UPX-12 - UPA-38 - IFF equipment for all ROKN ships that do not have or not on order. Required to provide positive, rapid identification of ROKN ships. (32 sets at $3,430 a copy)

AN/UQN series - Fathometer for all ROKN ships not already on order. Required to provide accurate depth equipment, to replace outdated hard to support equipment of many different types.

AN/SPS-6C - Air search radars for APD-81, PG-85, 86, 87. To provide ROKN with additional air search capability. (4 sets at $21,500 a set)

Figures include $540,973 for installation costs, ancillary equipment and required test equipment.

B.3 Armament Improvements

The costs largely reflect the purchase of fifty-five MK-63 Gunfire Control Systems. The systems will be allocated in the following manner:

SHIP TYPE	5" MOUNT	40MM MOUNT
DD	--	4
APD	2	4
PG	8	8
DE	2	5
PF	--	4
PCEC	--	8
MSF/PCE	--	3
PCE	--	7
TOTAL	12	43 (55)

The fifty-five MK-63 GFCS represent a total cost of $1,650,000.00. This system is primarily designed for surface-to-air gunnery. However, it also possesses surface-to-surface and shore bombardment capability and ROKN shipyard has the capability to install this system. The twelve MK-63 GFCS for 5" mounts are considered to have higher priority than those listed for 40MM usage.

The overall cost of this alternative is summarized on the following page:

COST SUMMARY (US DOLLARS)

SHIP TYPE	NR	ANNUAL MAINTENANCE	COSTS LOGISTICS	FUEL	TOTAL	COMMUNICATION	MODERNIZATION ELECTRONICS	ARMAMENT	TOTAL
DD 1/	3	99,828	806,148	549,360	1,455,336	160,986	167,655	120,000	448,641
APD	2	44,478	219,504	113,050	377,032	69,047	176,287	420,000	665,334
PG	4	89,120	316,510	276,968	682,598	54,020	67,150	240,000	361,170
DE	3	45,009	322,784	246,039	613,832	24,655	207,225	210,000	441,880
PF	4	50,416	448,500	271,940	770,856	99,581	43,063	120,000	262,644
PC	4	53,668	143,904	110,028	307,600	28,020	95,362	--	123,382
PCE	7	61,957	413,856	230,356	706,169	85,206	200,188	300,000	585,394
PCEC	4	52,788	276,076	108,068	436,932	56,000	150,690	240,000	446,690
LSMR	1	13,824	229,290	43,348	286,462	14,000	38,038	--	52,038
LSM	11	155,485	414,912	344,168	914,565	154,000	131,825	--	285,825
LST	8	154,840	498,836	157,432	812,108	142,775	139,700	--	282,475
MSC	10	84,460	185,100	193,050	462,610	162,625	113,375	--	276,000
ARL 2/	1	19,595	238,167	20,011	277,773	13,625	25,163	--	38,788
AKL	5	35,785	76,670	113,250	225,705	68,125	91,687	--	159,812
AO(YO)	4	16,160	71,969	82,616	170,745	54,500	100,850	--	155,350
ATA	2	11,374	55,966	26,664	94,004	28,000	21,175	--	49,175
LCPL 3/	10	--	--	10,000	10,000	6,250	--	--	6,250
SB (40) 3/	4	--	--	4,752	4,752	2,000	--	1,476	3,476
FB (65) 3/	9	--	--	25,659	25,659	--	--	10,800	10,800
LPB (95) 4/	9	--	138,438	48,312	186,750	71,865	--	10,800	82,665
GT	32/73	988,787	4,857,630	2,975,071	8,821,488	1,295,280	1,769,433	1,673,076	4,737,789

1/ Density figures for FY69 reflect three DD's even though the third DD will not arrive until spring of FY69.

2/ ARL costs (in Logistics column) include ROV costs. Present accounting system in ROKN precludes separation of ARL costs from other vessel repair costs.

3/ M&L costs are included in support unit costs to which boats are assigned. Only POL costs are feasible for breakout.

4/ LPB logistics and fuel costs are estimates based on O&M cost data furnished by USCG. There is no maintenance costs available on this class.

APPENDIX F

INCREASING FUEL REQUIREMENTS

Increased fuel requirements have been caused by increased tempo of operations, increased density of the fleet and increased requirements for new construction radar sites and boats. Requirements projected for FY 70 are considered to be near the maximum requirement for the ROKN as presently planned.

(1) NSFO requirements have increased fastest due to the arrival of ROKS PUSAN (DD-92) and SEOUL (DD-93) during FY69 and the activation of five EX-USN APD's during FY68. The total number of NSFO burning ships in the ROKN is at the maximum planned level and totals 14. The addition of the seven ships recently added to ROKN more than doubled NSFO requirements over FY67 needs.

(2) Diesel fuel requirements have increased with the increased tempo of operations primarily and with the addition of nine Cape Class Cutters funded under FY 68 MAP augmentation.

REQUIREMENTS TABLE

	FY 68	FY 69	FY 70
NSFO	$ .784 - 15.680 mil gal	$1.080-21.6 mil gal	$1.271 - 25.4 mil gal
D.O.	$ 1.618 - 16.0 mil gal	$1.713-15.6 mil gal	$2.018 - 18.35 mil gal
TOTAL	$ 2.402	$2.793	$3.289

Underway replenishment capability - The ROKN has two small tankers which were purchased from Norway. These ships have been modified to permit underway replenishment; however, they are barely satisfactory due to slow speed and poor steerage capability. Consequently, ROKN does not UNREP as a rule. They practice UNREP during training periods and are capable of UNREP in low sea states. Most fueling from the AO's is accomplished at anchor.

ANNEX V

CHAPTER SIX: THE ROK ECONOMY

APPENDIX A
AN ECONOMETRIC MODEL OF KOREA

A.1 Introduction

The process of economic development in Korea has brought with it rapid structural changes. As new techniques of production were borrowed from more advanced economies, particularly Japan and the United States, the entire urban-industrial sector began to grow much more rapidly than the agricultural sector, and the structure and size of the export sector changed and expanded rapidly. These changes were reflected in movements of the aggregate indicators, such as the capital-output ratio and the marginal import ratio, which showed rapid and uneven alterations in the course of the last ten to fifteen years.

