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STRUCTURE OF A RECURSIVE MODEL FOR POLICY ANALYSIS IN THAILAND

by

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FOREWORD

This report summarizes initial work involved in constructing a recursive policy model with applications especially to the Thai agricultural sector. The work is conducted in the Division of Agricultural Economics (DAE), the Ministry of Agriculture and Cooperatives, Royal Thai Government. The project under which the work was accomplished is a cooperative one between the Division of Agricultural Economics and the Center for Agricultural and Rural Development and the Economics Department of Iowa State University. It is funded by the Agency for International Development and the Royal Thai Government.

The overall project has several phases including regional, interregional and national programming models for analysis of policies and development programs of Thai agriculture; regional development models to evaluate effecient means of generating income and employment particularly in Northeast Thailand; individual farm models to evaluate the impact of agricultural policies and development programs on various types of individual farms in specific agro-economic zones; macro models to quantify the interrelationships between national economic policies and the agricultural sectors; market and demand studies for major agricultural commodities; market sector and transpartation models directed at improving the marketing efficiency; and related studies.

The current report provides background in the initial steps of linking the national and interregional programming model of agriculture with the macro economic model of the Thai economy. The quantification of this linked model is now underway; the resulting recurrsive modeling system is designed for economic development analyses over short time periods. A main purpose is for analysis of development plans in the agricultural sector on the nonagricultural sector and vice versa.

This model linkage is a first generation attempt. Its specification is limited considerably by available time series data for the macro model. Further details and disaggregation of variables will be attained with subsequent generations of the model.

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INTRODUCTION AND PREVIOUS WORK

The purpose of this paper is to discuss the approaches and progress in development of policy planning models in the Division of Agricultural Economics (DAE), Ministry of Agriculture and Cooperative in Thailand. Development of the DAE planning capability is a cooperative project with Iowa State University and funded by AID.[1]

Previous Research

The DAE is not a policy making group but rather a research group charged with objective analysis of alternative policies or sets of policies. To date, the cooperative DAE-ISU research program has produced a set of linear programming models of crop production with production detail specific to each of 19 agroeconomic zones in Thailand. The national crop production model has been used in the development of guidelines for the current Fourth Five-Year Development Plan [Framingham et al. 1]. In simultaneous research Stephenson and Itharattana [2] have completed an independent macro macroeconometric model of the Thai economy. In other current research the DAE staff members are completing a national combined crop livestock model and initiating construction of farm type models with detail to the level of the 71 changwants.

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[1]AID Project CM/SA/C/73-19; July 1, 1973. Project directors are Dr. Earl O. Heady and Dr. Somnuk Sriplung. The staff members serving in Thailand to date have been: Keith Rogers, Western Illinois University; Lee Blakeslee, Washington State University; Arthur Stoecker, Iowa State University; Dennis Conley, Illinois State University; James Stephenson, Iowa State University; Charles Framingham, University of Manitoba; Herbert Fullerton, Utah State University; Ken Nicol, Iowa State University; Neal Walker, Iowa State University; and Larry Kinyon, Iowa State University.

Staff members are also proceeding on the development of input-output models of the agricultural service sectors for regional analysis. The demand analysis group in DAE is completing a set of econometric commodity models for the major commodities. Other programming models which have been constructed with emphasis on processing, storage, and transportation of rice, kenaf, and sugar are described by Sukdidee and Sriplung [3].

Linkage Between the Macroeconometric Model and the Linear Programming Models

Objectives

The main objective of the particular planning model whose structure is discussed here is to pull together or link the agricultural sector parameters from a recursive linear programming (RLP) model of the agricultural sector with the macro econometric model (MM) which reflects changes in the total economy.

The linkage is being developed to allow those people in the policy making positions to relate the effects of changes in one sector (in this case agriculture) to the remaining sectors of the economy. It is also desirable to know the impacts of changes in the nonagricultural sectors on the agricultural sector.

There has been considerable interest in interfacing detailed models of a particular sector with more general models of the rest of the economy. Some examples of work in this area can be found in articles by Fox [4], Chen [5], Roop and Zeither [6], and Hein [7]. The above authors have been concerned with the interface between two levels of econometric models but the principles involved are relevant here. There are also examples of linkages or interfaces between linear programming and input-output or interface between a linear programming model and an econometric model. Researchers with the Michigan State sector analysis team working in Korea have developed a general simulation system which includes an interface between a recursive linear programming model of the agricultural sector and a recursive input-output model of the national economy [8, 9, 10].

Some of the policy issues which can be considered for Thailand when the interface between linear programming model(s) and the macro econometric model is completed include:

1. Influence of export expansion and import substitution policies on farm income and the balance of payments.

2. Effect of agricultural price policies on the cost of living.

3. Ability of the economy to provide employment for a growing population.

4. The effect of agricultural development policies on the nonagricultural sector and total economy as related through:
    a. The level of farm income.
    b. The level of agricultural employment.
    c. Changes in investment in agriculture and related agricultural industries.
    3. Changes in purchases of inputs by agriculture from nonagricultural sectors.

5. Annual update to the Five-Year Development Plan.

The essential features in the linkage are:

1. The interface between the linear programming model and the macro model will be recursive. This is dictated in part by the recursive nature of the macro model and in part by the algebraic differences between the two models.

2. A system of crop flexibility restrictions is being used to constrain the linear programming model to reflect observed annual rates of change in planted area. The flexibility restraints assume an adaptive expectations hypothesis and allow researchers to simulate disequilibrium conditions in what is normally an equilibrium model.

Phases of the development planning and implementation and model types

The planning process may be divided into discussion, formulation and monitoring phases. In the planning work we expect more use of static partial equilibrium models in the discussion phase followed by more intensive use of the recursive models in the plan formulation and monitoring phases. These phases are shown in Figure 1.

