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KOREAN AGRICULTURAL SECTOR STUDY

Special Report 10

A MACRO MODEL OF ECONOMIC GROWTH AND INCOME DISTRIBUTION: AN APPLICATION OF SYSTEMS SIMULATION TO THE KOREAN CASE

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PREFACE

This is another in the series of Korean Agricultural Sector Study reports published jointly by the National Agricultural Economics Research Institute, Ministry of Agriculture and Fisheries, Seoul, Korea and the Department of Agricultural Economics, Michigan State University, East Lansing, Michigan. The Korean Agricultural Sector Study is a field activity of the Agricultural Sector Analysis and Simulation Project funded at Michigan State University by the Agency for International Development under Contract AID/csd-2975 in cooperation with the National Agricultural Economics Research Institute. The author of this report did his research as part of the requirements for completion of the Development Analysis Study Program, an activity of the Agricultural Sector Analysis and Simulation Project. He was in residence at Michigan State University on a post-doctoral fellowship during the 1974-1975 academic year.

In this report Dr. Ho Tak Kim, assistant professor of Agricultural Economics, Seoul National University, develops a systems simulation model relating income distribution within and between the agricultural and non-agricultural sectors of the Korean economy with Korean gross national product. The model is based on the theoretical relationships implied by his statement--"Given a state of income distribution, corresponding levels of capital formation and effective demand will prevail, resulting in a specific rate of economic growth."

Data and time constraints did not allow full development and use of the model for analytical purposes. However, the model as formulated provides the core for further work on model development and on analysis in Korea or elsewhere.

Dong Hi Kim, Director
National Agricultural
Economics Research Institute

George E. Rossmiller, Director
Agricultural Sector Analysis and
Simulation Projects

I. Introduction

A. The Problem

Throughout the last decade, the Korean government has set up a high rate of sustained economic growth as a prime goal of its economic policies. A large portion of public and private investment has been spent for the development of the industrial sector during the period. As a result, the country was able to maintain a high rate of economic growth and studies indicate that the future prospects for the Korean economy promise prosperity.[1/]

Such a high rate of economic growth, however, has brought about undesirable by-products to the economy. Income distribution inequalities are a distinctive example in point. Large gaps exist in income between sectors, between regions, and among people within a sector; and these gaps are expected to widen in the future, as long as the present policies continue to pursue the same goal, as in the last decade. Tables 1 and 2 show some of the indicators of economic growth and income distribution in Korea.

The income distribution inequalities between sectors and among people have many implications not only for the welfare of the people involved but also for further growth of the economy. Perpetuation of low levels of income in one sector of the economy implies a low purchasing power of

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[1/] See for a further reference, Cole, David C., and Princeton N. Lyman, Korean Development, Harvard University Press, Cambridge, Massachusetts, 1971, and Rossmiller, G. E., et al., Korean Agricultural Sector Analysis and Recommended Development Strategies, 1971-1985, Michigan State University, Korean Agricultural Sector Study Team, 1972.

Table 1

Some Economic Indicators for Korea
1960-1972, in 1970 Prices

Indicator	1960	1972	Increase 1960-72	Annual Growth Rate
	---billion won---		%	%
Total GNP	1,129.72	3,023.63	146.0	12.2
Agricultural GNP	466.57	760.93	63.1	5.3
Agriculture as Share of GNP (%)	41.3	25.2		
	------won--------			
Per Capita GNP				
Nonagricultural	65,200	125,468	92.4	7.7
Agricultural	30,673	51,845	69.0	5.8
Agricultural Population as Percent of Total Population	58.0	44.9		

Data Source: Economic Statistics Yearbook, The Bank of Korea, 1973.

Table 2

ndicators of Income Distribution
at Farm Level in Korea, 1970

Indicators	Less Than 0.5 Chongbo	More Than 2.0 Chongbo
Number of Farms	842,171	169,904
	------------won------------	
Agricultural Income/Farm	72,407	369,073
Total Farm Income Per Farm	139,786	428,804
Farm Surplus	8,726	110,781

Data Source: Yearbook of Agriculture and Forestry Statistics, MAF, ROK, 1972.

this sector for the commodities produced by other sectors, which in turn restricts further growth of the other sectors. Also, a low level of income in the agricultural sector slows the adoption of new agricultural technologies and thus higher income opportunities are lost. In this sense, a more even distribution of income is desirable not only for the improvement of the welfare of the people at the low end of the income distribution but also for further growth of the economy.

On the other hand, a high rate of economic growth requires a high rate of capital formation. It is true that, other things being equal, a more even distribution of income reduces savings as a whole. Thus, trade-offs are necessary between a higher rate of growth and a more equitable distribution of income.

Several studies have been done in Korea on the distribution of income,[2] but they have failed to relate the subject to economic growth in a systematic way.

B. Objective of the Study

This paper is a broad view and is preliminary in the sense that it is not looking for any particular solution for policy problems posed above. The paper is designed primarily to broadly view the interrelationships expected to exist among the variables of income distribution, savings, effective demand, and the economic growth of the Korean economy; to examine the impact and consequences of alterrative policy measures for the redistribution of income on economic growth and on other related variables; and to suggest some implications for policy formulations for the future of the Korean economy. Due to the complexity of the problem, discussion of the welfare aspects of income distribution will be avoided in this paper. The principal tool of analysis used in this study is the systems simulation approach.

Description of Model

A. General Description of Model

A macro-systems simulation model has been developed to meet the objective described in Section I-B. The overall system of the model and interrelationships among subcomponents and among major variables are shown in Figure 1. The model consists of four basic subcomponents: economic growth, capital formation, effective demand, and income distribution. A theoretical

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[2]Park, K. H., "Income Distribution in the Agricultural Sector in Reference to the Farm Land Reform in Korea," The Industrial Management Research Center, Yonsei Business Review, Vol. 9, April 1972. Other references can be found in this article.

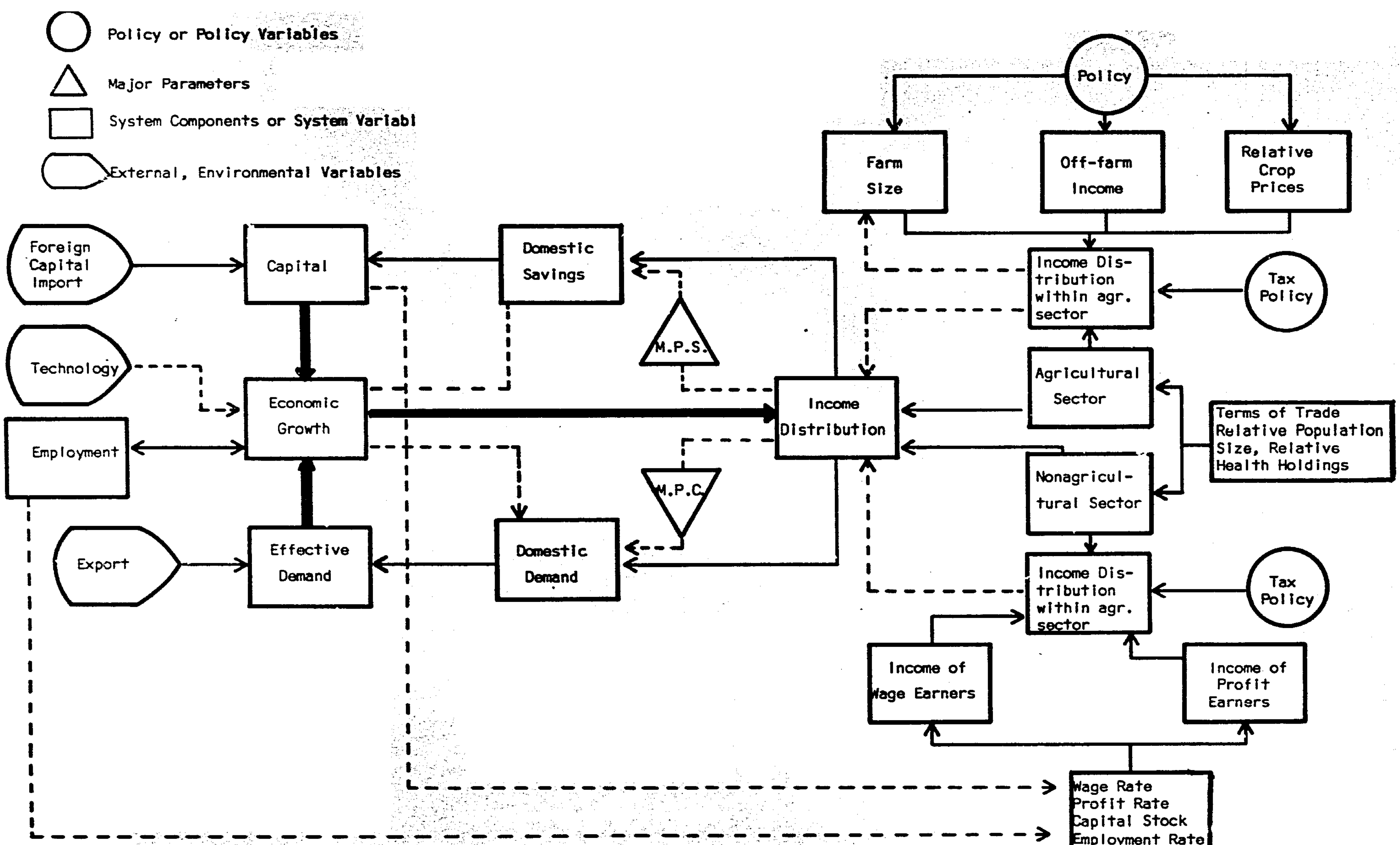

Figure 1. A Model of Economic Growth and Income Distribution--Relationships and Flow of Variables.

basis exists for the relationships among these subcomponents. Given a state of income distribution, corresponding levels of capital formation and effective demand will prevail, resulting in a specific rate of economic growth.