In the face of this rapid change, simple policy questions take on added importance and complexity. For example, the amount of foreign capital required to sustain a specified growth rate depends not only on the target growth rate, but also on such diverse factors as how rapidly the industrial sector is to grow relative to the agricultural sector, what import restrictions are to be adopted, and how rapidly the local government improves tax collection efficiency. Under these circumstances, the best that can be hoped for on an economic model is that it simulates with reasonable accuracy most of the important processes. The model used in this study is designed to quantify the effect on the economy of alternative policies and assumptions dealing with the balance of payments, the budget variables, and the foreign capital requirements implicit under various circumstances. Production, investment, and import behavior had to be studied at a disaggregated level to show more clearly the importance of the various factors which influence the capital output ratio and the import rate.

The actual model is rather large, incorporating twenty stochastic and many nonstochastic relationships in order to describe the various adjustment processes of the economy. To handle all these equations, a recursive, iterative solution procedure has been adopted. Since solution proceeds period by period with iterative adjustments to equilibrium in each period, the model may be regarded as a type of simulation model.

Other more or less unusual features for a developing-economy model include the following: (1) incorporation of nonlinear production functions; (2) iterative convergence of the import-export and investment-savings gaps to equilibrium from ex ante estimates; (3) incorporation of a price-adjustment mechanism for attainment of equilibrium in the balance of payments; (4) specification of different sources of demand for two classes of foreign savings; foreign capital inflows (loans) and foreign counterpart budget support revenues (usually grants); (5) the option of using different techniques to achieve government equilibrium (in the national accounts sense); and (6) use of both supply-side and demand-side estimates of GNP.

A.2 Structure of the Model

The model consists of several sets of behavioral equations and four equilibrium conditions. The equations describe expenditures by national accounts categories, income generation by sector, capacity limitations on production, government revenues, foreign capital inflows, foreign exchange accumulation, the debt service burden, and the exchange rate. Equilibrium conditions govern the balance of payments, the government budget, the income-expenditure identity, and the savings-investment identity.

On the income side, five sectors are distinguished: agriculture and fisheries, mining and manufacturing, social overhead, services, and net factor income from abroad. Income equations are specified for all five sectors, and investment functions are specified for the first four of these sectors, and for inventories. Imports are further sub-divided into the following four groups: grains, capital goods, fuels, and all other commodities. Government revenues were sub-divided into four categories and government expenditures were broken into three categories.

Major exogenous elements include exports of goods and services, part of transfer payments from abroad, government defense expenditures, government capital formation (savings), or counterpart budget revenues, an interest rate, the effective tax rate, and the rate of inflation.

In the working of the model, four "gaps" are created because more equations exist than there are variables -- the main variables are over-determined -- and the gaps describe the difference between two values of the same variable. Several adjustment mechanisms have been postulated to close the gaps by which the equilibrium conditions are met. On the budget side, two alternative adjustment devices are used: the difference between total domestic revenues and desired outlays is made up either through receipt of foreign counterpart revenues or through altering the planned government capital formation (government saving). During the post-war years in Korea, both techniques had been used, with fairly heavy reliance on foreign budget support, but the trend is toward increasing reliance on domestic revenues. Government saving is an important variable in the investment functions for agriculture and social overhead, so reductions in planned government saving affect future income levels by lowering capital formation.

The second equilibrium condition, controlling the balance of payments, is stated in two parts, one determining foreign capital inflows and the other determining the amount of foreign exchange accumulation. Foreign capital inflows are sensitive to a variety of economic and non-economic factors. However, there tends to be a certain inertia in long-term capital movements, and investors and importers in the debtor nation anticipate certain approximate amounts of long-term credit and make their plans on this basis. Forecasts of long-term foreign credit availability during the sample period have not been explicitly specified in the investment and import equations in this model, but nonetheless they have influenced the parameter estimates.

Throughout the analysis foreign capital inflows were considered either to be given exogenously or to be a flexible function of the (different) capital inflows <u>desired</u> by investors and by importers: in alternate solutions, capital inflows can be set equal to the smaller of the two desired amounts, to the larger, to the mid-point, etc. Experimentation in "backcasting" over the 1957-67 period yielded estimates of the parameter relating foreign capital inflows to investing and importing behavior.

The third equilibrium condition governs savings and investment, and it corresponds to the real-world process of investors altering their plans to conform to the available savings. After foreign capital inflows are established in the model, the investment inputs and consumption estimates are adjusted so that balance of payments equilibrium holds and investment equals domestic savings plus foreign saving ex post. These iterations correspond to the monthly or quarterly process of investors and importers gradually adjusting their plans as they see each other's behavior developing. Foreign exchange reserves are maintained at one-quarter of annual imports.

Once imports are adjusted to foreign exchange availability investment and production levels are recalculated to reflect the final estimate of imports for that year. In this process of adjustment, the model allows more realism than more aggregative models: fixed investment and non-agricultural GNP adjust to import availability in different proportions, due to different import coefficients in the stochastic equations for these activities. It might be noted that grain and fuel categories of imports do not adjust, since demands for them is assumed to be inelastic; only non-grain and non-fuel imports adjust to foreign exchange availability. Agricultural income and investments in Korea are largely independent of imported goods (except fertilizer - but that too is considered independent of foreign exchange restrictions), so they are not recalculated on the basis of imports.

The net consequence of this adjustment mechanism is that import availability affects income and investment differently, and consequently consumption and investment respond differently to import availability. To look ahead for a moment, the sets of projections with this model show that consumption responds to imports more than investment does; i.e., investment plans are "stickier" -- slower to respond to increased availability of foreign exchange.

The fourth adjustment process in the model is a simple device which insures that the aggregate income-expenditure identity holds. GNP is calculated from expenditure equations, subject to capacity constraints, and it is disaggregated into sectoral income estimates by use of sectoral production functions. The disaggregation of GNP into sectors of origin is accomplished through first making sectoral income estimates with production functions and then adjusting these estimates so that total income equals total expenditures. As a result, the burden of adjustment falls on the mining and manufacturing, social overhead, and service sectors, which are more sensitive to demand conditions: the estimates of agricultural income and net factor income from abroad remain fixed at their initial levels.

