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Chapter 9

Effects of the Exchange Rate Regime on Growth: A Simulation Approach

The econometric model estimated in the previous chapter establishes a framework within which we can appraise the influence of commercial policy on the growth and structure of the South Korean economy. In chapters 6 and 7 we have already attempted to assess the effect of commercial policy on the efficient allocation of investment. It is difficult, however, to use the analysis of efficiency loss that results from tariffs and quantitative restrictions indicate that the loss is at most only a very small fraction of current output. Far more important may be the consequences of commercial policy for savings and investment relationships, export and import patterns, availability of foreign exchange, and government budgets. The strength of these relationships may have such bearing on the growth process that the growth effects very much outweigh the static efficiency effects.

COMMERCIAL POLICY VARIABLES

The basic commercial policy variables to be considered are: (1) the official exchange rate; (2) the export premium per dollar of exports which arises from a multiple exchange rate system that favors export earnings; (3) other subsidies and subsidy equivalents per dollar of exports; (4) tariffs and foreign exchange taxes per dollar of imports. All basic commercial policy variables are computed on a purchasing-power-parity basis.

The basic commercial policy variables are combined to form a number

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of derived commercial policy variables. The effective exchange rate on imports is a combination of the official exchange rate, tariffs and foreign exchange taxes per dollar of imports, and total export premia per dollar of imports. That is, the cost of imports is raised above the official rate not only because of tariffs and foreign exchange taxes but also because some imports are financed by purchases of export dollars under the multiple exchange rate system. The effective exchange rate on exports is a combination of the official exchange rate, the export dollar premium, and the total of other subsidies per dollar of export. The overall effective exchange rate is defined as the weighted average effective exchange rate on exports and imports (where the weights are exports and imports). Finally, the rate of devaluation is defined as the percentage increase in the overall effective exchange rate averaged over the current year and the two previous years.

INTERACTIONS BETWEEN BASIC COMMERCIAL POLICY VARIABLES AND THE BEHAVIOR OF ECONOMIC AGGREGATES

A major effect of the commercial policy variables is the influence of the effective exchange rate for exports on export performance and of the effective exchange rate for imports on import demand. The export performance, of course, affects the availability of foreign exchange required to finance purchases of imported capital goods for investment and imported raw materials and intermediate goods for current production. The demand for imports affects the amount of foreign exchange required to finance a given level of production or investment.

The rate at which devaluation of the overall effective exchange rate takes place affects the real private cost of servicing foreign loans. The more rapid the rate of devaluation, the greater the local cost of financing foreign loans and the lower the demand for foreign commercial capital imports. A drop in the level of foreign capital imports reduces the availability of foreign exchange to finance imports for current production as well as for investment *and* reduces total savings and investment because of the reduction in foreign savings.

The way in which various effective exchange rates are maintained also affects macroeconomic relationships. To the extent that exports are encouraged by tax subsidies, either direct or indirect, the government budget is affected. An increase in export subsidies of this sort, at given levels of government expenditure, reduces government savings and hence total investment. Encouragement of exports by a multiple exchange rate system, however, does not have the same adverse effect on government revenues.

Similarly, tariffs and foreign exchange taxes affect government revenues.

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If the aggregate elasticity of demand for imports is less than unity, an increase in the average tariff rate increases government revenues and savings at a given level of government expenditures. Purchases of export certificates which carry import entitlement, while they add to the local currency cost of imports beyond the official exchange rate, do not yield government revenue in the same way as tariffs.

The *net* effect of all these relationships and interactions is difficult to determine a priori. The interactions are too complex. For example, an increase in import tariffs reduces the demand for imports and hence conserves foreign exchange but may reduce government revenues if the aggregate elasticity of import demand is greater than unity.¹ The conservation of foreign exchange makes more rapid growth possible when the supply of foreign exchange is limited, but a reduction in government revenues, if it curtails government savings and investment, hinders growth. Similarly, an increase in the rate of devaluation boosts export earnings while reducing import demand and thus fosters more rapid growth when foreign exchange is scarce. But by also reducing the inflow of foreign commercial capital a higher rate of devaluation tends to retard growth. The net effect of various policies depends on a complex set of interrelations among the parameters of the aggregate behavioral functions. In this chapter, we shall perform some experiments on a simulation model using different policy strategies to attempt to determine the efficacy of various exchange rate policies in promoting growth. Our results will be analyzed to determine the important parameters and relationships.

THE SIMULATION MODEL

The basis of the simulation model is the econometric model estimated in the previous chapter. In more general form the model may be written as follows.

$$B \cdot \psi_t + \Gamma_1 \phi_{1t} + \Gamma_2 \phi_{2t} + \Gamma_3 \phi_{3t} + \Delta \psi_{t-\tau} + e_t = 0 \quad (9-1)$$

where ψ_t is a vector of endogenous variables, ϕ_{1t} is a vector of basic commercial policy variables, ϕ_{2t} is a vector of derived commercial policy variables, ϕ_{3t} is a vector of all other exogenous variables in the model, $\psi_{t-\tau}$ is a vector of predetermined endogenous variables and e_t is a vector of error terms. B , Γ_1 , Γ_2 , Γ_3 , and Δ are matrixes of parameters of the model and are estimated in the previous chapter. The variables in the system and the structure of the matrixes are given in tables 8-1 through 8-5.