A macro-income determination model is postulated for the economic growth subcomponent, where economic growth is determined by changes in autonomous aggregate demand and the size of the marginal propensity to consume. Other factors contributing to economic growth, such as improvement in technology are implicitly assumed to remain constant.

The economy is divided into two sectors: agriculture and nonagriculture. Effective demand and savings are assumed to vary by sectors and by income classes within a sector. Farm families are classified into three groups according to the size of their farm. Urban families are classified into two groups: profit earners and wage and salary earners. A consumption function is built for each of the groups and used to estimate consumption and the marginal propensity to consume of each group. The aggregate consumption and the average marginal propensity to consume are derived from the set of group consumption functions.

Distribution of income is principally determined by economic factors such as productivity of resources in each sector and group, terms of trade between sectors, and level of employment of resources in each sector. However, institutional and policy variables such as wealth holdings, taxation, price control, public investment, and subsidies and other welfare programs are no less important than the economic factors in a consideration of income redistribution. This is especially true in countries such as Korea where the government is highly centralized and controls the economic system to a significant degree.

Once the distribution of income is determined, savings and aggregate demand can be determined, which in turn determine economic growth. The relationships among the subcomponents and variables involved are specified in more detail below.

B. Details and Specification of Model

1. Growth Component.

The following systems of equations are posed to explain the time path of the determination of the gross national product.

$$GNP(t+DT) = GNP(t) + DT \cdot RGNP(t) \qquad (1$$

where:

GNP(t) = the gross national product at time t

DT = time increment

RGNP(t) = rate of change in GNP during a time period DT.

The RGNP(t) is given by:

$$RGNP(t) = (CAGDEM(t))/(1-RMPC) \qquad (2$$

where:

RMPC = the aggregate marginal propensity to consume

CAGDEM(t) = changes in autonomous aggregate demand.

The RMPC is calculated by equation (16) in the following subsection a CAGDEM(t) is given by equation (3).

$$CAGDEM(t) = AGDEM(t) - AGDEM(t-DT) - (DGNNP(t) - DGNNP(t-DT)) \cdot RMPC(t) \qquad (3$$

where:

AGDEM(t) = aggregate demand

DGNNP(t) = aggregate disposable income for the economy.

These two variables are determined by equations (34), (53), and (54), respectively.

To see the effect of economic growth on employment, the following equation systems are posed.

EMPLOY(t+DT) = EMPLOY(t) + DT·REPLOY(t) (4)

REPLOY(t) = CLR·(TINVT(t) - TINVT(t-DT)) (5)

where:

EMPLOY(t) = total employment at time

REPLOY(t) = rate of change in employment during a time period DT

CLR = capital labor ratio

TINVT(t) = total net investment at time t

In addition, some simple accounting equations are needed to calculate indicators of GNP growth to show the performance of the system.

RGGNP(t) = (GNP(t) - GNP(t-DT))/GNP(t) (6)

SRG1(t) = (GNP1(t) - GNP1(t-DT))/GNP1(t) (7)

SRG2(t) = (GNP2(t) - GNP2(t-DT))/GNP2(t) (8)

PGNP1(t) = GNP1(t)/GNP(t) (9)

PGNP2(t) = GNP2(t)/GNP(t) (10)

where:

RGGNP(t) = growth rate of GNP at time t

SRG1(t) = growth rate of agricultural sector

SRG2(t) = growth rate of nonagricultural sector

PGNP1(t) = percentage of GNP shared by agricultural sector

PGNP2(t) = percentage of GNP shared by nonagricultural sector.

GNP1(t) and GNP2(t) are given by equations (35) and (36), respectively.

Other indicators of economic growth and income distribution will be calculated in the income distribution subcomponent.

2. Effective Demand and Savings Component.

The effective demand consists of four subcomponents: private consumption expenditure, private net investment, government expenditure, and net export. The private consumption expenditure is obtained by estimating a consumption function for each income class by the following equation systems.

$$CONEXP(t) = CONEX1(t) + CONEX2(t) \quad (11)$$

$$CONEX1(t) = \sum_{i=1}^{3} CONC1_i \cdot POPC1_i(t) \quad (12)$$

$$CONEX2(t) = \sum_{j=1}^{2} CONC2_j \cdot POPC2_j(t) \quad (13)$$

where:

CONEXP(t) = aggregate private consumption expenditure at time t

CONEX1(t) = aggregate consumption expenditure of agricultural sector

CONEX2(t) = aggregate consumption expenditure of nonagricultural sector

$CONC1_i(t)$ = consumption expenditure of a farm household in size class i

$CONC2_j(t)$ = consumption expenditure of an urban household in income class j.

$CONC1_i(t)$ and $CONC2_j(t)$ are given by equations (14) and (15) and $POPC1_i(t)$ and $POPC2_j(t)$ are calculated by equations (73) through (78).

$$CONC1_i(t) = CA_i + ECY1_i \cdot PCDGP1_i(t) + CT1_i \cdot t \quad (14)$$

$$CONC2_j(t) = CB_j + ECY2_j \cdot PCDGP2_j(t) + CT2_j \cdot t \quad (15)$$

where:

CA_i = constant term for farm households

CB_j = constant term for nonfarm households

$ECY1_i$ = marginal propensity to consume of a farm household in class i

$ECY2_j$ = marginal propensity to consume of a nonfarm household in class j

$PCDGP1_i(t)$ = per household disposable income of farm households in class i

$PCDGP2_j(t)$ = per household disposable income of nonfarm households in class j

$CT1_i$ = coefficient reflecting trends in consumption of farm househ(in class i over time

$CT2_j$ = coefficient reflecting trends in consumption of nonfarm households reflecting trends in consumption.

$PCDGP1_i(t)$ and $PCDGP2_j(t)$ are calculated by equations (57) and (58). Equations (14) and (15) will be estimated by least squares method.

The aggregate marginal propensity to consume is obtained on the basis of the equations (14) and (15).

$$RMPC(t) = \sum_{i=1}^{3} ECY1_i \cdot POPC1_i(t)/POP(t) + \sum_{j=1}^{2} ECY2_j \cdot POPC2_j(t)/POP(t). \quad (16)$$

where:

POP(t) = total number of households in the country at time t, which is given by equation (69).

Savings are simply a residual of household income after consumption given by:

$$SAV(t) = SAV1(t) + SAV2(t) \quad (17)$$

$$SAV1(t) = \sum_{i=1}^{3} SAVGC1_i(t) \quad (18)$$

$$SAV2(t) = \sum_{j=1}^{2} SAVGC2_j(t) \quad (19)$$

$$SAVGC1_i(t) = DGNPC1_i(t) - CONC1_i(t) \quad (20)$$

$$SAVGC2_j(t) = DGNPC2_j(t) - CONC2_j(t) \quad (21)$$

where:

SAV(t) = total amount of savings of the country at time t

SAV1(t) = total amount of savings in agricultural sector

SAV2(t) = total amount of savings in nonagricultural sector

$SAVGC1_i(t)$ = savings of farm households in class i

$SAVGC2_j(t)$ = savings of nonfarm households in class j

$DGNPC1_i(t)$ = aggregate disposable income of farm households in class i

$DGNPC2_j(t)$ = aggregate disposable income of nonfarm households in class j.

$DGNPC1_i(t)$ and $DGNPC2_j(t)$ are calculated by equations (55) and (56), respectively.