In the solution sequence the agricultural income estimate is calculated first, followed by total GNP, and then the individual expenditure components and income in the non-agricultural sectors. Throughout the process, the distinction between agricultural and non-agricultural income is maintained because it is important in many of the expenditure equations. Capacity constraints are applied at the sectoral level in the form of bounds on the ratios of output to imports, to capital stock, etc. Total GNP is calculated from a reduced form equation. The major elements in the solution sequence are as follows:

TABLE 1-A

SOLUTION SEQUENCE

Causal Order	Endogenous Variables	Exogenous and Pre-determined Variables
0	Investment in agriculture, overhead, and mining and mfg; agricultural income; net factor income from abroad.	Lagged capital stock in agriculture; lagged income; government savings; interest rate.
1	GNP (expenditures).	Various lagged variables; exports; government defense expenditures; exchange rate-price level ratio; endog. variables in causal order 0.
2	Income in social overhead sectors (prelim.).	Capital stock (at beginning of period) in overhead.
3	Income in mining and mfg. (prelim.).	Capital stock in mining and mfg; income in overhead.
4	Income in services (prelim.).	Income in overhead, mining and mfg.; net factor income from abroad.
5	Adjusted sectoral income levels.	Variables in order 1 - 4.
6	Government non-defense consumption; internal taxes; non-tax revenues; investment in services.	GNP; non-agricultural GNP.
7	Private consumption	GNP; internal taxes; lagged values of both variables.
8	Imports: capital goods, fuels, grains, other commodities.	Investment in non-agricultural sectors; exchange rate-price level ratio; coal production; private consumption; agricultural income (lagged).
9	Customs duties; inventory accumulation.	Imports; grain imports; change in agricultural income.
10	Budgetary gap (needed foreign revenues); current account deficit.	Government defense and non-defense consumption; government savings; internal taxes; customs duties; non-tax revenues; total imports and exports.
11	Foreign capital inflow; revised investment, imports; return to order 1 for iteration.	Current account gap; total investment; domestic savings (GNP less consumption). Alternatively, capital inflows are exogenous.
12	Total transfer payments.	Exogenous transfer payments; foreign budget support; foreign capital inflow.
13	Foreign exchange accumulation.	Current account gap; foreign capital inflow; transfer payments.
14	Exchange rate.	Price index; foreign exchange accumulation.
15	Sectoral capital stocks at beginning of next period.	Capital stocks; investment by sector; depreciation rate.

The workings of these various adjustment mechanisms can be more readily visualized with the equations of the model at hand. The stochastic equations are listed together in an appendix and discussed individually in the next section.

A.3 Parameter Estimates

Several hundred functional relationships were fitted to the 1957-67 data before arriving at suitable stochastic forms for the 19 equations. A few of the equations are non-linear, as permitted by the generally block-triangular nature of the systems of equations. Single-equation least squares estimators were used in all cases; it is planned to revise some of the equations with simultaneous estimators eventually. Most equations were estimated over the years 1957-67. Data for 1954-56 are available for some variables, but the figures for the immediate post-war years are felt to be less reliable than later figures. Variables were measured in billions of 1965 won unless otherwise noted.

In selecting among the alternative equations, six criteria were used, two judgmental and four statistical: (1) the signs of the parameters were required to conform to specifications of economic theory; (2) magnitudes of parameters were required to conform reasonably well to cross-section estimates and judgment based on selected data; (3) the T-ratio on all estimates was required to be greater than unity whenever possible; (4) high values of the goodness, adjusted for degrees of freedom, were sought; (5) low values of the standard error of estimate, divided by the mean value of the dependent variable, were preferred; and (6) appropriate magnitudes of the Durbin-Watson statistic were selected.* It should be noted, however, that with only 11 time-series observations the Durbin-Watson statistic is not very meaningful.

A.3.1 Production Functions

A.3.11 Agriculture

Five factors were used, in varying combinations, to arrive at the agriculture production functions: Capital, arable land, weather, fertilizer, and time. (See Table 1). The weather variable is a crude dummy variable taking on values of -1, 0, or +1 (or 1, 2, 3 in the multiplicative equations), and it proved to be statistically significant in all cases. Only the functions with weather yield the turning points in the agriculture time series.

Arable land proved to be a highly significant variable in all cases with a fairly stable coefficient. This is consistent with statements by agriculturists in Korea who point to land reclamation as one of the major factors in the growth of agricultural production over the past decade. However, the significance of the land coefficient could be due to the fact that national income estimates are based, in part, on the quantity of land under cultivation. In any case, arable land has been increasing by less than one percent per year; so the land and weather variables alone do not explain the yield improvements underlying the long-term production increases, which averaged about 4% per year from 1956 to 1967.

* In each of the tables which present the parameter estimates, there is a column labelled "Serial Corr." with the entries "none," "pos.", or "neg." These entries tell whether there is zero, positive, or negative serial correlation of the residuals according to the Durbin-Watson test, at the 5% confidence level. Zero correlation means non-rejection of the hypothesis of non-correlation.

Capital stock is a significant variable, but it is closely related to land - the partial correlation between the two variables is 0.958: Much of the agricultural capital formation in the past decade has gone into land reclamation. The land variable generally is more significant than the capital stock variables but this may well be due to the fact that the capital series is synthetic. It was constructed by summing depreciated fixed investment from 1955, using a base-year capital-output ratio of 0.55 and a depreciation rate of 0.96. (Both parameters were derived from cross-sectional data.) Time limitations did not permit analysis of the results of using different capital stock series.

The fertilizer variable was not highly significant, and in one equation it took the wrong sign, probably because of the rough method of construction of the variable. The dollar value of aggregate fertilizer imports was added to the quantity of domestic production, valued in aggregate at the 1965 dollar import price. No allowances were made for percentage nitrogen content or price variations over time. A time trend variable proved insignificant, and it is highly correlated with land and capital stock, so it was dropped after one trial.