Discussion Phase. The authority for development planning in Thailand lies with the National Economic and Social Development Board (NESDB). NESDB is attached to the Office of the Prime Minister. In the lengthy process of drafting a development plan, a series of formal and informal meetings and/or contacts are made between NESDB and the Ministries, Universities and other groups concerned. Different groups take actual responsibility for planning in such broad areas or sectors as Agriculture, Industry, Education, National Defense, and Health. The planning process is structured so that, by representation on committees and formal and informal contacts, the planners in one sector are aware of at least the broad outline of the development plan being formulated

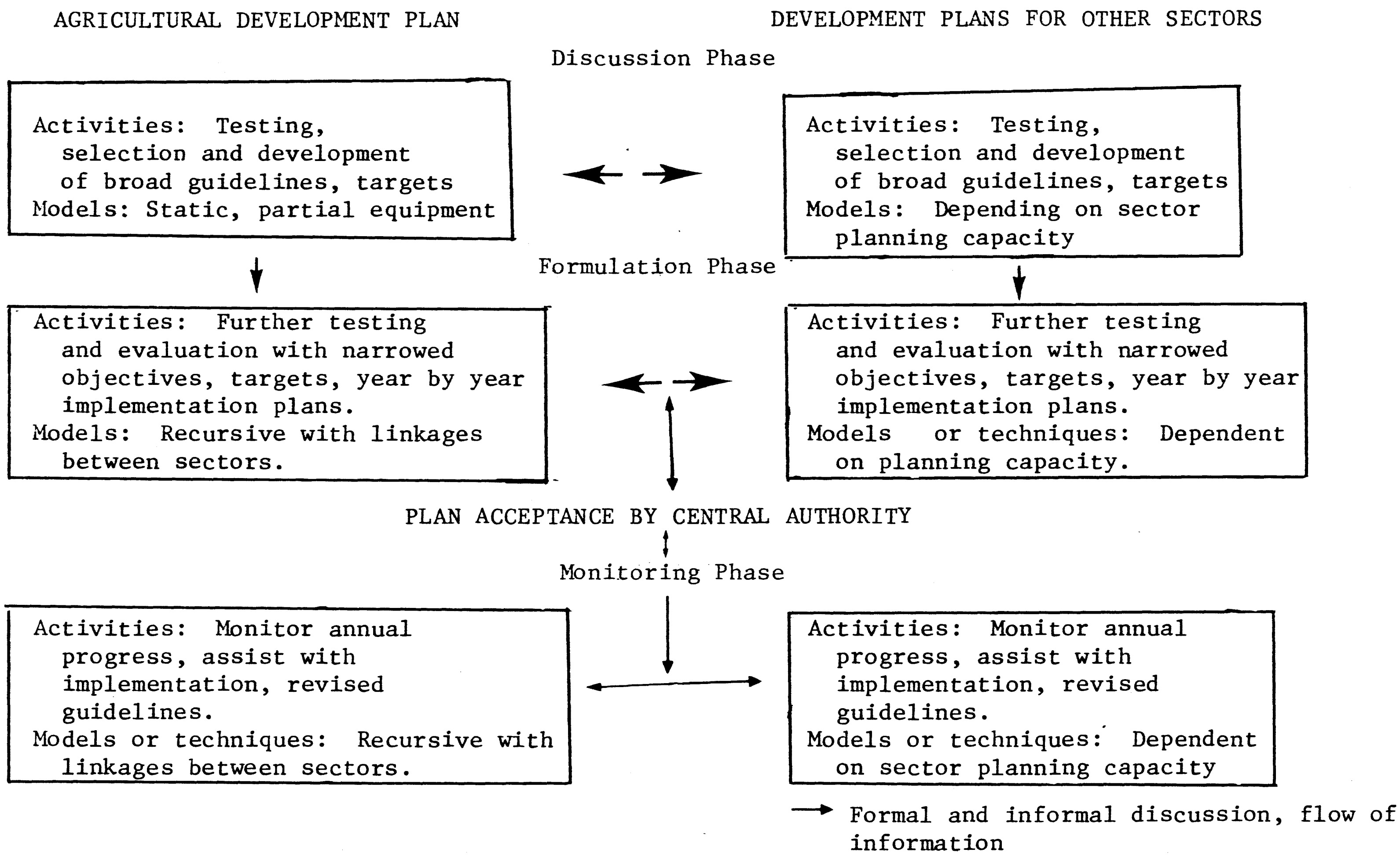

Figure 1. Use of alternative forms of planning models in the process of plan formulation and follow-up.

in any sector which would interact with or influence his sector. At this time the plan for agriculture may deal with broad ranges of export targets and funding levels for investments. The alternative levels of investment and targeted outputs in each sector may be flexible and may also change rapidly. A planner in agriculture may wish to know quickly the impacts of changes in, for example, the number of miles of feeder roads on agricultural production. This requires a rapid flow of information between the person responsible for the plan and the persons carrying out the analysis of the plan. Static partial equilibrium models which represent a distant point in time, such as the end of the proposed planning period, are more flexible than are annual recursive systems. In previous work the DAE considered the feasibility of meeting alternative export targets given alternative population growth rates and investments in agriculture at a point five years in the future. The analysis permitted a reduction in the number of alternatives and agreement on narrower guidelines for further planning. The analysis required seven static solutions whereas a recursive system would have required 35 solutions.

Formulation Phase. Planners, of course, must make the best of existing data sources and operational techniques. In previous work, the operational techniques in the DAE had progressed through the formulation and operation of static partial equilibrium models of agriculture. These models were able to provide guidelines for planning but information related to the year by year effects of investments on outputs in agriculture and in other sectors could not be easily obtained.

As plans for agriculture and other sectors become finalized, it is desirable to model a year-by-year walk through the development plan. It is in this phase of planning that we expect the recursive form of the programming model with its linkage to the nonagricultural sectors to be especially useful.