Other components of aggregate demand--government expenditure, net export, and a part of the private net investment--should be generated within the system to realistically estimate the growth of GNP. However, these components are externally determined in the model. The external determination of these components is not critical to derive a consistent conclusion of the model, if th level of these components remains the same from one simulation run to another. These are determined by equations (22) through (33).

$$GEXP(t) = GTAX1(t) + GTAX2(t) + GSUPL(t) \quad (22)$$

$$GSUPL(t) = GSUPL(0) + GEL1 \cdot (GNP(t) - GNP(t-DT)) \quad (23)$$

$$GINVT1(t) = PG1 \cdot GEXP(t) \quad (24)$$

$$GINVT2(t) = PG2 \cdot GEXP(t) \quad (25)$$

$$GEXPC(t) = GEXP(t) - GINVT1(t) - GINVT2(t) \quad (26)$$

where:

GEXP(t) = total government expenditure at time t

GTAX1(t) = tax revenue of the government from the agricultural sector

GTAX2(t) = tax revenue of the government from the nonagricultural sector

GSUPL(t) = government surplus or deficit

GINVT1(t) = government investment in the agricultural sector

GINVT2(t) = government investment in the nonagricultural sector

GEXPC(t) = government expenditure for consumption purposes.

In the above system of equations, GSUPL(t), GINVT1(t), and GINVT2(t) are determined by the controllable parameters, GE1, PG1, PG2, over which the government exerts control. GTAX1(t) and GTAX2(t) are determined by equations (63) and (64), respectively.

The net private investment is a sum of savings and foreign capital import. The latter is again determined externally to the model.

$$PNINVT(t) = SAV(t) + CAPIM(t) \tag{27}$$

$$CAPIM(t) = CAPIM(0) + CC1 \cdot (GNP(t) - GNP(t-DT)) \tag{28}$$

where:

PNINVT(t) = net private investment at time t

CAPIM(t) = foreign capital import.

It is assumed in the equation (28) that foreign capital import is a function of the growth of GNP.

The net export is the last component of the aggregate demand, which is externally determined to the model by equations (29) through (33).

$$EXPNET(t) = EXPORT(t) - IMPORT(t) \tag{29}$$

$$EXPORT(t) = EGP(t) \cdot GNP(t) \tag{30}$$

$$IMPORT(t) = RGPM(t) \cdot GNP(t) \tag{31}$$

$$EGP(t) = EGP(0) + (EGPM(t) - EGP(0))(1-EXP(-EX1 \cdot t)) \tag{32}$$

$$RGPM(t) = RGPM(0) + (RGPMD(t) - RGPM(0)) \cdot (1-EXP(RIM \cdot t)) \tag{33}$$

where:

EXPNET(t) = net export at time t

EXP(t) = percentage of GNP exported

RGPM(t) = proportion of GNP imported

EGPM(t) = desired level of GNP exported

RGPMD(t) = desired level of GNP imported

EX1 and RIM = controllable parameters.

Finally, the aggregate demand is determined simply by summing th subcomponents described above.

$$AGDEM(t) = CONEXP(t) + PNINVT(t) + PGEXP(t) + EXPNET(t) \quad (34)$$

where:

PGEXP(t) = government expenditure after transfer.

3. Income Determination Component.

The following systems of equations are employed to determine the distribution of GNP produced by each sector of the economy.

$$GNP1(t) = SHARE1(t) \cdot GNP(t) \quad (35)$$

$$GNP2(t) = GNP(t) - GNP1(t) \quad (36)$$

where:

SHARE1(t) = percentage of GNP1(t) to GNP(t).

The proportion of GNP(t) shared by the agricultural sector is determined by the following equation:

$$SHARE1(t) = A1 + CRPI \cdot PIAP(t)/PINAP(t) + CPOP \cdot POP1(t)/POP(t) + CK \cdot TWLTH1(t)/TWLTH(t) \quad (37)$$

where:

A1 = constant term

CRPI = coefficient of terms of trade between the agricultural and nonagricultural sectors

PIAP(t) = price index of agricultural products

PINAP(t) = price index of nonagricultural products

CPOP = coefficient for the relative number of farm household to total households

POP1(t) = number of households in the agricultural sector

CK = coefficient for the relative capital stock in the agricultural sector to total capital stock

TWLTH1(t) = capital stock in the agricultural sector

TWLTH(t) = total capital stock of the country.

The growth of the relative productivity of resources in the two sectors should be an important factor in determining the share of GNP of the two sectors. However, this factor is not considered in the present model, due to lack of data at this time.

The capital stocks, TWLTH1(t) and TWLTH(t), are generated within the system by equations (38) through (42); and other independent variables in equation (37) are determined externally.

$$TWLTH(t) = TWLTH1(t) + TWLTH2(t) \tag{38}$$

$$TWLTH1(t) = \sum_{i=1}^{3} TWLTC1_i(t) \tag{39}$$

$$TWLTH2(t) = \sum_{j=1}^{2} TWLTC2_j(t) \tag{40}$$

$$TWLTC1_i(t) = TWLTC1_i(t-DT) + DT \cdot SAVGC1_i(t) \tag{41}$$

$$TWLTC2_j(t) = TWLTC2_j(t-DT) + DT \cdot SAVGC2_j(t) \tag{42}$$

where:

$TWLTC1_i(t)$ = capital stock of farm households in class i

$TWLTC2_j(t)$ = capital stock of nonfarm households in class j.

To determine the terms of trade, price indexes of the agricultural and nonagricultural products are obtained by equations (43) and (44):

$$PIAP(t) = PIAP(0) \cdot EXP(C1 \cdot t) \quad (43)$$

$$PINAP(t) = PINAP(0) \cdot EXP(C1 \cdot t) \quad (44)$$

C1 and C2 are controllable parameters, which can be estimated with past data. The government can manipulate these parameters to a certain extent.

The distribution of income for income classes within a sector is determined by equations (45) through (52):

$$GNP1(t) = \sum_{i=1}^{3} GNPC1_i(t) \quad (45)$$

$$GNPC1_i(t) = CSHAR1_i \cdot GNP1(t) \quad (46)$$

$$CSHAR1_i(t) = CS1_i + CTW1_i \cdot TWLTC1_i(t)/TWLTH1(t) + CPOP1_i \cdot POPC1_i(t)/POP1(t), \quad \text{if } i=1,2 \quad (47)$$

$$CSHAR1_3 = 1 - \sum_{i=1}^{2} CSHAR1_i(t) \quad (48)$$

$$GNP2(t) = \sum_{j=1}^{2} GNPC2_j(t) \quad (49)$$

$$GNPC2_j(t) = PSHAR \cdot GNP2(t), \quad \text{if } j=1 \quad (50)$$

$$GNPC2_j(t) = GNP2(t) \cdot (1-PSHAR(t)), \quad \text{if } j=2 \quad (51)$$

$$PSHAR(t) = CP + CRC \cdot TWLTC21(t)/TWLTH2(t) + CP21 \cdot POP21(t)/POP2(t) \quad (52)$$

where:

$GNPC1_i(t)$ = gross products of farm households in class i

$CSHAR1_i(t)$ = percentage of GNP1(t) shared by class i

$CTW1_i$ = coefficient of relative wealth holdings of class i

$TWLTC1_i(t)$ = total wealth holdings of class i

$CPOP1_i(t)$ = coefficient for the relative number of households i class i

$POPC1_i(t)$ = number of farm households in class i

GNPC2(t) = gross products shared by nonagricultural households in class j

PSHAR(t) = percentage of GNP2(t) shared by profit earners

CP21 = coefficient of the relative number of households of profit earners

POP2'(t) = number of households of profit earners.

The number of households in each class, $POPC1_i(t)$ and POP21(t) are determined by equations (73) through (79).

The following system of accounting equations are employed to calculate disposable income of each group and households, which will be fed back to consumption functions and used as indicators of income distribution.

$$DGNNP1(t) = GNP1(t) - GTAX1(t) + TRASF1(t) \quad (53)$$

$$DGNNP2(t) = GNP2(t) - GTAX2(t) + TRASF2(t) \quad (54)$$

$$DGNPC1_i(t) = GNPC1_i(t) - RTAX1_i \cdot GNPC1_i(t) - RPTAX1_i \cdot TWLTC1_i(t) + TRASC1_i(t) \quad (55)$$

$$DGNPC2_j(t) = GNPC2_j - RTAX2_j \cdot GNPC2_j(t) - RPTAX2_j \cdot TWLTC2_j(t) + TRASC2_j(t) \quad (56)$$

$$PCDGC1_i(t) = DGNPC1_i(t)/POPC_i(t) \quad (57)$$

$$PCDGC2_j(t) = DGNPC2_j(t)/POPC2_j(t) \quad (58)$$

$$TRASC1_i(t) = CTRA_i \cdot TRASF1(t) \quad (59)$$

$$TRASF2(t) = RTRAS2 \cdot GEXP(t) \quad (60)$$

$$TRASC2_j(t) = CTRB_j \cdot TRASF2(t) \quad (61)$$

$$TRASF1(t) = RTRAS1 \cdot GEXP(t) \quad (62)$$

$$GTAX1(t) = YTAX1 \cdot GNP1(t) + PTAX1 \cdot TWLTH1(t) \quad (63)$$

$$GTAX2(t) = YTAX2 \cdot GNP2(t) + PTAX2 \cdot TWLTH2(t) \quad (64)$$

$$TAX1(t) = \sum_{i=1} RTAX1_i \cdot GNPC1_i(t)/GNP1(t) \quad (65)$$

$$TAX2(t) = \sum_{j=1}^{2} RTAX2_j \cdot GNPC2_j(t)/GNP2(t) \quad (66)$$

$$TAX1(t) = \sum_{i=1}^{3} RPTAX1_i \cdot TWLTC1_i(t)/TWLTH1(t) \quad (67)$$

$$PTAX2(t) = \sum_{j=1}^{2} RPTAX2_j \cdot TWLTC2_j(t)/TWLTH2(t) \quad (68)$$

where:

DGNNP1(t) = aggregate disposable income of the agricultural sector

DGNNP2(t) = aggregate disposable income of the nonagricultural sector

TRASF1(t) = transfer income of the agricultural sector

TRASF2(t) = transfer income of the nonagricultural sector

$DGNPC1_i(t)$ = aggregate disposable income of farm households in class i

$DGNPC2_j(t)$ = aggregate disposable income of the nonagricultural households in class j

$RTAX_{ki}$ = income tax rates for sector k, class i

$RPTAX_{ki}$ = property tax rates for sector k, class j

$CTRA_i$ = proportion of transfer income enjoyed by farm households in class i

$CTRB_j$ = proportion of transfer income enjoyed by nonagricultural households in class j

RTRAS1 = ratio of transfer income of farm households to government expenditure

RTRAS2 = ratio of transfer income of nonagricultural households to government expenditure

$YTAX_k$ = aggregate income tax rate for sector k

$PTAX_k$ = aggregate property tax rate for sector k.

Migration and movement of households between sectors and among classes 'ithin a sector should be determined by the system structure as a function f the economic, social, and institutional factors. However, this could ot properly be done in the system. The country wide total number of households and their distribution between sectors and within a sector are predicted by the following system of equations.

$$POP(t) = POP(0) \cdot EXP(RGP \cdot t) \quad (69)$$

$$POP1(t) = PRR \cdot POP(t) \quad (70)$$

$$POP2(t) = POP(t) - POP1(t) \quad (71)$$

$$PRR(t) = PRRMI + (PRRMA - PRRMI) \cdot EXP(RGP1 \cdot t) \quad (72)$$

where:

POP(t) = total number of households of the country at time t

POP1(t) = number of households in the agricultural sector

POP2(t) = number of households in the nonagricultural sector

PRR(t) = percentage of farm households to total households.

RGP and RGP1 are controllable parameters, the size of which will depend on population control programs and other government policies on population. The percentage of farm households to total, given by equation (72), is illustrated graphically in Figure 2. The minimum percentage, PRRMI, can be determined by looking at the development history of other countries which passed through a similar path of development. The maximum ceiling for the percentage of farm households will be that in the base year.

A similar relationship and equation system is postulated to predict the number of households in each class as follows:

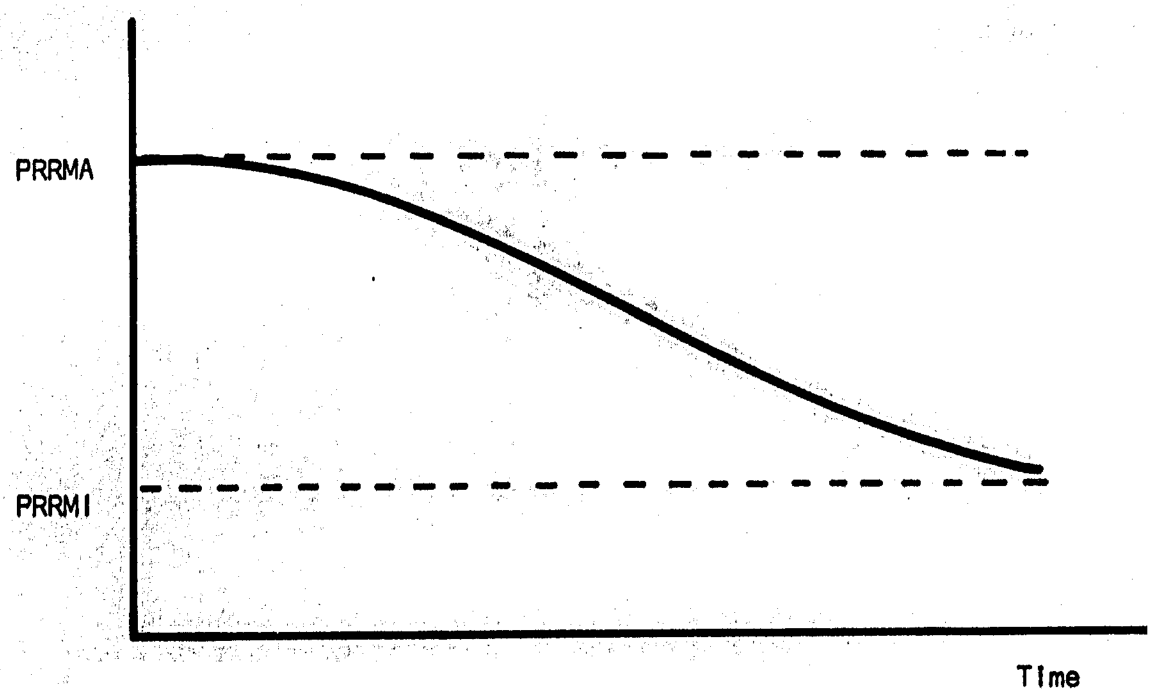

Figure 2. Hypothetical Representation of the Changes in the Percentage of Farm Households to Total as a Function of Time.

$$POPC11(t) = PRR1 \cdot POP1(t) \tag{73}$$

$$POPC13(t) = POPC13(0) \cdot EXP(RGPP3 \cdot t) \tag{74}$$

$$POPC12(t) = POP1(t) - POPC11(t) - POPC13(t) \tag{75}$$

$$PRRI(t) = PRR1MI + (PRR1MA - PRR1MI) \cdot EXP(RGPP1 \cdot t \tag{76}$$

$$POPC21(t) = POPC21(0) \cdot EXP(RGP2 \cdot t) \tag{77}$$

$$POPC22(t) = POP2(t) - POP21(t) \tag{78}$$

where:

$POPC1_i(t)$ = number of farm households

$POPC2_j(t)$ = number of nonfarm households

III. Empirical Analysis and Implications

The model specified in Section II-B has been transferred to FORTRAN language and programmed for CDC 6500. A detailed computer program for a base run is attached in the Appendix.

The base year of the analysis was 1973. The empirical analysis is solely based on secondary data sources.[4/] Difficulties were confronted in the analysis due to data availability and accuracy and credibility of data.

Some of the parameter estimations failed completely. For example, the estimation of parameters in equations (37) and (47) was attempted by applying the least squares method. Neither CRPI nor CK were shown to be related to SHARE1 in a statistically significant sense. The same was true for the estimation of parameters of equation (52). And furthermore, the sign of CRPI turned out to be negative, which by no means can be justified theoretically.

[4/]Main sources of data are: (1) Economic Statistics Yearbook, The Bank of Korea, 1965, and 1973; (2) Korea Statistics Yearbook, Economic Planning Board, ROK, 1970, 1973; and (3) Yearbook of Agriculture and Forestry Statistics, The Ministry of Agriculture and Forestry, 1963, and 1973.

All of the estimated parameters except CT1 in the consumption functio of farm households in each class were statistically significant, as shown in Table 3. The relative sizes of the marginal propensity to consume for the three classes came out as hypothesized,[5/] but the absolute sizes of the marginal propensity to consume was unrealistically low across all classes

Consumption functions for urban families could not be estimated, because no income data for profit earners were available. A residual method could have been used to approximate income of this group.

Because of these difficulties, a part of the model was revised and guess methods were used to estimate some of the parameters so that the model yields a reasonable approximation of reality.

Thus, the equations (37), (47), (48), and (52) were revised as follows:

$$SHARE1(t) = SHMI + (SHARE1(0) - SHMI) \cdot EXP(EX1 \cdot t) \quad (37)$$

$$CSHAR11(t) = CSHAR11(0) \cdot EXP(CS1 \cdot t) \quad (47)$$

$$CSHAR13(t) = CSHAR13(0) \cdot EXP(CS3 \cdot t) \quad (47)$$

$$CSHAR12(t) = 1 - CSHAR11(t) - CSHAR13(t) \quad (48)$$

$$PSHAR(t) = PSHAR(0) \cdot EXP(PC \cdot t) \quad (52)$$

where:

SHMI = a minimum percentage of GNP share for the agricultural sector. EX1, CS1, CS3, and PC are all the controllable parameters. These parameters should be determined by a combination of policy considerations and the movement of other variables in the model. For example, EX1 can be determined

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[5/] Theoretically, it can be hypothesized that the marginal propensity to consume decreases as one moves from a low income level to a high income level.