In addition to the basic econometric model set forth in (9-1), the simulation model includes a number of equations that give the derived commercial policy variables as functions of the basic commercial policy variables and a number of inequality constraints which the system must satisfy. The first de-

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derived commercial policy variable, export premia per dollar of *imports*, is export premia per dollar of *exports* multiplied by total exports and divided by total imports.

$$\phi_{2,1,t} = XPM_t = (XPX_t \cdot X_t) / M_t \quad (9-2)$$

Total tariffs and tariff equivalents per dollar of imports, i.e., the difference between the official exchange rate and the effective rate on imports, is the second derived commercial policy variable and is the sum of tariffs and foreign exchange taxes per dollar of imports and export premia per dollar of imports.

$$\phi_{2,2,t} = SUBM_t = TAM_t + XPM_t \quad (9-3)$$

Similarly, total subsidies and subsidy equivalents per dollar of exports is the sum of export subsidies on exports and export premia per dollar of exports.

$$\phi_{2,3,t} = SUBX_t = SOX_t + XPX_t \quad (9-4)$$

Subsidies on exports in the form of internal tax relief is expressed as a fraction of total export subsidies times a factor required to express these total subsidies in 1965 prices.²

$$\phi_{2,4,t} = SXDT_t = \alpha_1 SOX_t \cdot X_t \cdot \alpha_{2t} \quad (9-5)$$

Total tariffs and foreign exchange taxes are equal to the effective tariff rate (i.e., total tariffs and foreign exchange taxes per dollar of imports) times total imports multiplied by the factor α_{2t} required to express these revenues in terms of 1965 prices.

$$\phi_{2,5,t} = TAR_t = TAM_t \cdot M_t \cdot \alpha_{2t} \quad (9-6)$$

The rate of devaluation is the percentage rate at which the overall effective exchange rate devalues. The overall effective exchange rate is a weighted average of the effective exchange rate on imports and exports. The effective exchange rates on exports and imports are

$$RX_t = ORD_t + SUBX_t \quad (9-7)$$

and

$$RM_t = ORD_t + SUBM_t \quad (9-8)$$

respectively. The overall or average effective exchange rate is

$$R_t = (RX_t \cdot X_t + RM_t \cdot M_t) / (X_t + M_t) \quad (9-9)$$

The rate of devaluation, then, is

$$RDEV_t = (R_t - R_{t-1}) / R_{t-1} \quad (9-10)$$

The moving average rate of devaluation is the last derived commercial policy variable:

$$\phi_{2,6,t} = MARDEV_t = (RDEV_t + RDEV_{t-1} + RDEV_{t-2})/3 \quad (9-11)$$

The model is also subject to a number of inequality constraints. The first set of them refers to the level of foreign exchange reserves at the end of year t denoted by $LFXR$. The level of foreign exchange reserves is determined recursively from period to period.

$$LFXR_{t+1} = LFXR_t + \Delta LFXR_t \quad (9-12)$$

where the change in reserves in year t is denoted by $\Delta LFXR_t$.³ The level of foreign exchange reserves must be greater than some minimum fraction of imports and less than some maximum fraction of total imports.

$$LFXR_{t+1} \geq \alpha_3 M_t \quad (9-13)$$

$$LFXR_{t+1} \leq \alpha_4 M_t \quad (9-14)$$

The purpose of these constraints is to require reserves which are "adequate" but not "excessive" where the policy parameters α_3 and α_4 define adequacy and excessiveness in terms of a fraction of imports.

Similarly, inventory levels are constrained to be greater than a minimum fraction of total income and less than some maximum fraction of total income.

$$LIV_{t+1} \geq \alpha_5 Y_t \quad (9-15)$$

$$LIV_{t+1} \leq \alpha_6 Y_t \quad (9-16)$$

where the level of inventories at end of year t is determined recursively as follows:

$$LIV_{t+1} = LIV_t + IV_t \quad (9-17)$$

where IV_t is the level of investment in inventories in year t (excluding grain inventories). Unless inventory levels are restricted to be greater than some fraction of total income, investment will not be constrained by availability of savings, i.e., investment could be financed by unlimited drawing down of inventories. The upper limit on inventories is to ensure that production is limited by total effective demand.

METHOD OF SIMULATION

The simulations of the model expressed in equations (9-1) through (9-17) were performed over the period 1960 to 1970 with several variations of the values of the basic commercial policy variables. These are:

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$\phi_{1.1,t} = ORD_t$, official exchange rate on a purchasing-power-parity basis;

$\phi_{1.2,t} = XPX_t$, export premia per dollar of exports;

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$\phi_{1.3,t} = SOX_t$, subsidies per dollar of exports;

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$\phi_{1.4,t} = TAM_t$, tariffs and foreign exchange taxes per dollar of imports.

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The parameters α_1 , α_3 , α_4 , α_5 , and α_6 are also basic policy parameters. These were set at values we regarded as reasonable, given past experience. The proportion of export subsidies in the form of internal tax relief (α_1) was, in fact, set equal to its historical value for each year from 1960 to 1970. In the final simulations values of α_3 through α_6 were set as follows:

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$\alpha_3 = 0.17$, lower limit on foreign exchange as a proportion of imports;

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$\alpha_4 = 0.35$, upper limit on foreign exchange as a proportion of imports;

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$\alpha_5 = 0.05$, lower limit on inventories (excluding grains) as a proportion of output;

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$\alpha_6 = 0.14$, upper limit on inventories (excluding grains) as a proportion of output.

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Historically, over the period 1960 to 1970, foreign exchange reserves ranged from 17 to 67 percent of total imports while inventories ranged from 10 to 14 percent of total GNP. If the historical upper limit on foreign exchange reserves is maintained in the simulations, considerable reserves are accumulated for some of the simulation runs. To translate excess reserves into extra growth, an upper limit of 35 percent, or four months' imports, is postulated as reasonable. Similarly we use a lower limit of 5 percent on inventories as a percent of output to allow a tighter regime that facilitates faster depletion of inventories to finance investment.

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In addition to the variations in these values and parameters, we use two policy adjustment variables, EC_t and IG_t . EC_t is an excess capacity variable that comes into play whenever foreign exchange reserves or inventories are inadequate. We assume that the government will attempt to adjust to a balance of payments crisis (inadequate reserves) or an inflationary gap (pressure on inventories indicating that desired investment exceeds savings) by pursuing deflationary monetary and fiscal policies that generate excess capacity in the economy. IG_t is a variable denoting a change in total investment induced by government policies, including inflationary or deflationary monetary policy and direct government investment. We assume that in addition to excess capacity, the government is able to reduce investment when a balance of payments problem arises or an inflationary gap emerges. Conversely, when

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reserves are excessive or inventories large, the government tries to increase total investment.

The model is nonlinear because of the relationships (9-2), (9-6), (9-9), and (9-10). Rather than use a general nonlinear solution technique such as Gauss-Seidel, a special solution technique was devised for this particular model which takes advantage of the rather simple nature of the nonlinearities. The nonlinear solution technique is described in the appendix to this chapter.