Clearly there is room for much more detailed quantitative study of Korean agriculture. The time limitations of this study permitted only the briefest of excursions into this field, but even so the results were encouraging. The data are summarized in Table 2-A.

A.3.12 Mining and Manufacturing

The main factors affecting the growth of mining and manufacturing over the past decade have been capital stock, social overhead investment (primarily electric power and transportation), and imported raw materials. Labor has been readily available throughout the period, due to the large influx of refugees from the north and because of migration from rural to urban areas caused by the historically high population density coupled with high birth rates. Capital stock data were developed by summing depreciated investment. Various categories of imported raw materials were reviewed to determine their relation to mining and manufacturing production; in doing this, it was found that minor changes in definitions of imported raw materials did not affect the regression results significantly.

Capital was a much more critical factor than imports of raw material. The argument for this conclusion is not straightforward, but is based on the following observation. When only capital and import data were used to determine output, the elasticity of capital with respect to output is about the same, 1.01 and 1.03. These elasticity estimates are statistically significant at the one percent confidence level. In the equations with imports and capital stock, the import elasticities and coefficients are not significantly different from zero. This indicates that capital was a much more critical bottleneck than imported raw materials.

The availability of social overhead investment, as measured by value added in overhead, was more critical than availability of capital during the sample period. However, there were somewhat decreasing returns to use of additional

TABLE 2-A

AGRICULTURAL PRODUCTION FUNCTIONS --

	Capital Stock in Agriculture[1]	Land[2]	Weather[3]	Fertilizer[5]	Time	Constant	$\bar{R}^2$	Statistics: SPC[6] (Elast.) Sum)	Serial Corr.
Additive Form[7]									
1.1		0.306	11.852			-373.643	.977	2.5	none
		(19.80)	(5.49)			(11.30)			
1.2									
1.3	1.622		11.794	0.436		21.994	.865	5.26	none
	(4.48)		(2.22)	(1.06)		0.60)			
1.4	-0.266	0.345	11.767			-419.200	.976	2.21	none
	(0.73)	(6.2)	(5.28)			(5.90)			
1.5		0.308		0.021		-380.824	.892	4.69	neg.
1.6	1.902		12.647			11.945	.863	5.28	none
	(7.64)		(2.39)			(0.34)			
1.7	1.549			0.575		20.807	.799	6.39	neg.
	(3.52)			(1.16)		(0.47)			
1.8			9.664	1.785		159.585	.545	9.63	neg.
			(0.99)	(3.45)		(4.45)			
1.9		0.321	12.077	-0.136		-395.686	.976	2.23	none
		(11.95)	(5.35)	(0.68)		(8.39)			
1.10		0.283	12.291		0.443	-328.325	.993	1.13	neg.
		(10.59)	(10.50)		(0.41)	(7.86)			
1.11		0.293	12.362			368.379	.994	1.06	neg.
		(35.76)	(11.37)			(20.98)			
Multiplicative Form									
1.20		2.373	0.069				.962	2.44	none
		(15.53)	(3.96)			(10.76)			
1.21	-0.157	2.708	0.069				.959	2.62	none
	(0.56)	(4.39)	(3.75)			(4.21)			
1.22	1.025		0.069			1.683	.864	1.09	none
	(7.84)		(2.08)			(0.81)			
1.23	0.927		0.068	0.071			.853	1.07	none
	(4.57)		(1.99)	(0.65)		(0.97)			
1.24			0.063	0.444			.488	0.51	neg.
			(1.01)	(3.24)		(6.48)			

1/ Capital stock in agriculture (synthetic).
2/ Arable land in 1000 chongbo (1 hectare = 1.008 chongbo).
3/ Weather dummy variable taking values of -1, 0 or +1.
4/ Total value of fertilizer supplied.
5/ Time variable taking values 10 . . . 21.
6/ SPC - standard error or estimate divided by average value of dependent variable % for equations 1.1-1.11. Sum of exponents of independent variables for 1.20-1.24.
7/ The T-ratio is in parentheses below the coefficient. For equations 1.1-1.9 and 1.20-1.24, 11 observations were used: 1957-1967. For equations 1.10 and 1.11, 10 observations were used (Weather = 1,2, or 3 in equation 1.11).

overhead inputs. When overhead investment is introduced, imported raw materials become statistically significant, although not very important quantitatively. The introduction of overhead investment also alters the Durbin-Watson statistic so that the hypothesis of serial correlation of residuals is gradually rejected.

It is likely that the social overhead constraint will become less binding in the next five to ten years because of investment underway and planned in that sector. Consequently, for forecasting purposes it would not be appropriate to use a function which included overhead but excluded capital stock. In the equations with all three factors - capital stock, overhead, and imports - the elasticity of capital stock becomes statistically insignificant, no doubt due to the high degree of multicollinearity present. Thus for forecasting, equation (2.1) in Table 3-A has been selected. (See Table 3-A on the following page.)

Exports have been a significant determinant of secondary sector production levels. Since the Korean exporters tend to meet their announced annual export volume targets with consistency, the export variable may be useful for obtaining good short-run forecasts but for the longer run it probably is safer to rely on the endogenously generated capital and overhead variables, because of the difficulty of forecasting export market conditions over the long-run.

A.3.13 Social Overhead

Before the model was built, shortages of capital stock and imported raw materials were judged to be the major constraints to social overhead production. This was found to be the case. Capital stock lagged one year was used on the grounds that most social overhead capital projects have a long gestation lag and generally in the first year of operation they do not operate at anything like full capacity because of technical problems. Use of the lagged capital stock variable in place of unlagged variable generally reduced the amount of unexplained variation in social overhead production.