Monitoring Phase. The planning process should not stop with plan approval and implementation. An annual monitoring of the plan with a series of recommendations for updating will be valuable because exogenous events and unforseen bottlenecks alter the set of assumptions used in planning and therefore the likelihood of meeting expected targets. Another major use of the recursive form of the agricultural model with its linkage to the nonagricultural sectors, then, is to provide annual updates to the Five-Year Development Plan.

Measuring Impacts of Alternative Policies

The modeling system being developed is an annual system within which the agricultural sector model is linked in block recursive form with an econometric model of the total economy. The results of either the ASM or the MM will be influenced by the forward and backward linkages between the sectors as well as by the levels of the government instrument variables built into each.

The performance of a particular set of policy instruments **is evaluated by comparing the predicted levels of specific** dependent variables to desired target levels for those same variables. The impacts of changes in exogenous variables on endogenous variables may also be measured in terms of multipliers. The procedure for calculating multipliers in a model of this type is to compare the results of two model solutions. The first or base solution is calculated with a particular level of an exogenous or policy instrument variable. The level of the exogenous variable is changed and a new time path is simulated. A comparison between two values of any endogenous variable at the same point in time relative to the two values of an exogenous variable provide a multiplier estimate of the form:

$$\frac{XEN_{2it} - XEN_{ijt}}{XEN_{2t} - XEX_{1t}}$$

where: i = 1 if base or controlled run

i = 2 if change in exogenous variable

XEN_{ijt} = level of the jth endogenous variable at time t for run i

XEX_{it} = level of exogenous variable for run i at time t

Comparison of differences between specific endogenous variables at particular points in time can be related to changes in sets of exogenous variables.

LINKAGE BETWEEN AGRICULTURAL SECTOR MODEL AND MACRO ECONOMETRIC MODEL

Summary

The objective is to interface the agricultural model with the model of the rest of the economy, so it would be useful to first review the macro model. The full macro models have been described by Stephenson and Itharattana [2]. The Gross Domestic Product of Thailand's economy is divided into seven major sectors which are consistent with the National Income Accounts. The variables of the macro model which represent the subaccounts in each sector are shown in Table 1. The second version of the macro model, which is being used for the linkage, contains 55 equations including nine accounting identities. The relationships or content of each variable of the macro model or account with respect to the agricultural or nonagricultural sectors is also shown in Table 1.

The linkage will retain the essential structure of the macro model but will substitute a disaggregated programming model of agricultural crop and livestock production processing, marketing and transportation for all or part of the relevant macro equations.

The combined macro-agricultural production model will be recursive in two senses. First the combined system is recursive in the traditional sense that current year variables are dependent in part on their values in previous years. However, within each year the models are recursive in the sense that the agricultural model depends on macro equations to set or partially determine domestic demand for agricultural products, exports, labor supply, and other factors which affect agricultural inputs and outputs. The outputs from the agricultural model then become predetermined variables which are used to solve the remaining equations of the macro model. The current period results of the combined macro linear programming system are then used to update the agricultural and macro model for the following year.

Table 1. Variables in Macro Model II classified according to whether they contain identifiable agricultural or nonagricultural components

Abbreviation	Macro Variables	Agricultural Components	Nonagricultural Components
	Consumption Sector		
FBT	Food, beverages, tobacco	X	X
RFLHHD	Rent, fuel, light, household operation		X
COPE	Clothing and other personal expense	X	X
FFHHE	Furniture, furnishings, household equipment		X
SERV	Consumption of services		X
TC	Consumption transportation and communication		X
RE	Recreation and entertainment		X
	Government Sector		
GADJP	Administration, defense, justice, police		X
GSERV	Services		X
GTC	Transportation and communication		X
	Export Sector		
XRICE	Export of rice	X	
XRUB	Export of rubber	X	
XMZE	Export of maize	X	
XTAP	Export of cassava	X	
XMFG	Export of manufactured goods	X	X
XOTH	Export of other goods	X	X
XSERV	Export of services		
	Imports		
IMP1	Consumer goods	X	X
IMP2	Intermediate products and raw materials for consumer goods	X	X
IMP3	Capital goods, raw materials for capital goods, fertilizer	X	X

Table 1. cont'd.

Abbreviation	Macro Variables	Agricultural Components	Nonagricultural Components
IMP4	Fuel and lubriant imports		X
IMP5	Other imports		X
Serv 1	Service imports (exogenous)		X
	<u>Capital formation</u>		
AGINV	Agricultural investment	X	
MANINV	Manufacturing investment	X	X
CONSINV	Construction investment		X
TCINV	Transportation and communication investment	X	X
WRTINV	Wholesale and retail trade investment	X	X
SERVINV	Service investment		X
OINV	Other investment		
	<u>Output equation</u> (value added)		
CROPOUT	Crop output	X	
OTHAG	Other agricultural output	X	
MGDP	Manufacturing output	X	X
CONSAT	Construction output		X
WRTOUT	Output, wholesale and retail trade	X	X
SERGDP	Output of services		X
TCOUT	Total output, transportation and communication		X
OTHOUT	Other output		
	<u>Income distribution equations</u>		
COMP	Compensation of employees	X	X
FY	Farm income	X	
YUE	Income, unincorporated enterprises		X
YPROP	Income from property	X	X
IDAX	Indirect taxes	X	X

Table 1. cont'd.

Abbreviation	Macro Variables	Agricultural Components	Nonagricultural Components
	Monetary and Price		
CHP	Currency in the hands of the public		X
DDHP	Demand deposits in the hands of the public		X
TDHP	Total demand deposits in the hands of the public		X
PGDP	Implicit price deflator for GDP		X
P_t	Price deflator for all consumption		X

Structure of the Modeling System

The relationships and operations of the programming model-macro model linkage have been grouped into three steps. These steps, shown in Figure 2, include an annual update, analysis of the agricultural sector (ASM) and the linkage with the model of the total economy (MM).