Table 3

Estimated Consumption Functions
for Farm Households, Korea@

Size of Farm	Constant Term CA_i	Marginal Propensity to Consume $ECY1_i$	Time Coefficient $CT1_i$	F-Value
	------------------won------------------			
Less than 1 Chongbo	38,809**	0.659**	-220	217.8**
1 - 2 Chongbo	90,158**	0.407**	1,317**	254.9**
Over 2 Chongbo	125,475**	0.364**	4,694*	67.4**

Note: ** indicates a statistical significance at least at tho 1 percent level
* indicates a statistical significance at the 5 percent level
@ 1955-1973 data were used for the estimation

in such a way that the agricultural share decreases over time, but not below a certain minimum level, and so that the rate of decrease should not exceed the rate of decrease of the relative number of farm households.

All the initial conditions and parameters estimated and/or adjusted, as such, are shown in the first part of the computer program in the Appendix. To start with, a base run was made, the outcomes of which can be compared with those of other runs under varying assumptions and parameters and under alternative policies. Tables 4 and 5 show some of the important variables for the base run.

A special notice is needed to interpret the results of the analysis. As described in Sections II-A and -B, the model did not estimate the growth of GNP over time by production function or by any form of trend function. Other factors affecting the growth of GNP, such as improvement in technology, were not considered in the model. Thus, it is not expected that the estimated GNP and other estimated values of the variables shown in Tables 4 and 5 should necessarily match with the actual growth of GNP and other values of the variables. This, however, would not affect the results and conclusions of this analysis, as long as the structural relationships of the model do not vary throughout the analysis. Important however are the relative magnitudes of the estimated values of the variables under varying assumptions and parameters and under alternative policies, not the absolute magnitudes.

The GNP, disposable income, and consumption expenditure per household shown in Tables 4 and 5 are estimated under the assumption that the past trend of income shares between and within sectors will remain the same as it has been in the past and no special considerations will be given to tax policies for redistribution of income between or within sectors.

Table 4

Estimated GNP, Share of Agriculture, Per Household GDP, for Base Run, 1974 - 1989, Korea*

Year	GNP billion won	Ag. Share %	Per Household Disposable Income by Class: Agriculture: Less Than 1 Chongbo PCDGC1(1)	1-2 Chongbo PCDGC1(2)	Greater Than 2 Chongbo PCDGC1(3)	Nonagriculture: Profit Earners PCDGC2(1)	Wages and Salary Earners PCDGC2(2)
			1000 won				
1974	3,593.8	23.71	297.2	488.3	672.7	1,326.4	551.7
1977	4,194.6	20.47	289.0	585.9	785.2	1,353.2	602.0
1980	4,814.4	17.99	294.8	678.5	926.9	1,379.2	653.9
1983	5,897.7	16.10	312.2	784.3	1,132.3	1,403.0	724.6
1986	7,494.0	14.66	348.2	936.0	1,475.2	1,674.3	845.3
1989	9,374.7	13.89	391.7	1,103.3	1,878.3	2,104.6	993.2

*For this base run, the following parameter values and tax rate are assumed.

For other parameter values and initial values of variables, see the Appendix.

SC = -0.09 CS1 = -0.05 CS3 = 0.05
RTAX1(1) = 0.0
RTAX1(2) = 0.00995
RTAX1(3) = 0.0254
RTAX2(1) = 0.11
RTAX2(2) = 0.0099

Note: SC = controllable parameter determining GNP share of agricultural sector.
CS1 and CS3 = controllable parameters determining GNP share of classes within agricultural sector.
RTAX1(i) = income tax rates by income classes for the agricultural sector.
RTAX2(j) = income tax rates by income classes for the nonagricultural sector.
1 Chongbo = 1 hectare (approximately)

Table 5

Estimated Per-Household-Consumption Expenditure of Agricultural and Nonagricultural Sectors, A Base Run, 1974 - 1989, Korea*

Year	Aggregate MPC RMPC	Consumption Expenditure Per Household by Income Classes				
		Agriculture			Nonagriculture	
		Less Than 1 Chongbo CONC1(1)	1-2 Chongbo CONC1(2)	Greater Than 2 Chongbo CONC1(3)	Profit Earners CONC2(1)	Wages and Salary Earners CONC2(2)
		1000 won				
1974	0.7334	277.6	412.1	488.4	681.3	437.2
1977	0.7282	279.4	488.9	566.0	731.5	476.3
1980	0.7237	287.3	562.0	662.6	776.1	516.5
1983	0.7200	305.2	644.9	800.6	818.1	569.9
1986	0.7167	338.7	762.3	1,028.0	958.8	658.3
1989	0.7147	377.7	890.2	1,293.2	1,177.4	764.4

*The parameters and tax rates are assumed as in the footnote of Table 4.

Under these assumptions, the agricultural share of GNP decreases consistently throughout the prediction period. The relative income of the medium- and large-sized farms is improving over time, but that of the small-size farms and wage and salary earners decreases. The same thing holds true in consumption expenditures. Again, the absolute sizes of GNP and disposable income can vary if there is an exogenous change in any or all of the components of the aggregate demand.

To see the effect of changes in the sectoral shares on the growth of GNP, predictions were made under different assumptions about sectoral shares. Table 6 shows predicted values of GNP and the share of the agricultural sector. It can be read from the table that as the share of the agricultural sector decreases, the GNP increases, as one compares the two alternatives. However, the difference in the growth of GNP under the two alternative shares is relatively small compared to the difference in the rate of decrease of the share of the agricultural sector. That the share of the agricultural sector decreases faster than GNP increases is not an unusual phenomenon in the history of economic development. Special considerations need to be given to the proble of the trade-offs between the growth of GNP and changes in the sectoral shares, since the rate of decrease in the share of the agricultural sector is greater than the rate of increase in the growth of GNP. This is especially true when one considers the welfare of people in one sector relative to the other.

The effect of tax policies on the redistribution of income and the growth of GNP has been examined. The income tax rates are changed such that the disposable income of low-income groups improves relative to that of high-income groups. Results of the examination are shown in Tables 7 and 8.

Table 6

Change of the Parameter for Sectoral Share and GNP Growth, 1974 - 1989, Korea*

	SC = -0.07		SC = -0.23	
Year	GNP	Agric. GNP SHARE1	GNP	Agric. GNP SHARE1
	--bil. won--	%	--bil. won--	%
1974	3,594.8	0.2399	3,587.8	0.2192
1977	4,197.6	0.2134	4,179.4	0.1598
1980	4,917.0	0.1919	4,907.0	0.1300
1983	5,898.1	0.1745	5,904.5	0.1150
1986	7,490.6	0.1604	7,518.8	0.1075
1989	9,367.6	0.1525	9,415.3	0.1048

*Income tax rates and all other parameters except SC are held constant, as in Table 4.

SC = controllable parameter determining GNP share of agricultural sector.

Table 7

Changes in Income Tax Rates, Estimated GNP, and
Per Household GDP, 1974 - 1989, Korea*

Year	GNP billion won	Per Household Disposable Income by Class: Agriculture: Less Than 1 Chongbo PCDGC1(1)	Agriculture: 1-2 Chongbo PCDGC1(2)	Agriculture: Greater Than 2 Chongbo PCDGC1(3)	Nonagriculture: Profit Earners PCDGC2(1)	Nonagriculture: Wages and Salary Earners PCDGC2(2)
		----------1000 won----------				
1974	3,631.3	294.9	494.7	653.8	1,259.5	558.3
1977	4,234.1	293.1	592.8	762.6	1,286.2	608.4
1980	4,958.1	298.9	685.9	899.8	1,268.8	660.4
1983	5,950.8	316.6	792.7	1,099.2	1,343.6	731.7
1986	7,570.2	353.6	947.0	1,433.4	1,611.1	854.5
1989	9,487.7	398.7	1,118.3	1,827.7	2,033.8	1,005.7

*The following tax rates and parameters are assumed for the estimation.

SC = -0.09
RTAX1(1) = 0.0
RTAX1(2) = 0.00975
RTAX1(3) = 0.0654

CS1 = -0.05

CS3 = 0.05
RTAX2(1) = 0.15
RTAX2(2) = 0.0095

Note: SC = controllable paramoter determining GNP share of agricultural sector
CS1 and CS3 = controllable parameter determining GNP share of income classes within agricultural sector.
RTAX1(I) = Income tax rates by income classes for agricultural sector.
RTAX2(J) = Income tax rates by income classes for nonagricultural sector.

Table 8

Effect of Changes in Income Tax Rates on Estimated Consumption Expenditure Per Household 1974 - 89, Korea*

Year	Consumption Expenditure Per Household by Income Classes				
	Agriculture			Nonagriculture	
	Less Than 1 Chongbo CONC1(1)	1-2 Chongbo CONC1(2)	Greater Than 2 Chongbo CONC1(3)	Profit Earners CONC2(1)	Wage and Salary Earners CONC2(2)
	1000 won				
1974	281.4	416.9	476.1	657.1	441.8
1977	282.9	494.1	551.3	716.5	480.8
1980	290.8	567.5	645.0	745.5	521.0
1983	308.9	651.2	779.1	788.4	574.9
1986	343.3	770.6	1,000.8	927.2	664.7
1989	383.7	901.4	1,260.2	1,142.0	773.2

*Income tax rates and parameters are fixed as in Table 7.