Imports of both fuels and raw materials have significant effect on output levels in the overhead sector, but the effect of raw materials imports is the stronger. Some sample equations are shown in Table 4-A on page

A.3.14 Net Factor Income from Abroad

Net factor income from abroad originates primarily from service contract earnings from US forces in Vietnam and Korea. Therefore, it was made a function of the two export categories which include these particular export earnings: exports on government account (EGSV) and exports of miscellaneous invisibles (EMSC). The resultant equation is

$$(4.1)\ NFI = \underset{(11.21)}{4.591} + \underset{(15.37)}{0.405}\ (EGSV + EMSC)$$

$$\bar{R}^2 = 0.959,\ \overline{SPC} = 10.79,\ \text{Serial corr.:pos.}$$

TABLE 3-A

MINING AND MANUFACTURING PRODUCTION FUNCTIONS, MULTIPLICATIVE FORM

Equation	Capital Stock 1/	Social Overhead Invest. 2/	Imports 3/ (01)	(02)	(03)	(04)	Constant	Statistics 4/ $\bar{R}^2$	Elast. Sum.	Serial Corr.
2.1	0.268 (0.91)	0.649 (2.51)					3.370 (2.03)	.994	0.92	neg.
2.2	1.004 (31.34)						0.773 (1.62)	.990	1.00	neg.
2.3	0.995 (14.29)		0.013 (0.15)				0.765 (1.48)	.989	1.01	neg.
2.4	0.993 (15.49)	0.831 (3.21)				0.017 (0.21)	0.760 (1.47)	.989	1.01	neg.
2.5	-0.008 (0.03)	0.831 (3.21)				0.098 (1.65)	4.621 (2.66)	.995	0.92	none
2.6	-0.012 (0.04)	0.830 (3.15)	0.101 (1.58)				4.715 (2.63)	.995	0.92	none
2.7		0.814 (22.69)		0.094 (2.20)			4.920 (16.39)	.996	0.91	neg.
2.8		0.820 (25.19)			0.092 (2.28)		4.836 (15.66)	.996	0.91	neg.
2.9		0.825 (24.61)				0.098 (2.07)	4.558 (11.44)	.995	0.92	neg.
2.10		0.820 (22.48)	0.099 (1.99)				4.616 (11.66)	.995	0.92	neg.
2.11	0.999 (13.90)			-0.006 (0.08)			0.770 (1.52)	.989	1.01	neg.
2.12	0.996 (15.27)				0.011 (0.15)		0.773 (1.53)	.989	1.01	neg.

1/ Capital stock in mining and manufacturing.
2/ Value added in the social overhead sector.
3/ 01 = 02 and fertilizer imports.
02 = Imports of services and all commodities except grains, other foods, fertilizer, capital goods, and fuels.
03 = 02 + non-grain food imports.
04 = 02 + fertilizer and non-grain food imports.
4/ Elast. Sum = sum of exponents of independent variables.
T ratios are given in parentheses below the coefficients.

TABLE 4-A

PRODUCTION FUNCTIONS, SOCIAL OVERHEAD

	Capital[1/] KO	Capital[1/] KOL	IMPF	Imports[2/] IMPO1	Imports[2/] IMPO4	Total*	Constant	R^2	Statistics[3/] SPC/ Elast. Sum.	Statistics[3/] Serial Corr.
Multiplicative[4/]										
3.1	0.839 (22.90)						0.436 (4.31)	.981	0.84	pos.
3.2	0.831 (22.79)		0.089 (1.21)				0.372 (4.47)	.982	0.92	none
3.3		0.839 (32.94)	0.225 (4.50)				0.302 (7.60)	.991	1.06	neg.
3.4	0.765 (12.61)			0.147 (1.50)			0.333 (4.42)	.984	0.91	none
3.5	0.772 (13.57)			0.141 (1.48)			0.327 (4.31)	.983	0.91	none
3.6	0.771 (13.79)					0.149 (1.55)	0.315 (4.27)	.984	0.92	none
3.7		0.726 (17.83)			0.274 (4.11)		0.257 (6.90)	.990	1.00	none
3.8		0.735 (20.73)				0.282 (4.41)	0.230 (7.48)	.992	1.02	none
3.9		0.852 (19.02)				0.471	0.471 (3.46)	.973	0.85	pos.
Additive										
3.13	0.166 (28.95)						3.817 (3.58)	.988	4.96	none
3.14	0.165 (24.57)		0.103 (0.49)				3.043 (1.56)	.987	5.18	none
3.15		0.209 (21.27)					2.202 (1.45)	.978	.672	pos.
3.16		0.120 (31.36)	0.648 (4.12)				-2.296 (1.89)	.992	4.04	none
3.17	0.158 (12.44)					0.026 (0.78)	2.863 (1.75)	.988	5.08	none
3.18		0.170 (17.61)			0.101 (4.48)		-1.149 (1.08)	.994	3.60	none
3.19		0.209 (21.27)					2.202 (1.45)	.978	6.72	pos.
3.20		0.172 (19.94)				0.092 5.22		.994	3.40	none

*/ In equation 3.6, this variable is IMPF+IMPO1; in equation 3.8 it is IMPF+IMPO4.

1/ KO - capital stock in social overhead.
KOL = capital stock in social overhead, lagged one year.

2/ IMPF = imports of fuels.
IMPO1, IMPO4: see note to Table 3.

3/ Elast. sum = sum of exponents of independent variables.
Serial corr.: see text and footnote on page
T-ratios are given in parentheses below the coefficients.

4/ Observation - 1957-67 for multiplicative; 1957-68 for additive. T-ratios are given in parenthesis below the coefficients. Elasticity of capital stock in equations 3.10, 3.11, 3.12, and 3.15, respectively: 0.82, 0.82, 0.78, 0.78. "IMPF+IMPO" is IMPF+IMPO1 in equation 3.20.

This equation captures very well the sharp 1966-67 upswing in net factor income from abroad.

A.3.15 Income in Services

Both supply and demand functions have been estimated for the service sector. Although both functions fit the sample data reasonably well, the demand formulation appears to be a more realistic statement of the true determinants of services output. Supply can be expanded substantially using present structures and other capital facilities, and employing labor which is in excess supply. Of course, expanding output in this manner produces crowded conditions in markets and offices, reducing efficiency, so in the long run investment responds to the rate of capacity utilization.

On the demand side, services were made a function of total non-service GNP, or non-Agricultural non-service GNP. The latter gives a better explanation of the 1957-67 data, probably because the dynamic element in demand for services has been the income in urban areas.