Annual update

The update step occurs before the production year. The first part in the update step relates to changes in government policy. For example, a price support policy would logically be announced before planting decisions are made. Funding changes can be made between projects based on past performance and/or observed economic conditions of specific target population groups.

As stated initially, one objective of the linkage is to provide a means of making annual updates in the five-year plans. In this stage, the means of implementing particular policy objectives can be adjusted somewhat based on realized results. In a simulation mode, specific decision rules by policymakers can be tested.

The next part of the update step relates to population projections and the determination of rural and urban migration. The DAE is currently developing a demographic model with age-sex cohorts including a migration component. However, this has not yet been completed. Currently the plans are to make the migration between agricultural areas and between the urban and rural labor force dependent upon population growth and

Figure 2. Sequence of operations involved in the interface between the agricultural sector and the nonagricultural sector

I. Update
1. Policy instruments based on previous results
2. Population projection, farm, nonfarm population
3. Imports and domestic production of inputs used in agricultural production (forward linkage)
4. Update demand equations for population changes, PDY-1, previous consumption levels
5. Determine nonagricultural employment

II. Agricultural Sector Model (ASM)
1. Determine output of agricultural products exogenous to the recursive linear programming (RLP) model
2. Determine remaining land, labor, capital supplies available for use in the RLP
3. Set flexibility coefficients for RLP
4. Solve RLP, sum for agricultural output, employment other resource use
5. Evaluate commodity models to determine realized wholesale price, domestic consumption, exports
6. Calculate farm price, retail price, farm income
7. Determine value added from agricultural processing
8. Calculate value added from agricultural purchases from nonagricultural sector

III. Macro Econometric Model (MM)
Solve remaining macro econometric model equations using the agricultural related variables as predetermined variables. The remaining items include:
1. Consumption of nonagricultural commodities
2. Government expenditures
3. Output of nonagricultural commodities
4. Exports of nonagricultural commodities
5. Gross domestic product, national income
6. Distribution of national income, personal disposal income
7. Investment, depreciation, capital stock

economic opportunity. The nonfarm demand for labor is related to the capital stock, the nonagricultural wage rate, and the rate of interest in the following manner. The estimates of value added per worker in each output sector (i) are explained in more detail later but are of the general form,

$$(V/L)_i = aK_i^b \text{ or}$$

$$V_i = aL_iK_i^b \qquad i = 2,3,\ldots,9$$

where b is the elasticity of value added per worker with respect to changes in the capital stock

V_i is total value added in sector i

L_i is the number of workers in sector i

K_i is the capital stock in sector i

For a given capital stock (k), a specified wage rate (w), and rate of interest (r), the optimal or profit maximizing labor input (L*) is given as

$$L_i^* = \frac{rKi}{bw}$$

the actual labor input (L) is then related to the optimal labor input (L*) as

$$L_i = d(L_i^*)^c$$

Total nonagricultural employment ($TNAE_t$) is obtained by simple summation of the employment in each industry.

$$TNAE_t = \sum_{i=2}^{9} L_{it}$$

The farm population is adjusted for out-migration based on the total employment in the nonagricultural sector less the current non-agricultural labor force. The agricultural labor force is based on the residual population in agriculture.

The intercepts of the domestic consumption equations are updated for influences of population growth, previous income, and previous consumption. The recursive formulation being followed does mean that only past income can influence current consumption of agricultural commodities. This is because consumption determinations are made before the entire macro model is solved. Current personal disposable income is not known until after GDP has been determined. The general form of the consumption equations is explained in a later part of the paper.

Availability of imports which are used in agricultural production are determined before the agricultural sector models are evaluated. The main items of interest are fertilizer, pesticides, and agricultural machinery. It seems logical to assume that decisions by importers are made on the basis of past import levels, domestic production, and past prices. The import equations have the general form.

$$Impt_t = a_0 + a_1(Pdom - Pimp * TR) - 1 + a_2 \ Imp - 1$$

where IR_t is the tarriff rate in year t

Pdom-1 is the lagged domestic price

Pimp-1 is the lagged import price

TR is the tarriff rate on imports

Imp_t is the quantity imported in year t.

Structural formulation of the agricultural sector model (ASM)

In this section the motivation behind the current structure of the recursive linear programming (RLP) model is discussed. This is followed by a description of the means of estimating exogenous agricultural commodities, a description of the RLP model, and, finally, by a description of the price determination and commodity distribution section.

Motivation for a recursive linear programming model There are at least two distinctly different methods for setting up an annual linear programming model. The methods relate to the assumptions about producer motives and market equilibrium. The first approach would be to formulate an interregional competition model. The work by Duloy and Norton [11] has shown sector model builders that nonseparable demand relations can be incorporated in linear programming models. This work by Duloy and Norton has extended the conditions whereby research can obtain approximate solutions to competitive equilibrium problems by computationally efficient linear programming techniques. By the grid linearization technique, estimates of both the equilibrium price and the equilibrium quantity can be obtained. Interregional competition models lend themselves well to the technique of comparative statics. The policymaker may wish to know the difference between several alternative investment strategies at some future day without examining all the intermediate points. For this, a comparison between alternative equilibriums may help the policymaker eliminate unlikely policy alternatives.

After the policy group has selected a general investment program, such as expanding the irrigated area by five million rai over a five year period, the research group may wish to examine the time path more closely in a setting where the interaction between the policymakers and decentralized decision makers can be made more explicit. The objective of analyzing the time path of alternative investment strategies as well as providing annual updates to the planning process leads to the recursive formulation and the solution methods.