At each period of time in the simulations, the constraints (9-13) through (9-16) are checked. If foreign exchange reserves are less than the required minimum level relative to imports or inventories are below the minimum level relative to income—constraints (9-13) and (9-15) violated—the excess capacity variable EC_t is increased and the level of investment is reduced by lowering IG_t .⁴ If there are excess reserves or excess inventories—constraints (9-14) and (9-16) violated—investment is increased by increasing IG_t . These policy adjustments are continued in an iterative fashion until the constraints violated are satisfied. Initially the policy values EC_t and IG_t are set equal to zero in each period; so if none of the constraints are violated there is no excess capacity and no government-induced changes in investment.

SIMULATION EXPERIMENTS

Using the model described above, two sets of simulation experiments were performed to determine the behavior of the macroeconomic aggregates over the period 1960 to 1970. The first set of experiments involved variations in the “pure” effective exchange rate, a completely unified exchange rate with no subsidies on exports and no tariffs or tariff equivalents on imports. With a “pure” effective exchange rate, there are no distortions of international prices and the exchange rate regime is completely liberal. These experiments are designed first of all to determine how much can be gained by complete liberalization and secondly to estimate various “equilibrium” exchange rates.

The second set of experiments involved variations, positive and negative, in the basic commercial policy variables in comparison with their historical values. The official exchange rate (ORD) was varied between 80 and 120 percent of its historical value. The exchange rate premium per dollar of export (XPX) was varied between 0 and 200 percent of its historical value to determine the effect of the multiple exchange rate system. Subsidies per dollar of exports (SOX) were varied between 0 and more than 500 percent of their historical value, and tariffs and foreign exchange tax per dollar of imports (TAM) were varied between 0 and more than 300 percent of their historical value.

In all of the experiments, we assume some “optimal” solution in the sense that there exists some combination of basic commercial policy variables

that maximizes a "well-behaved" utility function defined with respect to the endogenous macro-variables. We did not, however, attempt to define such a utility function and use optimization techniques to determine the maximum value of the utility function. Rather, we looked at two separate "performance indicators" for each simulation run: (1) the discounted value of total GNP from 1960 to 1970, and (2) the discounted value of consumption. Neither is really an appropriate measure of utility. The discounted value of consumption may be high because savings and investment are low in the last few years so that future growth beyond 1970 is sacrificed for consumption from 1960 to 1970. The discounted value of GNP may be high because consumption is low so that future growth beyond 1970 is bought at the price of low consumption from 1960 to 1970. One growth path, however, may dominate another in the sense that both consumption and total income are higher. This is, in fact, the situation most frequently encountered in our simulation runs so that there is no practical conflict between maximization of income or consumption.

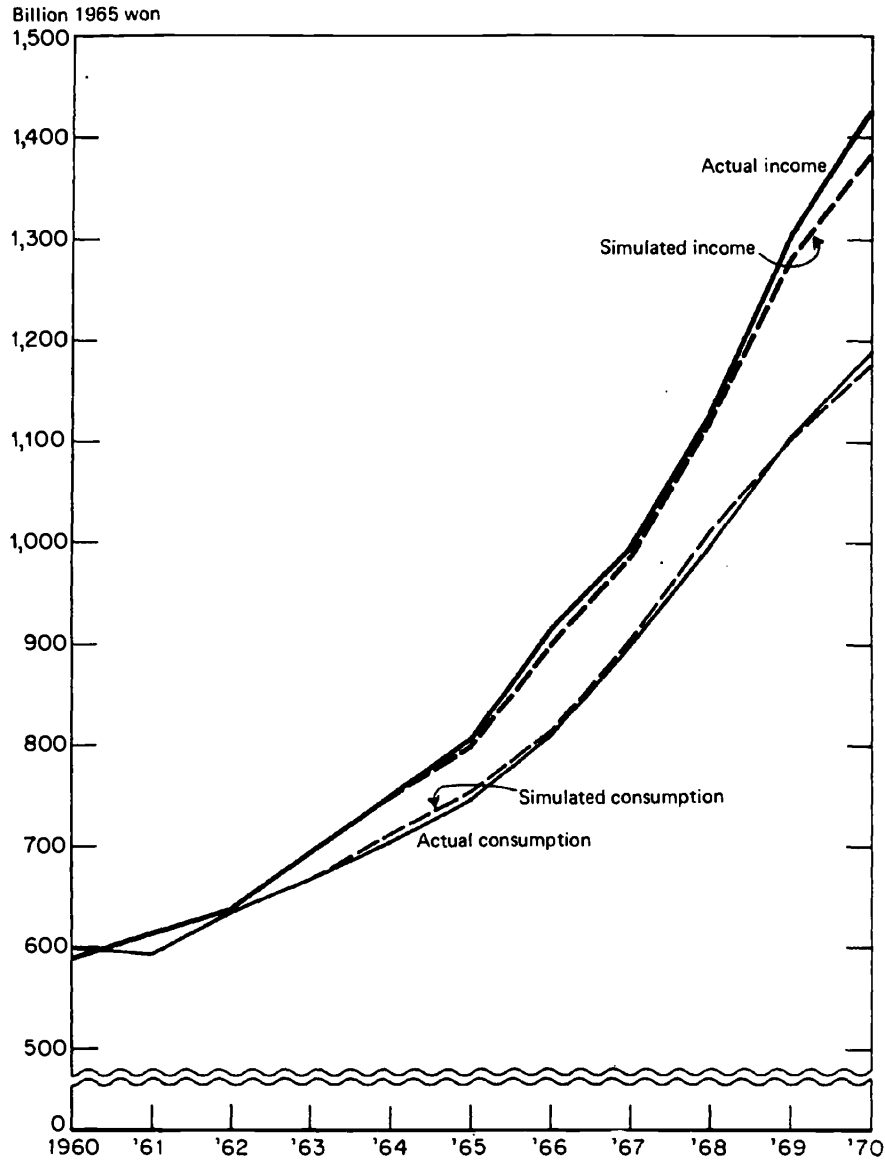
The use of optimization techniques presents problems beyond the appropriate definition of a utility function. The model is complex and nonlinear, involving 40 equations and inequalities in each time period. Thus there are more than 400 constraints from 1960 to 1970 and they would impose formidable computational difficulties on a nonlinear optimization model. Simulation enables us to determine "near optimal" solutions. Furthermore, we are able to examine the time path of the macro-aggregates for selected sets of policy choices which would not be possible if we used an optimization model.

