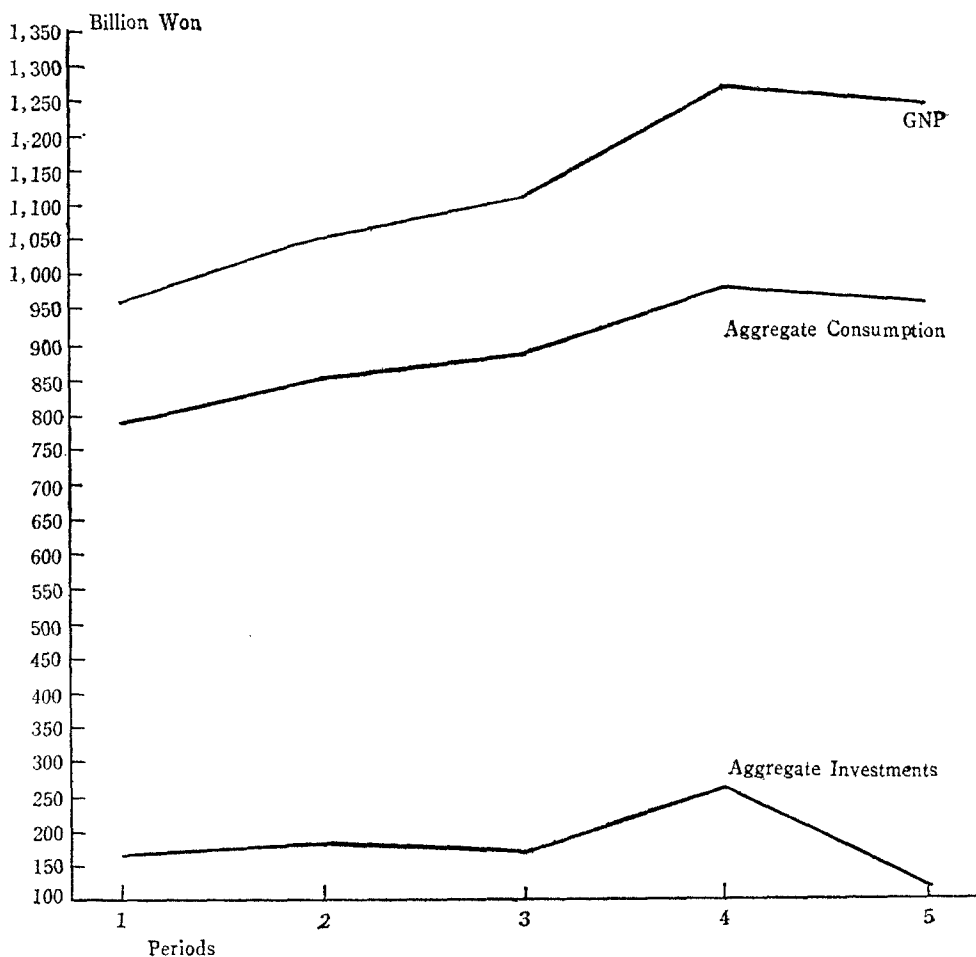


Fig. 1

and it is widely believed that this pattern will persist for the near future. We should attribute part of this mal-behavior of the model to the unknown defect in some or all of the coefficients involved. However, it is also illuminating the fact that Korea has to import large volumes of foreign raw materials like chemical fibers and intermediate manufactured goods. The exports and imports all landed on the upper bounds. This is a manifestation of the possibility indicated earlier.

GNP follows more or less the same line of development as consumption. More specifically, agriculture, light manufacturing, and service sectors show

rapid and steady growth. Outputs of the capital goods sectors are most precarious of all. As a whole, the growth rate of the economy is not at all impressive, although the economy saves a high proportion of its income. It seems to me that this is due more to the defective data than the model structure.

(B) Changing the Export and Import Constraints

To see how the competitive import bounds work, they are now being allowed to vary within the bounds twice their initial level. More flexibility seems to make the economy settle at a slightly higher level of consumption and GNP. The trade volume is also a bit higher but the pattern of trade remains substantively unchanged. Investments still have the alternating pattern and the aggregate investment reduces to a low level in period three rather than in period five as in the previous example. The rate of growth of GNP is of the same order of magnitude as before.