A comparison of Table 7 with Table 4 reveals that the projected GNP under the new income tax rates is consistantly higher than under the old income tax rates throughout the whole projection period. This improvement in GNP growth results from the increase in consumption expenditures of the low-income groups. Even though the consumption expenditure of the high-income groups decreases due to the new tax rates, the aggregate consumption expenditure of the country should increase, since the marginal propensity to consume of the low-income group is higher than that of the high-income groups

As expected from this income tax policy, the disposable income and consumption expenditures of the low-income groups improved relative to the high-income groups, as shown in a comparison of Tables 4 with 7 and 5 with 8 The degree of improvement in the relative position of the low-income groups will depend on the magnitude of the change in tax rates.

Even though both the GNP and the relative position of the low-income groups improved by the new income tax rates, this policy cannot be pursued without limit. A trade-off point will eventually be met, where the growth of GNP will start to decrease as the income tax rates turn more and more favorat to the low-income groups. The trade-off point has not been determined in thi paper. An optimum combination of tax rates for maximizing the growth of GNP can be determined with multiple computer runs of the model.

The effect of income redistribution within a sector has been examined. The sectoral shares and income tax rates were held constant while parameters determining the distribution of income within a sector were changed. Outputs of the model as a result of these changes are shown in Table 9. The table shows that when a greater portion of the agricultural share of GNP goes to high-income groups of farmers, the GNP grows more and more slowly. This observation reaffirms the conclusion reached above.

Table 9

Changes In Sectoral Share, Shares Within Agricultural Sector, and GNP Growth, 1974 - 1989, Korea*

	SC = -0.07		SC = -0.23	
	CS1 = -0.02 CS3 = 0.02	CS1 = -0.1 CS3 = 0.1	CS1 = -0.02 CS3 = 0.02	CS1 = -0.1 CS3 = 0.1
Year	GNP	GNP	GNP	GNP
	billion won			
1974	3,575.5	3,572.4	3.568.4	3,565.5
1977	4,163.9	4,247.1	4,143.6	4,130.9
1980	4,866.5	4,835.1	4,851.1	4,829.6
1983	5,826.2	4,774.6	5,823.2	5,788.9
1986	7,387.3	7,298.4	7,399.9	7,340.2
1989	9,230.0	9,088.7	9,254.7	9,157.8

*Income tax rates are held constant as in Table 4.

NOTE: SC = controllable parameter determining GNP share of agricultural sector.

CS1 and CS3 = controllable parameters determining GNP share of income classes within the agricultural sector.

Table 10

Changes in Shares, Transfer Income, and Income Tax Rates, and GNP Growth, 1974 - 1989, Korea (I)*

			Per Household Disposable Income by Class				
			Agriculture			Nonagriculture	
Year	GNP billion won	Ag. Share %	Less Than 1 Chongbo PCDGC1(1)	1-2 Chongbo PCDGC1(2)	Greater Than 2 Chongbo PCDGC1(3)	Profit Earners PCDGC2(1)	Wages and Salary Earners PCDGC2(2)
			----1000 won----				
1974	3,565.5	21.92	282.3	479.2	634.4	1,452.5	557.9
1977	4,130.9	15.98	238.7	519.5	703.7	1,437.1	625.3
1980	4,829.6	13.00	240.5	555.3	876.3	1,489.5	681.4
1983	5,788.9	11.50	268.0	598.9	1,217.9	1,546.7	750.3
1986	7,340.2	10.75	315.3	647.8	1,489.0	1,703.5	866.4
1989	9,157.8	10.48	361.2	681.2	1,937.4	2,113.5	1,009.7

*The following parameters and income tax rates are assumed:

RTRAS1 = 0.15 RTRAS2 = 0.05 CTRA(1) = 0.8 CTRA(2) = 0.2 CTRA(3) = 0

CTRB(1) = 0.0 CTRB(2) = 1.0

SC = -0.23 CS1 = -0.1 CS2 = 0.1

RTAX1(1) = 0.0 RTAX2(1) = 0.11

RTAX1(2) = 0.00995 RTAX2(2) = 0.0099

RTAX1(3) = 0.0254

Note: RTRAS1 and RTRAS2 = controllable parameters determining transfer of income of sectors from government.

CTRA(i) = controllable parameters determining tarnsfer income of income classes of agricultural sector.

CTRB(j) = controllable parameters determining transfer income of income classes of nonagricultural sector.

$RTAX_i(j)$ = income tax rates by income classes.

Table 11

Changes in Shares, Transfer Income, and Income Tax Rates, and GNP Growth, 1974 - 1989, Korea (II)*

			Per Household Disposable Income by Class				
			Agriculture			Nonagriculture	
Year	GNP billion won	Ag. Share %	Less Than 1 Chongbo PCDGC1(1)	1-2 Chongbo PCDGC1(2)	Greater Than 2 Chongbo PCDGC1(3)	Profit Earners PCDGC2(1)	Wages and Salary Earners PCDGC2(2)
			1000 won				
1974	3,612.8	24.00	330.0	468.4	621.2	1,332.0	553.9
1977	4,203.9	21.34	382.2	530.8	670.9	1,251.0	598.0
1980	4,911.5	19.19	440.9	597.8	731.5	1,223.1	645.1
1983	5,881.3	17.45	514.2	686.0	824.9	1,291.9	712.1
1986	7,465.8	16.04	617.9	827.7	993.0	1,550.0	829.6
1989	9,344.8	15.25	724.2	994.0	1,201.5	1,959.7	975.5

*The following parameters and income tax rates are assumed:

RTRAS1 = 0.15   RTRAS2 = 0.05   CTRA(1) = 0.95   CTRA(2) = 0.05   CTRA(3) = 0.0
CTRB(1) = 0.0   CTRB(2) = 1.0
SC = -0.07   CS1 = -0.02   CS3 = 0.02
RTAX1(1) = 0.0   RTAX2(1) = 0.15
RTAX1(2) = 0.00975   RTAX2(2) = 0.0095
RTAX1(3) = 0.065

Note: The parameters are defined in Table 10.

Two alternative policies for income redistribution between sectors and among classes within a sector were tested to see their effect on the growth of GNP and other related variables. Table 10 shows the results of the analysis for case (I) where the government adopts a policy which favors high income groups. The figures in Table 11 are the results of the analysis for case (II) where the policy of the government directs more favorably toward the low-income groups.

In case (I), a higher portion of GNP is shared by the nonagricultural sector than in case (II). Also, income tax rates for the high-income groups are relatively lower in case (I) than in case (II). In addition, transfer income of small-sized farms within the agricultural sector is relatively lower in case (I) than in case (II).

It can be read from Tables 10 and 11 that under these two alternative policies the growth of GNP was consistently higher in case (II) than in case (I). This again can be interpreted as the growth effect of the redistribution of income due to the increase in the aggregate consumption expenditure.

Comparing the distribution of income between sectors and among income classes within a sector under the two policy alternatives, the distribution is much more even in case (II) than in case (I). For illustration, the distribution of income at the beginning year of the simulation was similar in both cases as shown in Tables 10 and 11. However, as time passes the income gap increases much more widely in case (I) than in case (II). At the beginning year, the annual income per household of the small-sized farms was nearly half of that of the large-sized farms and that of the medium-sized farms was around two-thirds of that of the large-sized farms in both cases.

At the ending year, however, the annual income of the small-sized farms in case (I) was less than one-fifth that of the large-sized farms an the annual income of the medium-sized farms was a little more than one-third of that of the large-sized farms. On the other hand, the annual income per household of the small- and medium-sized farms in case (II) improved significantly relative to the large-sized farms and the nonfarm sector classes.

The major policy implication derivable from the above analysis is that the redistribution of income from high- to low-income groups improves the growth of GNP. This improvement is attributed to the increase in aggregate consumption expenditures due to the redistribution of income.

Which parameters should be used and how much they should be changed to improve a certain level of the growth rate have not been discussed in grea detail in the analysis. Only the direction and the corresponding effects c the changes of the parameters have been examined. The answers to such specific policy questions need more effort in specification of the model.

Summary and Conclusion

A model-building and empirical-analysis effort was attempted in this study to understand the interrelationships existing among the variables of income distribution, savings, effective demand, and the economic growth of the Korean economy. The main objective in understanding these interrelationships was to examine the impact and consequences of alternative policy measures for the redistribution of income on economic growth and on other related variables, and to derive implications for policy formulations for the future of the Korean economy.