EQUILIBRIUM EXCHANGE RATES

The first set of experiments were intended to determine the exchange rate that would result in a growth path which, if subsidies, taxes, and tariffs on foreign trade were eliminated, would be similar to the path the economy actually followed from 1960 to 1970. Variations above and below this "equilibrium" rate were also made to determine the behavior of the discounted value of output and consumption during the same period.

The first step was to set the official exchange rate so that the purchasing-power-parity effective exchange rate (without tariffs and subsidies) was equal to the historical purchasing-power-parity effective rate (including taxes, tariffs, and subsidies). This experiment yielded a growth performance somewhat inferior in GNP, but superior in consumption (Figure 9-1). The reason for the poorer growth in GNP is that government revenues from tariffs and foreign exchange taxes are reduced and government savings decline. The economy runs into inflationary pressures, especially in 1968 and 1969. Investment tends to exceed available savings, both domestic and foreign. Reduction of inventories violates the inventory (i.e., savings-investment) constraint in the model.

FIGURE 9-1
Income and Consumption over Time: Pure Effective Exchange Rate Equal
to Historical Exchange Rate Including Taxes and Subsidies

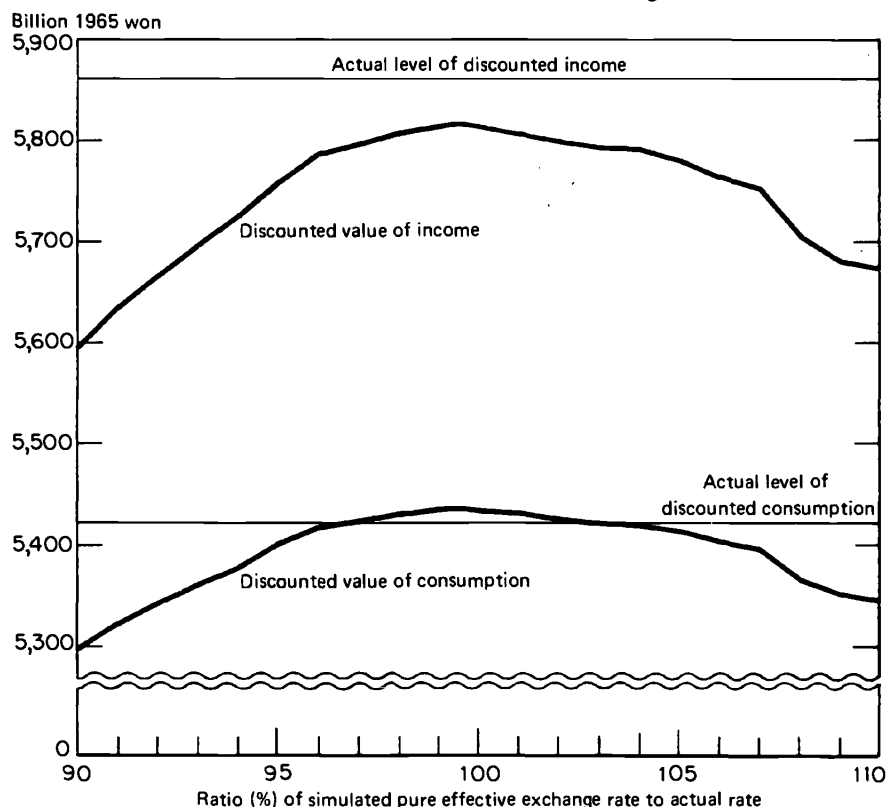


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Deflationary fiscal and monetary policies reduce investment and generate excess capacity, thus slowing the economy's growth. Consumption, by contrast, rises because reduced government revenues lead to increased disposable income.

The next step was to vary the "pure" effective exchange rate above and below the actual historical value of the effective exchange rate. The results in terms of the total discounted values of GNP and consumption are shown in Figure 9-2. If the "pure" rate is reduced to 99.5 percent of the historical effective rate, the results are slightly better, both for output and consumption, but the results are not significantly different. If the "pure" rate is reduced much below 99.5 percent, the results are worse, both for output and consumption.

FIGURE 9-2
Behavior of Discounted Values of Income and Consumption
with Variations in the Pure Effective Exchange Rate



For example, if the pure effective exchange rate is reduced to only 90 percent of the historical values, the total discounted value of income drops by more than 4 percent and of consumption by about 2 percent. This poorer performance is caused by a foreign exchange constraint encountered in the middle of the decade. Investment must be reduced and excess capacity appears. Similarly, if the pure effective exchange rate is raised above 99.5 percent of the historical levels, consumption and income growth are constrained by a lack of savings. Savings are insufficient because of the decline in foreign savings ($M-X$) brought about by the tendency of imports to contract more than exports when the pure effective exchange rate is reduced.

Conventional economic wisdom asserts that the 1965 exchange rate was an equilibrium rate and that if its purchasing-power-parity value had been maintained, it would have been unnecessary to increase export subsidies to maintain balance of payments equilibrium. This hypothesis was tested in the following way: The 1965 effective purchasing-power-parity exchange rate was converted to a pure exchange rate by eliminating export subsidies, import tariffs, and foreign exchange taxes. The pure exchange rate was varied between 90 and 110 percent of the 1965 effective exchange rate for the years 1964 to 1970.