In the second experiment the export growth rates of the light manufacturing, chemicals, machinery, and construction sectors have been increased from their previous level to .35%, .35%, .40%, and .50% respectively. The effect appears to be more of the same nature as above except that the export of light manufactured goods begins to appear from the 5th period. The consumption, investment, and pattern of trade follow the same path as before.

(C) Alternative Assumptions about Savings Rate and Terminal Debt

Going back to the typical set of parameter values and exogenous variables, the following combination of assumptions (see Table 5) about the marginal propensity to save and the terminal debt are made with others unchanged. In the previous typical solution it was shown that saving and foreign exchange had the highest shadow prices. Growth of the economy must be highly

Table 5. Alternative Savings and Terminal Debt Cnostraints

Case	MPS					Terminal Debt
Periods	1	2	3	4	5	
A	.15	.18	.20	.23	.25	\$2.5 billion
B	.15	.18	.20	.23	.25	\$3.5 billion
C	.25	.28	.30	.33	.35	\$2.5 billion
D	.25	.28	.30	.33	.35	\$3.5 billion

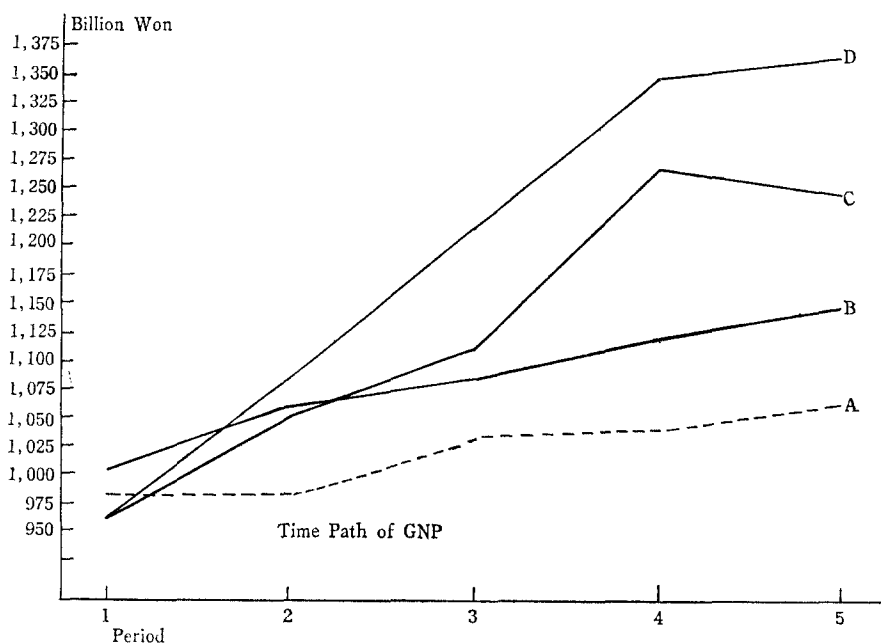


Fig. 2

sensitive to the alternative assumptions about these constraints. As can be seen in the following three figures, this expectation is generally confirmed. First, looking at the changes of GNP in Figure 2, it can be found that the case D which has higher MPS and terminal debt dominates others from the second period on. D dominates C in all periods and B over A. It is interesting to note the reversal taking place between the first and the second period and the gradual decline in the terminal year for the cases C and D. In the case for the consumption the situation is more acute. (Refer to the Figure 3)