A capital stock series for this sector was constructed by summing depreciated investment and adding this to depreciated base-year capital stock. Base year capital stock was estimated by using a cross-sectional estimate of the average capital-output ratio in this sector. The equations are indicated below:

TABLE 5-A

EQUATIONS FOR INCOME IN THE SERVICE SECTOR

Equation	Functional Relationship (Regression)	Statistics $\bar{R}^2$	Statistics SPC	Serial corr.
5.1	40.137 + 0.49 (VA + VO + VM + NFI) (2.95) (16.22)	.963	3.88	neg.
5.2	131.106 + 0.767 (VO + VM + NFI) (38.58 (38.85)	.993	1.64	neg.
5.3	24.265 + 0.741 (KS) (1.94) (18.91)	.973	3.34	none
5.4	131.862 + 0.814 (VM + VO) (34.12) (34.47)	.922	1.85	neg.

VA = Value added in agriculture; VM = Value added in mining and manufacturing;
VO = Value added in social overhead; NFI = Net factor income from abroad;
KS = Capital stock in services.
SPC = Standard error of estimate divided by mean value of the dependent variable %.
T-ratios are given in parenthesis under the coefficients. Eleven observations: 1957-67.

A.4.1 Consumption Functions

Consumption is divided into three parts: private consumption, government defense expenditures, and government non-defense consumption. Defense expenditures are considered exogenous. Government non-defense consumption, which represents the economy's need for government services, is made a function of GNP. In fact, non-agricultural GNP was found to be more significant than total GNP in explaining government consumption. This appears reasonable in view of the fact that the most rapidly growing part of government consumption is related to the growth of urban areas, which are increasing at a rapid rate becasuse of migration from rural areas.

Private consumption is considered a function of disposable income; however, some experimentation was conducted with different approximations to disposable income in order to reduce unexplained variation. The permanent income hypothesis was tested in distributed lag form, but the simple sum of two years' disposable income performed equally well or better. The high degree of collinearity (0.995) between current disposable income and lagged private consumption probably distorts the coefficients in full distributed lag formulation. If the distribution lag formulation were written

$$CP_t = a + b\sum_{i=0}^{t} \lambda^{t-i} V_i^* , \qquad 0<\lambda<1,$$

then

$$CP_{t-1} = a + b\sum_{i=0}^{t-1} \lambda^{t-i} V_i^*$$

multiplying the second equation by λ and subtracting,

$$CP_t - \lambda CP_{t-1} = bV_t^*$$

or

$$CP_t = bV_t^* + \lambda CP_{t-1}$$

This latter form of the hypothesis was tested (in equation 7.5).

The government non-defense consumption equations are listed below and the private consumption functions in Table 6-A.

TABLE 6-A

PRIVATE CONSUMPTION FUNCTIONS

	Equation[1/] [3/] (Regression)	$\bar{R}^2$	Statistics[2/] SPC	Serial corr.
7.1	131.890 + 0.722 (V-TAX) (8.90) (31.40)	.990	1.70	neg.
7.2	102.035 + 0.397 (V-TAX) + (VL-TAXL) (9.27) (44.95)	.995	1.20	neg.
7.3	148.138 + 0.702 (V-REVD) (11.66) (35.36)	.992	1.51	neg.
7.4	129.835 + 0.700 (V-TAXI) (8.61) (31.02)	.990	1.74	neg.
7.5	57.113 + 0.446 (V-TAXI) + 0.429 (CPL) (0.95) (2.18) (1.25)	.990	1.68	neg.
7.6	132.264 + 0.702 (V-TAXIM) (8.70) (30.59)	.989	1.76	neg.
7.7	111.183 + 0.379 /(V-TAXIM) + (VL-TAXIML)/ (9.27) (41.44)	.995	1.18	neg.
7.8	121.668 + 0.737 (V-TAX) (9.65) (36.88)	.992	1.62	neg.

1/ V = GNP.
TAXI = Internal taxes.
TAXIM = Internal taxes and monopoly profits.
TAX = Internal taxes, monopoly profits, and customs duties.
REVD = TAX + non-tax revenues (total domestic revenues).
CPL = Private consumption lagged one year.
VL, TAXL, TAXIML = one-year lagged values of above variables.

2/ SPC = Standard error of estimate divided by mean value of dependent variable %.

3/ T-ratios are given in parentheses below the coefficients. Eleven observations (1957-67) were used for equation 7.1 to 7.7, and twelve observations (1956-68) for 7.8.

A.5 Domestic Revenue Functions

In Korea domestic revenues are derived from three sources: customs duties, internal taxes plus monopoly profits, and non-tax revenues. Monopoly profits are normally a small item and are placed with internal taxes in the Korean accounts system. In real terms internal tax collections grew very slowly and customs duty collections not at all during 1957-64. In 1965-67 there were sharp increases in all collections. The earlier period was characterized by inefficient tax administration; real tax collections actually declined substantially in 1961, the year of the military revolution. Beginning in 1965, the Pak administration laid great emphasis on improvement in tax collection procedures. Late in 1967 the National Assembly passed a bill revising the tax structure itself, but this reform had a minor overall effect on collections - it has been estimated that it will yield less than a 5% increase in revenue, given the same tax base. The improvements in tax administration, together with growth of the tax base, yielded total real tax increases of 19%, 36% and 26% in 1965, 1966, and 1967, respectively. The 1968 percentage increase apparently was at least as great as any previous one.

To forecast future revenue collections, an attempt was made to distinguish the roles played by tax base increases and tax administration improvements in recent years. To do this, a variable representing administrative improvement has been used. This variable is not always important: for example, it was found that the growth of imports alone explained the increases in customs duty collection; that is, customs collections relative to the duty base have not increased. (See Table 7-A below.) In internal taxes, however, the tax base did not grow as rapidly as tax collections in recent years, so administrative reform accounted for most of the improvement. Non-tax revenues appear to have grown about as rapidly as the tax base.