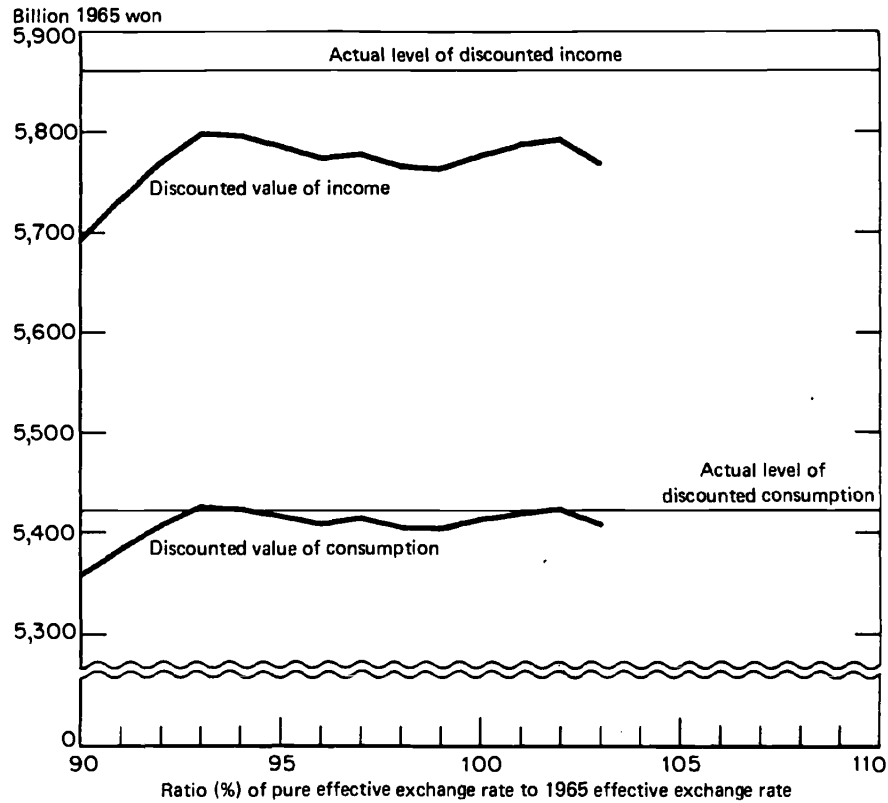
This experiment showed that when the pure exchange rate is set at 102 percent of the 1965 effective exchange rate, both the discounted value of total output and consumption achieve their maximum and the economy follows most closely its historical path. The discounted value of consumption is about the same as the historical value, but the discounted value of income falls about 1.2 percent short. This result stems from a lack of savings due to the reduction in government tariff revenues and hence in government savings. When the pure exchange rate is set at 100 percent of the 1965 effective exchange rate, the growth of income and consumption is somewhat less than that achieved with the 102 percent level (Figure 9-3). These results support the view that the 1965 rate was an "equilibrium" exchange rate in the sense that all tariffs and export subsidies could have been eliminated and the official exchange rate devalued to approximately the 1965 rate on a purchasing-power-parity basis and the economy would have followed most closely the same path in terms of all of the economic aggregates. Of course, maintenance of the 1965 rate on a purchasing-power-parity basis from 1964 to 1970 would have required a continuous devaluation in line with changes in domestic and international price inflation, that is, a gliding peg exchange rate.

When the pure effective exchange rate is reduced much below the 1965 effective rate during the period 1964 to 1970, say to 90 percent of the 1965 rate, the foreign exchange constraint becomes binding, particularly in 1965. This results in considerably less growth in income and consumption.

The behavior of the discounted values of income and consumption is

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FIGURE 9-3
 Behavior of Discounted Values of Income and Consumption with Pure Effective
 Exchange Rate Valued Relative to 1965 Effective Exchange Rate



erratic when the pure effective exchange rate is set between 93 and 102 percent of the effective rate. Local maxima for both income and consumption occur at 93, 97, and 102 percent. At 93 percent, there are some excess foreign exchange reserves in 1967. This helps growth. At 97 percent, excess foreign exchange reserves accumulate in 1966 and 1967. Policy variables then come into play, stimulating investment and increasing output. The result is more rapid growth in those years, but it leads to an inflationary gap and a savings-investment constraint in 1968 and 1969. At 102 percent, excess foreign exchange reserves appear even earlier, in 1964, but the savings-investment constraint takes effect earlier and more persistently from 1966 through 1970. The erratic behavior, then, is caused by the interaction of the savings-investment and foreign exchange constraints.

MANIPULATION OF COMMERCIAL POLICY VARIABLES

The next set of experiments attempted to determine an optimal set of commercial policy variables. This required simulations in which the four basic commercial policy variables were changed over a considerable range from their historical values. The official exchange rate (*ORD*) was set at 80, 100, and 120 percent of its historical values for the period 1964 to 1970. Export premia per dollar of export arising from the multiple exchange rate system (*XPX*) were varied between zero and more than three times their historical values in successive steps. Other subsidies per dollar of export (*SOX*) were varied from zero to more than five times their historical values in sequence. Finally, tariffs and foreign exchange taxes per dollar of imports (*TAM*) were varied between zero and three times their historical values.⁵ More than 1,000 experiments were run and the results demonstrate the responsiveness of the Korean economy to changes in commercial policy. Only a few of the more interesting are presented here.⁶

TABLE 9-1
Discounted Value of Total Output with Official Exchange Rate
at Its Historical Value and Variations in Tariffs and Foreign
Exchange Taxes per Dollar of Import (*TAM*) and Subsidies
per Dollar of Export (*SOX*)
(billions of won at 1965 prices)

<i>SOX</i> as a Percent of Historical Value	<i>TAM</i> as a Percent of Historical Value				
	80	120	160	200	240
0	5,830	5,891	5,920	5,985	nf
40	5,852	5,886	5,928	5,999	nf
80	5,850	5,882	5,938	6,015	nf
120	5,840	5,887	5,952	6,026 ^a	nf
160	5,839	5,897	5,953	6,013	nf
200	5,838	5,880	5,928	5,988	nf
240	5,820	5,853	5,894	5,937	nf
280	5,795	5,813	5,869	5,868	nf
320	5,752	5,776	5,807	5,820	nf

NOTE: nf—not feasible.

a. Maximum value of discounted value of output from 1960 to 1970.