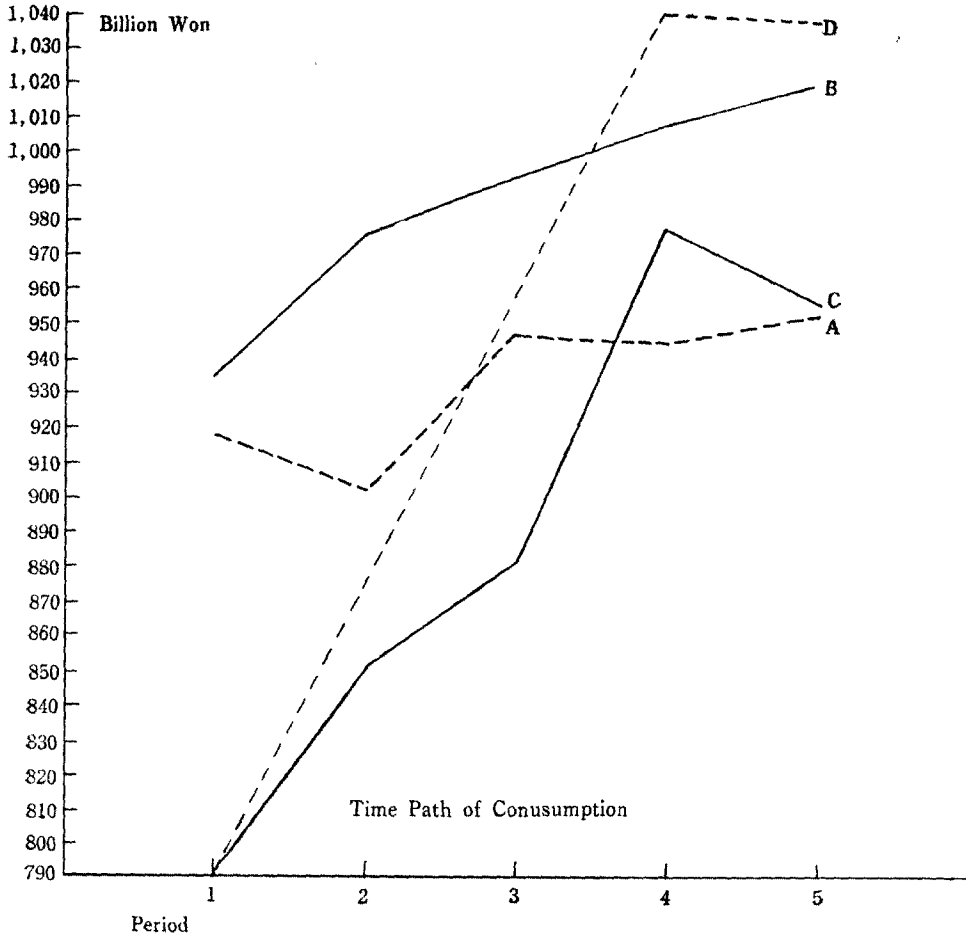


Fig. 3

The possible explanation seems to be this: while more foreign exchange available makes it possible to start off with higher consumption and GNP, higher savings rate takes part of the resource that might have been consumed to investment reducing consumption in the initial year. Higher investment in the earlier periods allows more consumption in the later periods than more foreign exchange can provide. This argument can further be substantiated by referring to the Figure 4, where investment paths are depicted. One can easily find that the aggregate investment is substantially higher in cases C