In the competitive equilibrium model, a simultaneous maximization of producer profits subject to conditions of perfect equilibrium can determine in a single solution the location of production, transportation pattern, quantity consumed and final price. It may be less restrictive to assume that the market would be in equilibrium at some point in the distant future than for the next period. If producers' expectation of price is based on past prices received, then, as in the simple cobweb model, the realized price may differ from the expected price. The environment in which a sequence of decisions is made, each dependent on the preceding decision, is commonly modeled by recursive methods. The steps followed here are to determine the quantity supplied if producers maximize expected profits. This is done by the use of a recursive linear programming model. The realized price is then determined by assuming supply is fixed and using a set of commodity demand equations to determine the price. Both the RLP model and the commodity distribution sector are described in more detail below.

The solution of the recursive linear programming model followed by the commodity equations allows determination of the following items which represent entries in the national accounts:

1. Consumption of food, beverage, and tobacco
2. Consumption of clothing
3. Export of agricultural products
4. Value added in agricultural manufacturing
5. Farm income + rent + compensation of agricultural employees
6. Value added from wholesale-retail trade in agricultural products.

Estimation of exogenous crops, livestock, forestry and fishing. The recursive linear programming RLP model described below does not include livestock nor does it include all crops. Notably, the production of fruits and vegetables is not contained in the RLP model. Forestry and fishing are also outside the RLP model. The supply of these items will be determined by the following recursive relationships.

Production and land area used for crops not in the RLP will be determined by the simple simultaneous recursive system.

(1) $\ln \text{area}_t = a_0 + a_1 \ln \text{Area-1} + A_2 \ln p^* + A_3 \ln \text{Ag House}_t$

(2) $\ln \text{Prod}_t = b_0 + b_1 \ln \text{Area}_t + b_2 \ln \text{Rainfall}_t + b_3 \ln P^*$

where P^*_1 is an expected price for year t

Ag House is the number of agricultural households

Rainfall is a weather variable. This is held equal to its mean value for projections.

The crops estimated via a simple supply model are listed in column 2 of Table 2. The above formulation provides estimates of response elasticities. The Changwat level time series estimates for fruits and vegetables are highly variable. Application of the national response elasticities to cross-section estimates of area planted in each agroeconomic zone is about all the data will allow.

Time series estimates of regional livestock production are available. The regional supply response can be specified as

$$(3)\ Qt = A_0 + A_1 \ln Qt\text{-}1 + A_3 Pet + A_4 \left(\frac{\text{Ag. Crop Area t-1}}{\text{Potential Ag. Area}}\right)$$

The actual land areas and labor requirements for livestock production are based on cross-section survey estimates. The last variable is equation (3) is to relate the livestock numbers to the amount of noncrop land remaining for livestock production.

The relationship between crops and livestock is both complementary and competitive. Livestock and crops must compete for the same land area. The relationship is complementary in that animal power is used for crop production and crop residues are available for animal feed. However, in the initial linkage, the resource requirements for livestock and crops exogenous to the RLP model are subtracted before the RLP model is solved.

The equations for output of forestry and fishing have not yet been specified. An attempt will be made to relate the output of forestry to remaining forest areas, the price of forest products, and

Table 2. Crop and livestock commodities method of supply estimation and method of market allocation and price determination

	Supply estimated by	Method of Estimation, Domestic Price Price, Consumption, and Exports			
		Price	Domestic Consumption	Ending Stock	Exports
Rice glutinous	RLP	EN	EN	EN	EX
Rice nonglutinous	RLP	EN	EN	EN	EN
Mung beans	RLP	EN	EN		EN
Soybeans	RLP	EN	EN		EN
Groundnuts	RLP	EN	EN		EX
Sesame	RLP	EN	EN		EX
Coconut	RLP,EE	EN	EN		EX
Sugarcane	RLP	EN	EN		EN
Watermelon	RLP	EN	EN		-
Kenaf, jute	RLP	EN	EN	EN	EN
Castor bean	RLP	PE	EN		EX
Tobacco	RLP	PE	EN		EX
Sericulture	RLP	PE	EN		EX
Cotton	RLP	EN	EN		EN
Cassava	RLP	EN	EN		EN
Garlic	RLP,EE	EN	EN		EN
Onion	EE	EN	EN		EN
Chilli	EE	EN	EN		EN
Vegetables	EE	EN,PE	EN		EX
Fruits	EE	PE	EN		EX
Other crops	EE	PE	EN		EX
Cattle	EE	EN	EN		EX
Buffalo	EE	EN	EN		EX
Swine	EE	EN	EN		EX
Poultry and eggs	EE	EN	EN		EX
Dairy	EE	EN	EN		EX
Fish	EE	EN	EN		EX
Forestry	EE	PE	EN		EX

RLP = recursive linear programming
EN = endogenous, EX = exogenous
PE = price predicting equation
EE = econometric equation
FPC = fixed per capita

levels of lagged construction output. Similarly, the output of fishing will be related to the price of fish and to the number of fishing boats.

Recursive linear programming model. A recursive linear programming technique is used to estimate the quantity supplied of each agricultural commodity in each of 19 agroeconomic zones. The behavioral assumption is that farmers maximize expected profits subject to previous production levels, resource supplies, capital availability from both farm and nonfarm sources, household consumption considerations, and supplies of nonfarm inputs. Currently, the zone crop production model is used in the linkage. The zone level crop-livestock or even changwat or province level farm-type models can be used rather than the zone crop model when the latter are completed.

The specification of the zone crop model in a recursive model is shown below:

1. Maximize expected $\sum_{z}\sum_{i} P_{izt}\, Y_{izt} - \sum_{z}\sum_{j} C_{jzslt}\, X_{jzslt} - \sum_{z}\sum_{k} b_{zkst}\, K_{zkst}$

where $P^{*}izt$ is an estimate of the expected farm price for commodity i, in zone z, in year t (Y_{izt}). The expected price may be simply a lagged price or it may be weighted average of past prices.