First, we discuss variations in export subsidies per dollar of exports (*SOX*) and tariffs and foreign exchange taxes per dollar of imports (*TAM*), holding the official exchange rate constant at its historical values. Table 9-1 gives the figures for the discounted value of output over the period 1960 to 1970 and Table 9-2 gives the discounted value of consumption over the same period for this set of experiments. The figures marked *a* in these tables give the maximum values of discounted output and consumption. The optimal value of discounted output exceeds the historical level, 5,860, by 4 percent; the optimal value of discounted consumption exceeds the historical level, 5,421, by about 1 percent. The underscored numbers in tables 9-1 and 9-2 represent combinations of values for *TAM* and *SOX* which result in *both* greater consumption *and* greater output over the period 1960 to 1970 than the historical values. Both the maximum value of output and the maximum value of consumption lie within the region for which both output and consumption exceed historical values. Thus one could maximize the discounted value of output without lowering the discounted value of consumption below its historical value. Alternatively, one could maximize the discounted value of consumption without lowering the discounted value of output below its historical value.

TABLE 9-2
Discounted Value of Consumption with Official Exchange Rate
at Its Historical Value and Variations in *TAM* and *SOX*
(billions of won at 1965 prices)

<i>SOX</i> as a Percent of Historical Value	<i>TAM</i> as a Percent of Historical Value				
	80	120	160	200	240
0	5,396	5,407	5,398	5,408	nf
40	5,416	5,411	5,411	5,424	nf
80	5,423	5,417	5,424	5,442	nf
120	5,425	5,428	5,441	5,458	nf
160	5,433	5,443	5,452	5,462 ^a	nf
200	5,442	5,443	5,447	5,458	nf
240	5,440	5,437	5,438	5,439	nf
280	5,435	5,423	5,433	5,410	nf
320	5,418	5,410	5,407	5,393	nf

NOTE: nf—not feasible.

a. Maximum value of discounted value of consumption from 1960 to 1970.

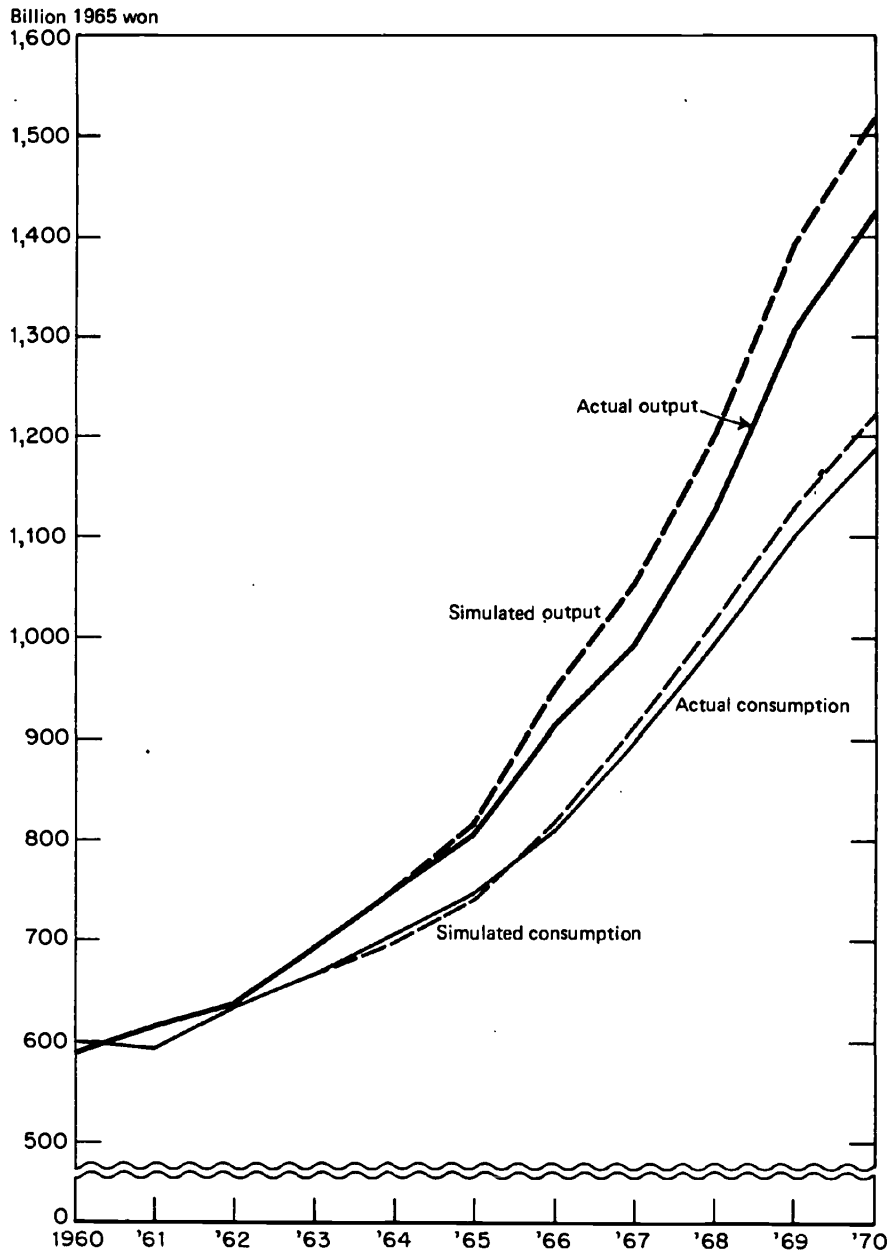
The maximum discounted values of output and consumption occur at very nearly the same combinations of the values of *SOX* and *TAM* (with the official exchange rate held at its historical value). The level of tariffs and foreign exchange taxes per dollar of imports (*TAM*) is double the historical level and the level of export subsidies is somewhat greater than the historical level (+20 percent in the case of maximum output and +60 percent in the case of maximum consumption). The increased value of *TAM* results in increased government revenues. Since the level of government expenditures is assumed to be exogenous, the effect is to increase government savings. The increase in the value of *SOX* tends to reduce government revenues, but since export subsidies are increased by a smaller percentage than tariffs, since exports are less than total imports, and since only part of export subsidies have a direct budgetary impact, the net effect is a substantial increase in government savings which increases total investment and accelerates growth. The increase in *SOX* and *TAM* both generates extra foreign exchange accumulation through increased exports and reduces imports. The accumulation of foreign exchange also makes possible increased investment and growth. The time path of output and consumption is shown in Figure 9-4 for the case in which the discounted value of output is maximized. By 1970, the simulated value of output exceeds the historical value by 95 billion won (constant prices) or almost 7 percent. Furthermore, historical values of output and consumption in the simulation are almost equaled or exceeded every year from 1960 to 1970. Thus the increase in *SOX* and *TAM* results in a dynamically more efficient growth path.