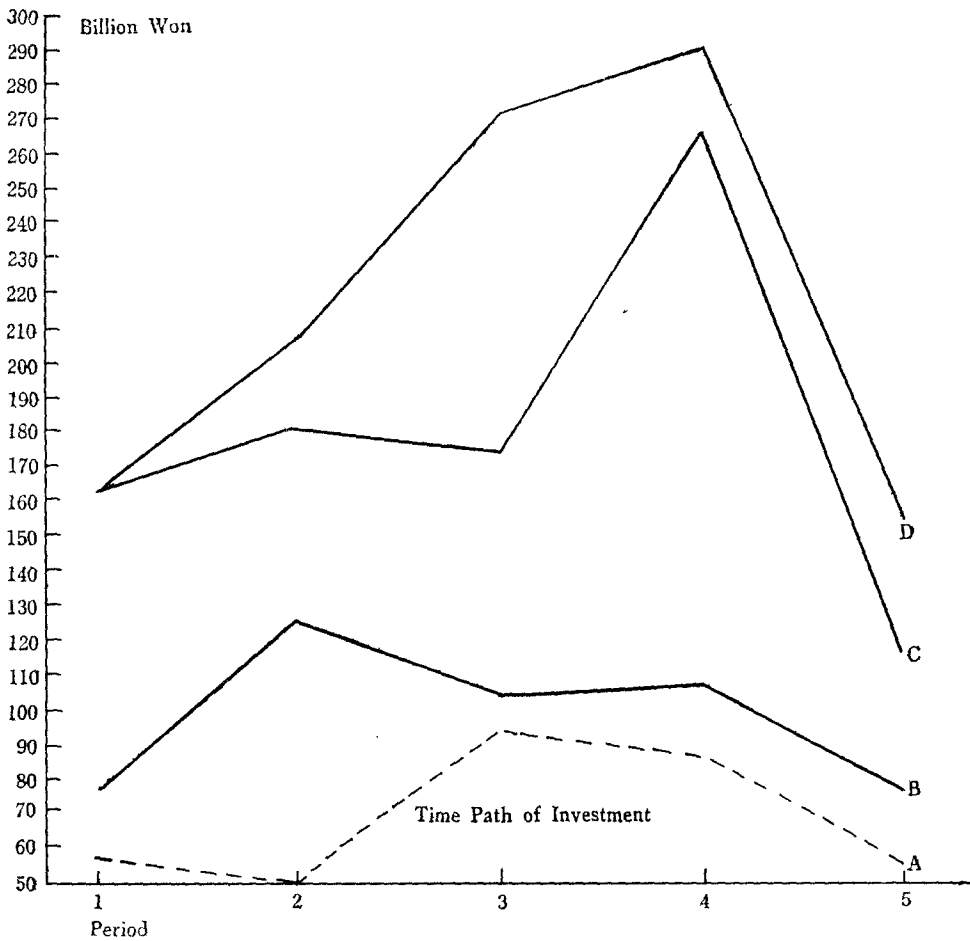


Fig. 4

and D than A and B. Available foreign exchange is used more in consumption than in investment, a possibility which was indicated earlier. The tapering-off of consumption and investment more in the case of higher MPS than in larger foreign exchange seems to indicate that in the later stage of development the foreign exchange constraint becomes more binding than the savings constraint. More investment becomes unprofitable since output and hence consumption can not expand because of the foreign exchange constraint. An examination of the shadow prices of both constraints indicates this point

more clearly. This point is another confirmation of the trend expounded by Chenery and Strout.⁽³⁾

The pattern of trade remains more or less the same between the cases with different terminal debt but differs between the cases with the same terminal debt. The difference in the latter case is limited to the machinery sector that becomes the import sector in the case with a low MPS. The reason is not at all clear. We may plausibly argue that investment goods become cheaper when more savings are available. But why only machinery? The possible transformation of the capital goods sector from import to export industry, if that is at all possible in an underdeveloped economy, should have begun with the construction sector which has lower capital-output ratio when more savings become available.

V. Conclusion

If more accurate data were available, especially the B matrix, the results might have been more meaningful. It seems to me that this is primarily responsible for some of the unrealistic trade patterns indicated in the solutions. There are, of course, a few aspects of the model that needs to be corrected like foreign capital inflow used for consumption. The problem of inter-temporal choice of borrowing has not been solved. In all the solutions the foreign capital inflow is concentrated in the first period. The interest costs of borrowed capital seem to be below the benefits of having it early and once and for all. This is a common desire of many underdeveloped countries. However, it is not clear at this point whether the model took full account of this consideration or the capital inflow activities had to be set equal to zero because

(3) H. Chenery and A Strout, "Foreign Assistance and Economic Development," *American Economic Review* (Sept. 1966), pp. 679-733.

of the lack of more binding constraints. The results concerning trade are generally disappointing. The problem of import substitution has not been adequately answered by the solutions.

Experiments with the other sets of parameters may reveal more interesting points as well as disturbing results. Other types of constraints, especially the labor constraint, can easily be introduced in the model. Shortage of skilled labor is becoming increasingly severe. All these problems are postponed until a later occasion.

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