TABLE 7-A

CUSTOMS REVENUE FUNCTIONS

	Equation 1/ (Regression)	$\bar{R}^2$	Statistics 2/ SPC	Serial corr.
10.1 3/	4.480 + 0.045 IMP (3.31) (4.90)	.697	15.77	none
10.2	2.871 + 0.089 IMP04 (2.41) (6.91)	.824	12.03	none
10.3	4.766 + 0.052 (IMP04 + IMPK) (4.68) (6.32)	.796	12.96	none
10.4	3.915 + 0.084 IMP01 (3.99) (8.01)	.888	8.84	none

1/ IMP = Total imports of goods and services; IMPK = Imports of capital goods; IMP04, IMP01 = See note to Table 3.
2/ SPC = Standard error of estimate, divided by mean value of dependent variable (%); T-ratios are given in parentheses under coefficients.
3/ 11 Observations: 1957-1967.

The administrative reform variable was designed to reflect improvements in the workings of the Korean tax collection system. To accomplish this, it was first assumed that during 1957-64 there was a constant level of efficiency in tax collection and then in 1956-67 the rate of collection with respect to the tax base increased by 20%, 25% and 20% respectively. Thus, the multiplicative administrative efficiency variable (ADMIN) has a value of 1.0 from 1957 through 1964 followed by values of 1.20, 1.50, and 1.80 in 1965, 1966, and 1967. Other versions of the variable were constructed analogously.

The results in Table 8-A (on the next page) show that use of the administrative efficiency variables improves the explanation of observed tax collections. Slight variations in the assumed rate of administrative reform do not have much effect on the calculated values. The best assumption appears to be a 10% decline in efficiency in 1964, followed by increases of 15%, 20%, and 15% in 1965, 1966, and 1967, respectively, (ADMIN 4). This conforms closely to prior judgment.

Since this variable changes the slope of the tax function, it reflects long-term changes in tax collection efficiency. Planned further improvements in collection efficiency may be incorporated in the model by increasing the administrative variable's value by given percentages. The calculated and actual values for all types of revenue functions are shown below:

TABLE 9-A

ACTUAL AND CALCULATED VALUES OF REVENUES

	CUSTOMS		TAXIM		NONTAX		SUM	
	Actual	Calc.	Actual	Calc.	Actual	Calc.	Actual	Calc.*
1957	7.3	9.4	38.0	38.4	1.2	5.1	46.5	52.9
1958	8.1	9.2	39.6	39.6	5.4	6.4	53.1	55.2
1959	8.2	8.2	42.2	42.2	5.8	7.4	56.1	57.8
1960	10.7	9.5	43.4	41.8	10.2	8.0	62.7	62.0
1961	9.5	8.3	43.4	41.3	10.7	9.1	61.5	60.8
1962	10.2	10.2	47.0	50.3	10.4	10.0	70.9	67.2
1963	9.0	10.4	50.8	52.0	14.3	12.6	75.3	73.8
1964	9.5	9.3	47.9	48.8	17.0	15.1	75.3	72.3
1965	12.6	10.6	59.5	56.7	20.3	17.5	89.6	87.7
1966	15.0	14.6	77.6	79.0	19.7	22.3	113.7	114.5
1967	17.0	17.3	101.1	100.6	24.4	25.9	142.0	144.3

* Sum of calculated values, not from separate equation.

TABLE 8-A

FUNCTIONS FOR INTERNAL TAXES PLUS MONOPOLY PROFITS

	ACTUAL REVENUE	CALCULATED WITH DIFFERENT INDEPENDENT VARIABLES1/2/ ADMIN1 VNA	ADMIN2 VNA	ADMIN3 VNA	ADMIN4 VNA	ADMIN5 VNA	ADMIN1 V	ADMIV2 V	VNA	V
1957	37.95	39.63	37.17	38.13	38.38	38.75	39.48	36.89	33.87	33.41
1958	39.60	40.53	38.54	39.39	39.64	39.81	40.85	39.03	35.97	36.82
1959	42.88	42.33	41.29	41.93	42.18	41.94	41.99	40.82	40.20	39.66
1960	41.75	43.20	42.62	43.15	43.41	42.97	42.62	41.80	42.25	41.22
1961	41.29	43.20	42.61	43.15	43.41	42.97	43.78	43.62	42.24	44.11
1962	50.26	45.73	46.47	46.71	46.98	45.96	44.79	45.21	48.18	46.63
1963	52.01	48.41	50.57	50.49	50.77	49.14	47.53	49.51	54.49	53.47
1964	48.79	49.32	51.96	47.64	47.91	50.22	50.24	53.75	56.63	60.21
1965	56.73	59.91	63.03	61.99	61.99	59.48	60.76	63.84	65.84	66.75
1966	79.01	77.35	77.79	78.83	78.83	77.57	79.57	80.07	77.49	79.47
1967	100.65	101.23	98.78	99.41	99.41	101.10	99.48	96.26	93.67	89.08
a		0.067	0.103	0.095	0.095	0.080	0.047	0.074	0.158	0.118
Constant term		19.947	7.131	10.422	10.587	15.475	14.771	-1.852	-12.344	-28.156
$\bar{R}^2$		.983	.977	.985	.991	.985	.976	.959	9.28	.874
SEE		4.68%	5.47%	4.46%	3.45%	4.48%	5.53%	7.28%	9.68%	12.80%
Serial corr.		neg.	neg.	neg.	neg.	neg.	neg.	neg.	pos.	none
Equation number		10.20	10.21	10.22	10.23	10.24	10.25	10.26	10.27	10.28

1/ V = GNP; VNA = non-agricultural GNP.
2/ The following administrative efficiency variables were used:

	ADMIN1	ADMIN2	ADMIN3	ADMIN4	ADMIN5
1964	1.00	1.00	0.90	0.90	1.00
1965	1.20	1.10	1.10	1.04	1.15
1966	1.50	1.21	1.27	1.24	1.38
1967	1.80	1.33	1.40	1.42	1.59

(the variables are identically equal to 1.00 for the years 1957-63.)