C_{jzslt} is the cost of one unit of process X_{jzslt} in zone z, season s, land 1 and year t.

b_{zkst} is the interest charge per unit of money borrowed (K_{zkst}) in zone z, source k, in season s. The sources of borrowing are identified as institutions, friends and relatives and merchants.

2. Land use in each zone is defined by type, by season, for period t

$$\sum_j X_{jzslt} \leq RAI_{zslt}$$

where: RAI_{zspt} is the area of land in zone z, seasons, class 1, year t available for crops

$j = 1,2,\ldots,$processes

$z = 1,2-19$ zones

$s = 1,2$ seasons

$1 = 1,\ldots,4$ land types

$t =$ time period.

3. Labor use in each zone is restricted by season for each year t.

$$\sum_j X_{jzslt} A_{jzslt} \leq LAB_{zst}$$

where LAB_{zst} is the quantity of labor available in zone z, season s, and year t

A_{jzslt} is the amount of labor required per unit of production process X_{jzslt}

The labor supply in each agroeconomic zone is a function of the previous number of agricultural households adjusted for migration, the labor force participation rate and agricultural activities exogenous to the programming model.

4. Credit use in each year is restricted to on-farm cash supplies available for agricultural production plus borrowings from institional sources, merchants, friends, and relatives.

$$\sum_s \sum_j X_{jzslt} Cr_{jzslt} \leq FCAB_{zt} + BI_{zt} + BM_{zt} + BR_{zt}$$

where Cr_{jzslt} is the amount of cash required for the production of one rai of production process j, in season s, on land l, in year t.

$FCAP_{zt}$ is the amount of capital available for agricultural production in zone z and year t. The on-farm capital is calculated from previous cash supplies, realized farm income less family living expense and debt repayment.

BI_{zt} is the estimated annual amount of credit which can be obtained from institutions in year t. Currently this may be specified to be a function of the number of up-country bank offices plus planned expansion of the Bank for Agriculture and Cooperatives.

BM_{zt} is the amount of credit which can be borrowed from merchants loaning to agricultural producers. This source is usually not limited, but annual interest rates are in excess of 30%.

BR_{zt} is the amount of credit available from friends and relatives. The interest rate is intermediate between the institutional rate and the rate charged by merchants. The annual amount per household is held constant so the total amount increases as the number of households is increased.

5. Production for household consumption. Food production for household consumption (nonmarket) is forced either through the use of lower bounds on production activities or by the use of equations. The subsistence requirements may be specified as

$$\sum_j Y_{ijzslt} X_{jzslt} \geq SD_{izt}$$

where Y_{ijzslt} is the expected production of commodity i from production activity X_{jzslt}

SD_{izt} is an estimate of commodity i consumed on the farm where it was produced in zone z in year t.

If there is only one production process for a commodity, a lower bound may be used rather than the above equation. However, in this case the user must specify the maximum of the lower bound for subsistence consumption and/or the flexibility coefficients discussed below.

6. Flexibility coefficients. The convention of using flexibility coefficients in recursive programming to represent adaptive expectations has been followed [12]. This formulation allows for a more realistic estimate of short-run changes in producer behavior. The flexibility coefficients are estimated from pooled cross-section and time-series data. The regression equations follow the recursive formulation:

$$X_t = a_0 + a_1 X_{t-1} + a_2 P^*_t + a_3 W_t + a_4 D$$

where: $D = 1$ if $x_t \geq X_{t-1}$

$D = -1$ if $x_t \leq X_{t-1}$

P^*_t = is the price which is expected in time t.

W_t = is a weather variable (rainfall during planting) in year t.

For projections, the weather variable is assigned to its mean value. The upper bound for each production activity is determined by the previous area planted, the expected price, D is assigned the value of 1.0. The process is repeated for the lower bound except D is assigned the value -1.0.[1]

7. Fertilizer supplies. The major portion of the fertilizer used in Thailand is imported. It seems reasonable to assume that total fertilizer supplies are limited to current imports plus expected domestic fertilizer production. In the initial linkage, the total fertilizer imports are allocated according to historic use in each agroeconomic zone. Within each agroeconomic zone, the fertilizer use is restricted to be less than or equal to the estimated supply in that zone.

$$\Sigma F_{njslt} X_{jzslt} \leq FS_{nzt}$$

where: F_{njslt} is the amount of fertilizer nutrient n used by production process j in zone z, season s, land l in year t.

FS_{nzt} is the supply of fertilizer in the form of nutrient n in zone z in year t. The nutrients are tons of N, P, and K. The nominal charges for fertilizer are included as part of the variable cost.

[1]Attempts are also being made to include variables relating to the variance of expected prices and revenue relative to actual prices and revenues in equation (6). The work follows the formulation outlined by Just [13].

8. Relationship of agricultural investment to the RLP. The estimate of the agricultural capital stock or agricultural investments is not directly usable in the RLP unless tied directly to specific investments in irrigation projects, ownership of machinery, farm buildings or other assets. Time-series estimates are available on total investment and total depreciation. Scattered estimates are available on the numbers of machines registered for agricultural production. There has been a rapid increase in the sales of locally assembled two-wheel tractors. The major linkages required here relate to the estimation of demands for farm machinery from domestic and foreign sources. The number of machines on farms will be related to the machine power constraints included in the crop-livestock model.

Commodity Distribution Section. The purpose of this section is to determine the Bangkok wholesale price, the farm price, domestic use, exports, and ending stocks. Estimates of transportation, services and agricultural processing are also obtained in this section of the model.

There are two procedures and accompanying analytical techniques by which to determine commodity distribution patterns. The first procedure is to use the national output of each commodity as a predetermined quantity and directly solve a set of econometric equations for price, domestic use, ending stocks, and exports. The analytical techniques are reduced form analysis if the equations are linear and the Gauss-Seidel technique, if the equations are nonlinear.