A macro-systems simulation model was developed to aid in the empirical analysis to meet the above objective. The model consists of four basic subcomponents--economic growth, capital formation, effective demand, and income distribution. A theoretical basis exists for the relationships among these subcomponents. Given a state of income distribution, corresponding levels of capital formation and effective demand will prevail, resulting in a specific rate of economic growth. These relationships were all specified in mathematical form in Section II and then transformed into FORTRAN for computer runs, as shown in the Appendix.

For empirical analysis secondary data provided mostly by government sources were used. Simulation runs were made projecting for the next 15 years, starting in 1974. The base year for the runs was 1973.

The economy was classified into two sectors: agricultural and nonagricultural. The agricultural sector was reclassified into three groups according to farm size; and the nonagricultural sector into two groups: profit earners and wage and salary earners. The whole analysis was done on the basis of this classification.

Difficulties were confronted in the analysis due to the problem of availability, accuracy, and credibility of data. Some of the parameter estimations failed completely. Thus, a part of the original model had to be revised and guess methods had to be employed to estimate some of the parameters.

Implications derived from the analysis were that the redistribution of income from high- to low-income groups in general improves the growth of GNP. This improvement is attributed to the increase in aggregate consumption expenditures due to the redistribution of income.

Several policy alternatives for the redistribution of income are available by which the government can achieve a certain level of growth rate. What alternatives, what parameters, and what values of these parameters should be chosen by the government to achieve the level of growth rate were not discussed in great detail in the analysis. Only the direction and the corresponding effects of the choice were examined. The answers to the specific policy questions, however, can be obtained by putting more efforts into improving the present model.

Some of the weaknesses of the model which will need improvement in the future should be pointed out here, along with some suggestions for the further development of the model. First of all, the model did not account for some of the important factors in determining the growth of GNP, such as the improvement of technology. To estimate the growth path of GNP more realistically, these factors need to be built into the model. Also, the estimation of the exogenous variables of aggregate demand, such as net export, the government surplus, and a part of private investment, needs to be improved to estimate the growth of GNP more realistically.

Secondly, the distribution and the movements of households between sectors and within a sector over time were determined externally in the present model. However, these components should be generated within the system structure as a function of related economic and policy variables to portray the system structure more realistically and to obtain more useful information for policy formation.

Thirdly, the present model did not incorporate time lags or delays properly. The time lags or delays need to be built into parts of the model to make it more realistic; for example, there should be a time lag between investment and both increase in production capacity and increase in employment. Also, a time lag exists between an increase in aggregate demand and the growth of GNP. These delays can be built into the model without major difficulties by using delay subroutines if the necessary parameters are determined by survey.

Finally, as data are more available, GNP shares between sectors and within a sector should be estimated and generated within the system structure as a function of related economic and policy variables. This point has been mentioned in Section III. The present analysis failed to estimate the parameters of equations representing the GNP shares, mostly due to data problems. This point, however, can possibly be improved in the future by revising equation specifications and collecting related data.