The doubling of *TAM* does not involve very high tariffs and foreign exchange taxes. In 1970, for example, tariffs (there were virtually no foreign exchange taxes) were only about 7 percent of imports so that doubling it would imply a tariff rate of about 14 percent. If tariffs and foreign exchange taxes are raised much above this level, however, the simulation run becomes unfeasible because some of the smaller import items turn negative. This result is inevitable whenever import demand functions are specified to be linear. Even if the specification were more realistic, the imposition of higher tariffs would probably lead to diminished growth by making the demand for imports very elastic. As tariffs are raised, import demand eventually decreases by a larger percentage; government tariff revenues drop; government savings are smaller; and investment and growth decline.

If export subsidies are raised by more than 20 percent above historical levels, growth in output also declines. This occurs because of the reduction in government revenue and savings which in turn decreases investment. In the simulation run with export subsidies higher than 120 percent of historical values and tariffs double historical values, the savings-investment constraint is violated in 1966 and 1967. Investment has to be curtailed because savings

FIGURE 9-4

Time Paths of Consumption and Output with SOX Equal to 120 Percent of Historical Values and TAM Equal to 200 Percent of Historical Values



are deficient, and in consequence growth is correspondingly diminished. Savings fall short because of the reduction in government revenues and savings.

If export subsidies are reduced to less than 120 percent of historical levels, growth is also decreased, since fewer foreign reserves are accumulated through which imports needed for investment can be increased. The increase in investment financed from accumulated reserves is smaller than it is for the optimal growth path.

Tables 9-3 and 9-4 show discounted values of output and consumption for simulations in which the official exchange rate is held 20 percent below its historical value and *SOX* and *TAM* are varied. Again the underlined figures represent combinations of *SOX* and *TAM* which would have resulted in equal or better than historical values for both output and consumption. In this case,

TABLE 9-3
Discounted Value of Output with Official Exchange Rate
at 80 Percent of Its Historical Value and Variations in
TAM and *SOX*
(billions of won at 1965 prices)

<i>SOX</i> as a Percent of Historical Value	<i>TAM</i> as a Percent of Historical Value					
	200	250	300	350	400	450
0	nf	nf	nf	nf	nf	nf
50	nf	nf	5,832	5,964	6,046	nf
100	nf	5,731	5,879	6,003	6,055	nf
150	5,612	5,776	5,911	6,029	6,065 ^a	nf
200	5,663	5,819	5,951	6,041	nf	nf
250	5,710	5,863	5,985	6,042	nf	nf
300	5,754	5,901	<u>6,018</u>	6,019	nf	nf
350	5,796	5,922	<u>6,010</u>	6,007	nf	nf
400	5,810	<u>5,943</u>	<u>5,977</u>	6,019	nf	nf
450	5,812	<u>5,961</u>	<u>5,963</u>	6,034 ^b	nf	nf
500	5,827	<u>5,921</u>	<u>5,962</u>	<u>6,032</u>	nf	nf
550	5,846	<u>5,900</u>	<u>5,931</u>	<u>5,985</u>	nf	nf
600	5,831	5,849	<u>5,883</u>	<u>5,931</u>	nf	nf
650	5,781	5,808	<u>5,806</u>	5,918	nf	nf

NOTE: nf—not feasible.

a. Maximum discounted value of output.

b. Maximum discounted value of output subject to the constraint that discounted value of consumption exceeds historical value.

TABLE 9-4
**Discounted Value of Consumption with Official Exchange Rate
 at 80 Percent of Its Historical Value and Variations
 in TAM and SOX**
 (billions of won at 1965 prices)

SOX as a Percent of Historical Value	TAM as a Percent of Historical Value					
	200	250	300	350	400	450
0	nf	nf	nf	nf	nf	nf
50	nf	nf	5,274	5,312	5,319	nf
100	nf	5,253	5,306	5,340	5,332	nf
150	5,217	5,286	5,331	5,362	5,346	nf
200	5,255	5,319	5,363	5,378	nf	nf
250	5,293	5,355	5,393	5,390	nf	nf
300	5,330	5,388	5,423	5,389	nf	nf
350	5,366	5,412	5,431	5,397	nf	nf
400	5,387	5,438	5,426	5,417	nf	nf
450	5,403	5,464 ^a	5,433	5,430	nf	nf
500	5,427	5,455	5,447	5,456	nf	nf
550	5,455	5,458	5,447	5,447	nf	nf
600	5,462	5,443	5,436	5,435	nf	nf
650	5,446	5,436	5,408	5,388	nf	nf

NOTE: nf—not feasible.

a. Maximum discounted value of consumption.

the maximum discounted value of output and the maximum discounted value of consumption require widely divergent policies. Output is maximized whenever export subsidies are increased 50 percent and tariffs 300 percent above their historical values. The discounted value of consumption, however, is far smaller than its historical value. The discounted value of consumption is maximized whenever export subsidies are raised 350 percent and import duties 150 percent above historical values. The former case emphasizes tariffs; the latter case emphasizes export subsidies. In both cases, additional growth results from accumulations of foreign exchange reserves which allow increased investment. Increased export subsidies, however, lead to relatively more consumption because the reduction of direct tax revenues as a means of subsidy results in an increase of disposable income.

Since the two objectives of output maximization and consumption maximization are divergent, one might determine the maximum discounted value

of output subject to the constraint that the discounted value of consumption be at least as great as its historical value. This point is reached whenever tariffs are 250 percent and export subsidies 350 percent above historical values. Perhaps an even better solution is achieved by increasing export subsidies 400 percent above historical values while holding tariffs at 250 percent. A large jump in consumption follows but only a small loss in output. The values of output and consumption are roughly similar to those in the prior case in which the official exchange rate is equal to its historical value. The difference is that when the official exchange rate falls below its historical value, tariffs and subsidies have to be raised to very high levels to increase the availability of foreign exchange. The high tariffs generate the revenue required to offset the loss in revenue caused by export subsidies.