The second procedure is to use the output of each commodity in each zone as a predetermined supply in a programming model of agricultural transportation, storage, and processing (TSP). This type of model could also incorporate the segmented domestic demand equations rather than fixed demands.[1] Linear programming can be used if the demand equations are properly formulated.

The second approach can provide a more complete estimate of spatially delineated transportation flows, storage, and processing requirements. However, the first approach is simpler and is being followed in the initial linkage.

The various methods and assumptions used in estimating domestic price, exports, and ending stocks are outlined in Table 2. The methods in Table 2 represent an intermediate-term goal, but not all parts have been completed. To date separate commodity models for rice, kenaf, soybeans, mung beans, maize, cotton and textiles, and sugar are giving reasonable results as separate models. In another study the methods given by Frisch [14] were applied to give estimates of direct and cross-price elasticities for another 13 crop and livestock commodities [Dadgostar,[15]. It is not presently believed that the current data base will support complete estimation of domestic demand equations for all products. In several cases, it will be necessary to estimate the price of certain minor commodities from the prices of more important crops.

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[1]The technique for incorporating prices and incomes in LP models is discussed by Duloy and Norton [11].

There is some interaction between specific commodity models. The domestic feed use of maize depends on the price of poultry and the price of rice bran. The commodity models which interact must be solved simultaneously. Since relationships in some equations are nonlinear, the Gauss Seidel technique will be used.

The general form of the commodity models can be illustrated by the kenaf submodel developed by Blakeslee [16].

$\text{Xport} = a_0 + a_1 (\text{PKLON} - \text{PKWH}_t) + a_2 (\text{Prod}_t + \text{Beg stock}_t)$

$\text{Millcon} = b_0 + b_1 \text{PKWH}_t + b_2 \text{Pgun}_t + b_3 \text{No. Mills.}$

$\text{End Stock} = c_0 + c_1 \text{PKWH}_t + c_2 (\text{prod}_t + \text{Beg stock}_t)$

Beg Stock + Production = Xport + Millcons + Endstock + Village Cons.

where PKLON is the London price of kenaf in year t, exogenous.

PKWH_t is the Bangkok wholesale price of kenaf in year t, endogenous

Pgun_t is the domestic gunny bag price in year t.

The export equation represents a demand by exporters at the wholesale level. The exports are in turn suppliers of exported goods in the foreign market. The export equation commonly keys on the difference between a foreign price and the Bangkok wholesale price. Depending on the commodity, exports may also be influenced by previous exports and/or production. Domestic use is negatively related to the Bangkok wholesale price but is also influenced by industry capacity if the product is processed. Domestic use is influenced by price, consumer income, and population size if the demand is for final consumption. If there is an ending stock equation, the level of ending stocks is also dependent on the Bangkok wholesale price. Production and foreign prices are assumed given. The equilibrium Bangkok wholesale price is determined by the allocation of the total supply among domestic demand, exports, and ending stock.

Any government policy interventions with respect to price supports, export restrictions, or export taxes would be included in this section of the model.

Reconciliation with data format of the macro-econometric model. The variables of the macro-econometric model are stated in 1962 prices. The macro model is a real or constant value measure of aggregate economic activity in Thailand. The national income accounts are also presented in 1962 prices for the purpose of measuring real output.

To make the models compatible, it is necessary to value the total consumption of food, beverages, tobacco, and clothing from the agricultural sector in 1962 prices. The estimates of value added from agricultural commodities in the RLP model will be based on the difference between costs and returns expressed in 1962 Baht. The estimates of value added for production of those crops and livestock forestry and fishing to the RLP model are made by methods similar to those used in the national accounts [17].

We plan to base the estimates of value added from food processing and manufacture on cross-section studies and such time-series data as is available. The estimates of value added to wholesale and retail trade are based on price margins less adjustments for transportation and for manufacturing. Similarly, the value added by transportation and communication of agricultural commodities is calculated from previously estimated transportation costs and current transportation flows. If the agricultural output were formerly modeled in a TSP mode, the estimates of value added could be generated by that modeling system.

Macro Econometric Model

The macro econometric model receives agricultural and agricultural related final consumption levels, value added estimates, exports, imports and farm income estimates from the ASM. The macro model uses the predetermined agricultural variables in determining nonagricultural consumption, value added, exports, and imports. The estimates of gross domestic product, national income, and personal disposal income are also determined in the macro model.

The equations from version II of the macro model are given in the appendix. The data base for the model extends from 1962-1975. The model as originally specified contained 55 total equations. There were 46 behavioral equations and 9 identities. The MM is nonlinear in the variables but linear in the parameters. Private consumption and imports are specified in per capita terms. There are seven equations relating to gross fixed capital formation. These seven gross fixed capital equations relate capital changes in agriculture, manufacturing, construction, transportation-communication, wholesale retail trade, service investment, and other investment to changes in gross domestic product

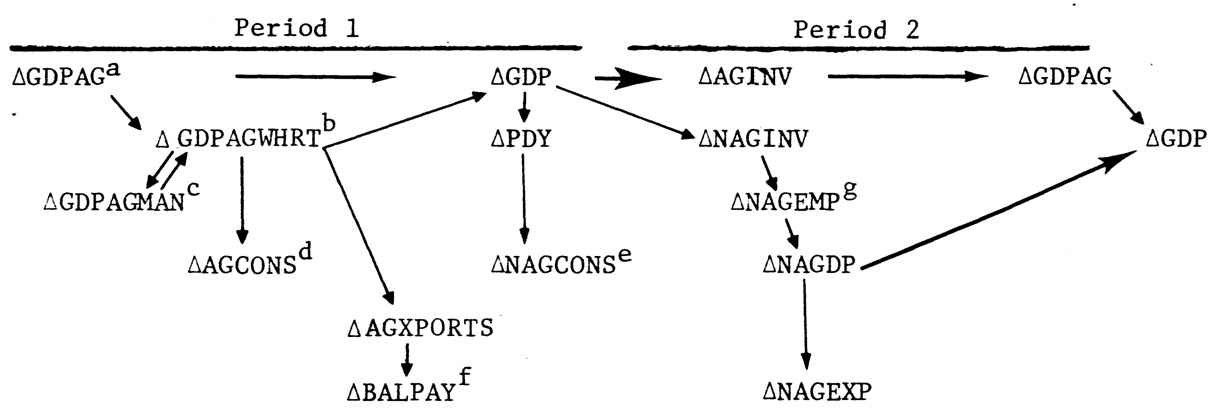
(GDP) or to changes in sector output. The gross fixed capital formation equations are based on an accelerator principle. The macro model was designed as a stand-alone model and is capable of doing some types of policy analysis independently of the more detailed ASM models.