APPENDIX

```
      PROGRAM GROWTH(INPUT,OUTPUT)
      DIMENSION CSHARE1(3),RTAX1(3),RTAX2(2),RPTAX1(3),RPTAX2(2),
     1CTRA(3),CTRP(2),CA(3),ECY1(3),ECY2(2),ECP1(3),CT1(3),CB(2),ECP2(2)
     1,CT2(2),TWLTC1(3),TWLTC2(2),GNPC1(3),GNPC2(2),TRASC1(3),DGNPC1(3),
     1PCDGC1(3),POPC1(3),TRASC2(2),SAVGC1(3),SAVGC2(2),R1(6),CNF1(3),
     1CET1(3),POPC2(2),DGNPC2(2),PCDGC2(2),CONC1(3),CONC2(2)
      REAL IMPORT,IMPORJ
      SC=-0.25

      OUTER LOOP FOR THE CHANGE OF PARAMETERS START

      DO 95 K=1,9
      SC=SC+0.02
      RTAX1(1)=0.0
      RTAX1(2)=0.01
      RTAX1(3)=0.0154
      RTAX2(1)=0.10
      RTAX2(2)=0.01
      DO 85 KM=1,5
      RTAX2(1)=RTAX2(1)+0.01
      RTAX2(2)=RTAX2(2)-0.0001
      RTAX1(1)=RTAX1(1)
      RTAX1(2)=RTAX1(2)-0.00005
      RTAX1(3)=RTAX1(3)+0.01
      CS1=-0.12
      CS3=0.12
      DO 83 IK=1,5
      CS1=CS1+0.02
      CS3=CS3-0.02
      PRINT 65,SC
   65 FORMAT(//,5X,*SC=*,F10.5)
      PRINT 75,(RTAX2(KL),KL=1,2),(RTAX1(LK),LK=1,3)
   75 FORMAT(* *,3X,*RTAX2(1)=*,F10.5,*RTAX2(2)=*,F10.5,*RTAX1(1)=*,
     1F10.5,*RTAX1(2)=*,F10.5,*RTAX1(3)=*,F10.5)
      PRINT 66
   66 FORMAT(* *,6X,*GNP*,11X,*GNP1*,10X,*GNP2*,4X,*PCDGC1(1)*,4X,
     1*PCDGC1(2)*,4X,*PCDGC1(3)*,4X,*PCDGC2(1)*,4X,*PCDGC2(2)*,4X,
     1*SHARE1*)
      PRINT 63,CS1,CS3
   63 FORMAT(* *,3X,*CS1=*,F10.5,5X,*CS2=*,F10.5)
      PSH=0.28
      PSHMI=0.28
      PSHMA=0.35
       EGP=.3354
      RGPM=.3487
      PC=0.01
      GPEMI=.3354
      GPIMI=.3487
      GPIMMA=.40
      GPEXMA=0.40
      POPC01=151715.
      BGPP3=0.007
      CSH01=0.529
      CSH03=0.116
      SHARE0=0.1
      SHAMA=0.25
      PRR=0.416
      PRRMA=0.416
      RGP=0.02
      PRRMI=0.150
      PR21=0.10
```

```
PR2MI=0.05
RG21=0.002
PR2MA=0.10
BP21=0.0001
BGP1=-0.05
PRR1=0.667
POP0=5900000.
PRR2=0.269
PRR1MI=0.4
PRR2MI=0.15
PRR1MA=0.667
BGPP1=-0.01
PRR2MA=0.269
RGPP2=0.0002
SHARE1=0.25
CSHARE1(1)=0.529
CSHARE1(2)=0.355
CSHARE1(3)=0.116
RPROF=0.3
EMPLOY=50.0
CONY1=1131731.
RPTAX2(1)=0.1
RPTAX2(2)=0.0
SAV=600.E09
BTRAS2=0.05
RTRAS1=0.1
CTRA(1)=0.8
CTRA(2)=0.2
CTRA(3)=0.0
CTRB(1)=0.0
CTRB(2)=1.0
CB(1)=100000.
CB(2)=50000.
CT2(1)=1700.
CT2(2)=1300.
ECY2(1)=0.5
ECY2(2)=0.70
ECY1(1)=0.85
ECY1(2)=0.75
ECY1(3)=0.65
CT1(1)=1000.
CT1(2)=1200.
CT1(3)=1500.
CA(1)=30000.
CA(2)=45000.
CA(3)=50000.
RPTAX1(1)=0.0
RPTAX1(2)=0.0
RPTAX1(3)=0.0
CPINV=0.15
PG1=0.16
PG2=0.16
CLR=0.01
GNP=3534.28E09
TWLTH1=1022.52E09
TWLTH2=5952.58E09
TWLTC1(1)=513.71E09
TWLTC1(2)=338.96E09
TWLTC1(3)=119.34E09
TWLTC2(2)=2952.58E09
TWLTC2(1)=3000.E09
```

```
      CONY2=1500000.
      PCDGP=530000.
      DGNNP=2827.2E09
      TINVT=635.E09
      AGDEM=3534.28E09
      AUTOINC=50.E09
      AUTOIN=50.E09
      CC1=0.08
      DO 3 JJ=1,3
    3 SAVGC1(JJ)=0.0
      DO 4 KK=1,2
    4 SAVGC2(KK)=0.0
      TIME=0.0
      EXPORT=1185.59E09
      IMPORT=1232.52E09
      EXPOR0=1185.59E09
      IMPOR0=1232.52E09
      POP1=2451844.
      POP2=3448156.
      POPC1(1)=1578304.
      POPC1(2)=636710.
      POPC1(3)=151715.
      POPC2(2)=3048156
      POPC2(1)=400000.
      POP=5900000.
      GSUPL0=50.E09
      GSUPL=50.E09
      GE1=0.05
      TINC=100.E09
      GNP0=3534.28E09
      EX1=0.15
      RIM=0.1
      CTINP=300.E08
      CP=360.E09
      OLGNP=3023.63E09
      BMPC=0.75
      TIME=0.0
      DT=0.25
      T=0.0

      A SIMULATION FOR A PERIOD OF 15 YEARS STARTS

      DO 100 MJ=1,15

      THE INNER LOOP STARTS FOR 4 QUARTER OF THE YEAR

      DO 105 JM=1,4

      GNP PRODUCED SHARED BETWEEN AG. AND NON-AG. SECTORS

      OLGNP1=SHARE1*OLGNP
      GNP1=SHARE1*GNP
      OLGNP2=OLGNP-OLGNP1
      GNP2=GNP-GNP1
      RGGNP=(GNP-OLGNP)/OLGNP
      SRG1=(GNP1-OLGNP1)/OLGNP1
      SRG2=(GNP2-OLGNP2)/OLGNP2
      DO 110 KK=1,3
      TWLTH1=TWLTH1+DT*SAVGC1(KK)
  110 CONTINUE
      DO 115 MN=1,2
```

```
      TWLTH2=TWLTH2+D1*SAVGC2(NN)
  115 CONTINUE

      DISPOSABLE INCOME IS DETERMINED FOR EACH SECTOR AND FOR GROU

      YTAX1=0.0
      PTAX1=0.0
      DO 120 II=1,3
      GNPC1(II)=CSHARE1(II)*GNP1
      YTAX1=YTAX1+RTAX1(II)*GNPC1(II)/GNP1
      PTAX1=PTAX1+RPTAX1(II)*TWLTC1(II)/TWLTH1
  120 CONTINUE
      GTAX1=YTAX1*GNP1+PTAX1*TWLTH1
      GNPC2(1)=PSH*GNP2
      GNPC2(2)=GNP2-GNPC2(1)
      YTAX2=RTAX2(1)*GNPC2(1)/GNP2+RTAX2(2)*GNPC2(2)/GNP2
      PTAX2=RPTAX2(1)*TWLTC2(1)/TWLTH2+RPTAX2(2)*TWLTC2(2)/TWLTH2
      GTAX2=YTAX2*GNP2+PTAX2*TWLTH2
      GEXP=GTAX1+GTAX2+GSUPL
      TRASF1=RTRAS1*GEXP
      DGNNP1=GNP1-GTAX1+TRASF1
      PCDGP1=DGNNP1/POP1
      DO 125 KK=1,3
      TRASC1(KK)=CTRA(KK)*TRASF1
      DGNPC1(KK)=GNPC1(KK)-RTAX1(KK)*GNPC1(KK)-RPTAX1(KK)*TWLTC1(KK
     1+TRASC1(KK)
      PCDGC1(KK)=DGNPC1(KK)/POPC1(KK)
  125 CONTINUE
      TRASF2=RTRAS2*GEXP
      DGNNP2=GNP2-GTAX2+TRASF2
      DO 130 NN=1,2
      TRASC2(NN)=CTRB(NN)*TRASF2
      DGNPC2(NN)=GNPC2(NN)-RTAX2(NN)*GNPC2(NN)-RPTAX2(NN)*TWLTC2(NN
     1+TRASC2(NN)
      PCDGC2(NN)=DGNPC2(NN)/POPC2(NN)
  130 CONTINUE
      PCDGP2=DGNNP2/POP2
      OLPCD=PCDGP
      PCDGP=(DGNNP1+DGNNP2)/POP

      CONSUMPTION EXPENDITURE IS DETERMINED FOR SECTOR AND GROUPS

      DO 135 II=1,3
      CONC1(II)=CA(II)+ECY1(II)*PCDGC1(II)+CT1(II)*TIME
  135 CONTINUE
      OLCOY1=CONY1
      CONY1=ECY1(1)*PCDGC1(1)+ECY1(2)*PCDGC1(2)+ECY1(3)*PCDGC1(3)
      DO 140 JJ=1,2
      CONC2(JJ)=CB(JJ)+ECY2(JJ)*PCDGC2(JJ)+CT2(JJ)*TIME
  140 CONTINUE
      OLCOY2=CONY2
      CONY2=ECY2(1)*PCDGC2(1)+ECY2(2)*PCDGC2(2)
      CONEX1=0.0
      DO 145 MM=1,3
      CONEX1=CONEX1+CONC1(MM)*POPC1(MM)
  145 CONTINUE
      CONEX2=0.0
      DO 150 II=1,2
      CONEX2=CONEX2+CONC2(II)*POPC2(II)
  150 CONTINUE
      CONEXP=CONEX1+CONEX2
```

```
      THE AGGREGATE DEMAND IS DETERMINED

      PNINVT=SAV+AUTOIN
      GINVT1=PG1*GEXP
      GINVT2=PG2*GEXP
      GINVT=GINVT1+GINVT2
      OLTINT=TINVT
      TINVT=PNINVT+GINVT
      REPLOY=CLR*(TINVT-OLTINT)
      EXPNET=EXPORT-IMPORT
      OLDGP=DGNNP
      DGNNP=DGNNP1+DGNNP2
      OLDAGD=AGDEM
      PGEXP=GEXP-TRASF1-TRASF2
      AGDEM=CONEXP+PNINVT+PGEXP+EXPNET

      AGGREGATE MARGINAL PROPENSITY TO CONSUME IS DETERMINED

      RMPC=0.0
      RMPC1=0.0
      DO 111 JJ=1,3
  111 RMPC1=RMPC1+ECY1(JJ)*POPC1(JJ)/POP
      RMPC2=0.0
      DO 112 KK=1,2
  112 RMPC2=RMPC2+ECY2(KK)*POPC2(KK)/POP
      RMPC=RMPC1+RMPC2

      GNP GROWTH IS DETERMINED AS A FUNCTION OF AGGREGATE DEMAND AND RMP

      CAGDEM=AGDEM-OLDAGD-(DGNNP-OLDGP)*RMPC
      RGNP=CAGDEM/(1-RMPC)

      SAVINGS IS DETERMINED AS A RESIDUAL OF INCOME AFTER CONSUMPTION

      SAV1=0.0
      DO 155 JJ=1,3
      SAVGC1(JJ)=DGNPC1(JJ)-CONC1(JJ)
      SAV1=SAV1+DT*SAVGC1(JJ)
  155 CONTINUE
      SAV2=0.0
      DO 160 KK=1,2
      SAVGC2(KK)=DGNPC2(KK)-CONC2(KK)
      SAV2=SAV2+DT*SAVGC2(KK)
  160 CONTINUE
      SAV=SAV1+SAV2
      IF(.NOT.((J.EQ.1).OR.(J.EQ.4.AND.I.EQ.15)))GO TO 163
      PRINT 900,GNP,GNP1,GNP2,(PCDGC1(I),I=1,3),(PCDGC2(J),J=1,2),
     1SHARE1
  163 T=T+DT

      NUMBER OF HOUSEHOLDS IN EACH GROUP AND SECTOR IS DETERMINED

      POP=POPO*EXP(RGP*T)
      POP1=PRR*POP
      POP2=POP-POP1
      PRR=PRRMI+(PRRMA-PRRMI)*EXP(RGP1*T)
      POPC1(1)=PRR1*POP1
      PRR1=PRR1MI+(PRR1MA-PRR1MI)*EXP(RGPP1*T)
      POPC1(3)=POPC01*EXP(RGPP3*T)
      POPC1(2)=POP1-POPC1(1)-POPC1(3)
```

```
      POPC2(1)=PR21*POP2
      PP21=PR2MI+(PR2MA-PR2MI)*EXP(RG21*T)
      POPC2(2)=POP2-POPC2(1)
C
C     ALL RATE VARIABLES ARE DETERMINED
C
      OLGNP=GNP
      GNP=GNP+DT*RGNP
      DO 165 LL=1,3
      TWLTC1(LL)=TWLTC1(LL)+DT*SAVGC1(LL)
  165 CONTINUE
      DO 170 MM=1,2
      TWLTC2(MM)=TWLTC2(MM)+DT*SAVGC2(MM)
  170 CONTINUE
      EMPLOY=EMPLOY+DT*REPLOY
      TIME=TIME+DT
      PSH=PSHMI+(PSHMA-PSHMI)*EXP(PC*T)
      AUTOIN=AUTOIN0+CC1*(GNP-OLGNP)
      GSUPL=GSUPL0+GE1*(GNP-OLGNP)+TINC*T
      EXPORT=EGP*GNP
      IMPORT=RGPM*GNP
      EGP=GPEMI+(GPEXMA-GPEMI)*EXP(EX1*T)
      RGPM=GPIMI+(GPIMMA-GPIMI)*EXP(RIM*T)
      SHARE1=SHARE0+(SHAMA-SHARE0)*EXP(SC*T)
      CSHARE1(1)=CSH01*EXP(CS1*T)
      CSHARE1(3)=CSH03*EXP(CS3*T)
      CSHARE1(2)=1-CSHARE1(1)-CSHARE1(3)
  105 CONTINUE
      PRINT 900,GNP,GNP1,GNP2,(PCDGC1(I),I=1,3),(PCDGC2(J),J=1,2),
     1SHARE1
  900 FORMAT(* *,9E13.5)
  100 CONTINUE
   83 CONTINUE
   85 CONTINUE
   95 CONTINUE
      END
```

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