Aggregate tax and domestic revenue functions which embrace all of these determinatesof revenues, implicitly or explicitly, were found to have a higher goodness-of-fit over the sample periods, but the coefficient values are inappropriate, assigning, for example, too much weight to imports in the absence of an administrative improvement variable. Therefore, the disaggregated functions are used in forecasting.

A.6.0 Investment Functions

Total fixed capital formation has grown unevenly in the past decade in Korea, declining in 1958 and 1964 and increasing by more than 60% in 1966. In individual sectors the pattern of fluctuations differs. Inventory investment has, of course, fluctuated even more sharply, registering values from minus six billion won to plus thirty one billion won (in 1965 prices).

The rate of fixed investment has been tied closely to the volume of foreign capital inflows, but it is also related to growth of output and to existing capital stock levels. Since one of the main purposes of this model is to forecast foreign capital requirements, investment in most sectors is specified to be dependent on output and capital, and, as will be seen later, foreign capital inflows are made a function of investment. Inventories comprise mostly grains, so the inventory function includes the change in agricultural output and grain imports in the arguments.

As noted above, in all four sectors capital stock series were synthesized by summing depreciated investment. Different capital stock series can be derived by using different assumptions on base year capital stock and different depreciation rates. When this is done the investment equation coefficients are more sensitive to the particular measure of capital stock employed. Time limitations have permitted only brief experimentation with different definitions of capital stock.

A.6.1 Agricultural Investment Functions

Fixed capital formation in agriculture was considered a function of government savings and lagged income in agriculture. The current level of capital was not included: a number of capacity accelerator hypotheses were tested, but the capital stock coefficient was not statistically significant in any of them.

These results confirm evidence from other sources, including anthropological studies, which indicates that farmers in Korea do not make their production/investment plans with demand levels in mind. Rather, income windfalls and loans from the government are consistently put toward additional investment in productive capacity regardless of existing capacity. The fact that farm households have existed not much above subsistence level during most of the period studies may account for this strong tendency to increase production whenever possible.

The important role of the government's urban-rural redistribution of savings is shown in the equations: the sum of current and lagged government savings is significant in almost all formulations. The greater significance of lagged savings reflects the gestation lag in public supported projects such as irrigation and land reclamation. Other econometricians also have found the availability of government savings (defined somewhat differently than here) to be a significant variable in agricultural investment.

Equation (11.17) was selected for forecasting purposes. (See Table 10-A, page .)

A.6.2 Mining and Manufacturing Investment Functions

The general capacity accelerator investment function used here was derived as follows:

(1) $I = \theta (K^* - K)$

I = fixed capital formation

K = capital stock at beginning of current period, measured in capacity units

K^* = desired capital stock next period

θ = that portion of the shortfall in capital stock which is to be made up by investment this period;

Generally $0<\theta<1$ because some previously initiated investment will contribute to closing the current gap between K^* and K and because uncertainty about the future inhibits investing fully for demands expected several periods in the future. However, these two provisos are somewhat offsetting, so one would guess that generally $\theta > 0.5$.

Then

(2) $$I = \left[K\left(\frac{u}{u^*}\right)(1+r) - K\right]\theta$$

where u = current rate of utilization of capacity

u^* = desired long-term value of u

r = expected growth rate of demand for output

and therefore

(3) $$I = \left[K\left(\frac{Vk'}{u^*K}\right)(1+r) - K\right]\theta$$

where V = current output

k' = capital-output ratio

this yields $I = \left[\left(\frac{Vk'}{u^*}\right)(1+r) - K\right]\theta$

(4) $$= \left[\left(\frac{Vk'}{u^*}\right) + \left(\frac{rVk'}{u^*}\right) - K\right]\theta = \frac{\theta k'}{u^*}V + \frac{\theta k'}{u^*}\Delta V^* - \theta K$$

where ΔV^* = expected increment in demand for output. This is equivalent to

$$(5) \quad I = \frac{\theta k'}{u^*}V + \mu\frac{\theta k'}{u^*}\Delta V - \theta K$$

where ΔV = increment in output over previous period

$\mu = \Delta V^*/\Delta V$

Note that $\mu > 1$ in a growing economy. Therefore, the relationship can be stated

$$(6) \quad I = aV + b\Delta V - cK$$

with $b > a$, $c < 1$

and since $1/u^* \cong 1.15$, then $a \cong 1.15\theta \cong 1.15c$.

There is an approximation to this standard accelerator formulation in equation (12.6). (See Table 11-A following.) Since this particular equation employs KML instead of KM, and VML instead of VM, and ΔVML instead of ΔVM, we should expect the estimated $\hat{c}$ in equation (12.6) to be smaller than otherwise, $\hat{a}$ to be larger than a by $\frac{VM}{VML}$, and $\hat{b}$ to be larger than b by $\frac{\Delta VM}{\Delta VML}$.

These expectations are roughly confirmed in the regression results, with the exception that $\hat{b}$ is not statistically significant. (Even so $\hat{b}$ is of the right order of magnitude.) It turns out that $\hat{c}$ (or $\hat{\theta}$) is about 0.5 and $\hat{a}$ is 0.9, which is more than $1.15\hat{c}$, but as noted that is expected in view of the lags in the estimated equation and the rapid growth of VM in recent years.

Equation (12.6) also can be used to derive estimates of the capital-output ratio k'. The coefficient of KML, equal to 0.47, may be taken as an estimate of θ. Given that $1/u^* = 1.15$, and correcting for the lags, we have

$$(7a) \quad k' = \frac{\hat{a}u^*}{\hat{\theta}} \Big/ \frac{VM}{VML} = 1.50.$$

Alternatively,

$$(7b) \quad k' = \frac{\hat{b}u^*}{\hat{\theta}\mu} \Big/ \frac{\Delta VM}{\Delta VML} = 0.77.$$

Since the estimate $\hat{a}$ is statistically more significant than the estimate $\hat{b}$, the capital-output ratio in this sector is likely to be closer to 1.50 than 0.77. From the manufacturing production functions, the estimate of k' is 1.21, so it appears that the true value lies in the range 1.2-1.5.

Dropping VML and substituting VNAL for VML, equation (12.2) (see Table 11-A on page) can be derived. As expected, the coefficient of VNAL is about