TABLE 9-5
Discounted Values of Output and Consumption with Official
Exchange Rate at 120 Percent of Its Historical Value
and Variations in TAM and SOX
(billions of won at 1965 prices)

SOX as a Percent of Historical Value	Output				
	TAM as a Percent of Historical Value				
	0	10	20	30	40
0	5,717	5,713	5,738	5,745 ^a	nf
10	5,690	5,717	5,726	5,740	nf
20	5,697	5,707	5,713	5,729	nf
30	5,684	5,693	5,714	5,712	nf
40	5,671	5,694	5,702	5,688	nf

SOX as a Percent of Historical Value	Consumption				
	TAM as a Percent of Historical Value				
	0	10	20	30	40
0	5,373	5,366	5,376 ^a	5,376 ^a	nf
10	5,358	5,370	5,370	5,374	nf
20	5,365	5,366	5,365	5,370	nf
30	5,358	5,359	5,367	5,361	nf
40	5,352	5,362	5,361	5,348	nf

NOTE: nf—not feasible.
a. Maximum values.

"pure" exchange rate is slightly higher than the actual (about 102 percent of the historical) and is combined with more expansionary monetary and fiscal policies. If subsidies and taxes on exports and imports are combined with exchange rate policy, the optimal exchange rate is about equal to the historical rate. The optimal rate should be combined, however, with higher import duties (or fewer exemptions) and roughly similar export subsidies.

APPENDIX: SOLUTION OF THE NONLINEAR SIMULATION MODEL

The simulation model given by equations (9-1) through (9-17) is nonlinear because of equations (9-2), (9-6), (9-9), and (9-10). The way in which the nonlinear solution is obtained involves first the solution for YNA_t . See equation (8-2).

$$YNA_t = -281.8254 + 0.9413YNA_{t-1} + 80.0668 \log_e (INA_{t-1}) + \hat{e}_{1,t} - EC_t \quad (9-18)$$

All the variables on the right hand side are predetermined; $\hat{e}_{1,t}$ is the estimated residual from the regression equation (8-2) and EC_t is excess capacity, a policy adjustment variable. The value of the derived commercial policy variable $SUBX_t$ can be determined from (9-4), since it is the sum of two basic commercial policy variables SOX_t and XPX_t . Then exports of manufactured goods can be determined from

$$XGM_t = -241.4847 + 0.3323 YNA_t + 0.2629 ORD_t + 0.1471 SUBX_t + \hat{e}_{19,t} \quad (9-19)$$

where ORD_t is also a basic commercial policy variable and $\hat{e}_{19,t}$ is the estimated residual from regression equation (8-27). Equation (8-29) may be used next to determine the value of total exports X_t as the sum of XGM_t and primary product exports XGP_t , which is exogenous to the model. Equation (9-2) may be used then to obtain a first estimate of XPM_t as follows:

$$XPM_t = (XPX_t \cdot X_t) / M_t^0 \quad (9-20)$$

where M_t^0 is the actual historical value of imports in year t . This enables us to obtain initial first estimates of all the remaining derived commercial policy variables $\phi_{2,t}^0$ from equations (9-3) through (9-11).

After initial estimates of the derived commercial policy variables have been determined, initial estimates of the endogenous variables of the linear econometric model (9-1) may be obtained recursively by inverting the B matrix.

$$\psi_t = -B^{-1}\Gamma_1\phi_{1t} - B^{-1}\Gamma_2\phi_{2t}^0 - B^{-1}\Gamma_3\phi_{3t} - B^{-1}\Delta\psi_{t-\tau} - B^{-1}\hat{\epsilon}_t \quad (9-21)$$

where $\hat{\epsilon}_t$ are the estimated residuals from the regression equations used to estimate the linear system. Note that although the exogenous variables, ϕ_{1t} , ϕ_{2t}^0 , and ϕ_{3t} and the predetermined variables $\psi_{t-\tau}$ will change from simulation to simulation, we continue to use the estimated error terms $\hat{\epsilon}_t$ derived from the regressions on the original data. The justification for this is the assumption that the error terms are assumed to be uncorrelated with the exogenous variables, and we would like to determine the path of the economy under different assumptions concerning the values of the commercial policy variables.

The solution of (9-21) results in a new estimate of total imports:

$$M_t^1 = MC_t^0 + MK_t^0 + MI_t^0 + MG_t^0 + MNC_t \quad (9-22)$$

which may differ from the original estimate M_t^0 . If this new estimate is substituted in (9-20) for the original estimate M_t^0 and the remaining derived commercial policy variables are determined from equations (9-3) through (9-11), we obtain a second estimate of the derived commercial policy variables $\phi_{2,t}^1$. Similarly, a second estimate of the endogenous variables ψ_t is determined by solving (9-21) recursively with $\phi_{2,t}^1$ substituted for $\phi_{2,t}^0$. This process is repeated as often as is necessary until the successive estimated values of total imports differ by an arbitrarily small amount.

NOTES

1. We must also assume that the supply of imported goods is infinitely elastic.
2. In terms of the original data,

$$\alpha_{2t} = RY_t \cdot WPI_t / (OR_{1965} \cdot WPITP_t \cdot CY_t)$$

3. In terms of our original data, the change in reserves is

$$\Delta LFXR_t = -SK_t + DCKS_t \cdot (RMG_t + RMOS_t) / DMGS_t$$

See tables 8-8 and 8-9 for definitions of the variables.

4. Income and investment are reduced by 1:3.

5. It should be kept in mind that export subsidies and tariffs were a relatively small percent of the effective exchange rate (e.g., 13 percent and 9 percent, respectively, in 1965); so that a doubling or tripling is equivalent to a much smaller change in the effective exchange rate.

6. Export premia were very small during the period covered by the simulations. Variations in XPX , export premia per dollar of exports, did not make much of a difference to our experiments, so none of those results are reported here.