In 1975, the value added to GDP directly from agriculture, forestry and fishing accounted for 27% of the total. Value added from processing and manufacture of agricultural products accounted for 11% of the total GDP while wholesale retail trade in agricultural and agricultural manufacturing accounted for another 8% of total GDP [18].

The casual ordering by which changes in agricultural output lead to changes in other parts of the economic system is outlined in Figure 3. Changes in agricultural output cause further changes in value added from processing and direct movements of agricultural commodities. The additional changes are recorded as changes in the value added from agricultural manufacturing and from wholesale retail trade in agriculture. The total changes in current GDP are presently limited to changes in GDP from agriculture manufacturing of agricultural products, and trade movements of agricultural products. The changes in total GDP through changes in PDY affect nonagricultural consumption and imports. (Consumption of agricultural products is determined directly through supply-demand relationship.)

The changes in current GDP subsuquently affect investment and, hence, capital stock in the respective nonagricultural sectors. The induced changes in the capital stock in the nonagricultural sectors affect employment and output in the following period. The relationships

Figure 3. Causative chain by which a change in agricultural output affects the output of the total economy via the macro model.



Terms:
a. GDP from agriculture
b. GDP from trade in agriculture
c. GDP from manufacture of agricultural output
d. Domestic consumption of agricultural products
e. Consumption of nonagricultural products
f. Balance of payments
g. Nonagricultural employment

between the items predetermined in the agricultural sector model, the national accounts, and the macro-econometric model are shown in Figure 4. The calculations for the predetermined agricultural variables (labeled ASM) are completed after the solutions of the import, policy, and agricultural sector model sections have been obtained. The variables labeled MM are determined by the use of econometric equations in the macro model. The variables labeled EX are exogenous to both the macro and ASM models. The variables MMID are determined by accounting identities in the macro model. That is, the macro model identities represent the subtotal of accounts whose entries have been determined either by the ASM or MM. The variables labeled MMD are endogenous dummy variables determined by the macro model as residuals through the system of identities as the other endogenous variables.

Consumption sector. As stated previously, the consumption estimates for food, beverages, tobacco, and clothing will be derived from the ASM. The estimates of remaining (3-7) final consumption levels are determined from a consumption function which depends on population, income, a relative price, and past consumption.

$$\text{Cons}(i, t) = \text{Pop}(t)\, a_0\, \text{PDY}(t)^{a_1}\, \text{CONS}(i, t-1)^{a_2} \left(\frac{\text{PC}(i, t)}{\text{P}(t)}\right)^{a_3}, \quad i = 3, 7$$

where: Cons(i, t) is consumption of output i in year t

Pop(t) is population in year t

PDY(t) is personal disposable income (endogenous)

PC(t) is the implicit price deflator for commodity i in year t (exogenous)

Figure 4. Relation of national income accounts and macro-econometric model

	Consumption		Output and Income Districation
MMID	Total personal consumption (TPCT)	ASM	GDP agriculture
ASM	Food, beverages, tobacco	ASM	GDP agricultural manufacturing
ASM	Clothing expenditure	ASM	GDP agricultural wholesale-
MM	Furniture, furnishings		retail trade
MM	Rent, water, fuel, light, household	MM	GDP nonagricultural manufacturing
	operation	MM	GDP nonagricultural wholesale-
MM	Recreation and entertainment		retail
MM	Services	MM	GDP construction
MM	Transportation and communication	MM	GDP communication, transportation
MMID	Total government consumption (TGC)	MM	GDP services
MM	Administration, justice, police	MM	GDP other output
MM	Government services	MMID	Gross domestic product
MM	Government transportation and		
	communication		
MMID	Exports (TX)		Income Distribution
ASM	Agricultural exports		
ASM	Agricultural manufactured exports		
MM	Nonagricultural manufactured exports	ASM	Farm income, rent, compensation
EX	Service exports		agriculture employees
MMID	Imports (TIMP)	MM	Compensation, nonagriculture
ASM	Agricultural consumer goods		employees
MM	Nonagricultural consumer goods	MM	Income, unincorporated enterprises
ASM	Agricultural products for consumer good	MM	Income, property
	production	MM	Corporate savings
MM	Nonagricultural intermediate goods	MM	Direct taxes on corporations
ASM	Fertilizer and pesticides	MM	Government enterprises
MM	Intermediate goods for capital production	MM	Interest on public debt
MM	Fuel and lubricants	MM	Interest on consumer debt
EX	Other imports	MMID	National income

Table 4. Continued.

Consumption		Output and Income Distribution	
MMID	Investment (TINV)	MM	Indirect taxes
MM	Agricultural investment	MMID	Capital consumption allowance
MM	Manufacturing investment	EX	Net factor payments rest of world
MM	Construction investment	EX	Transfers from government and rest of world to households
MM	Transportation, communication		
MM	Wholesale retail trade	EX	Transfers from households to government and rest of world
MM	Service investment		
MMD	Statistical discrepancy (SD)	MMID	Personal disposal income
MMID	Gross domestic product		

P(t) is the implicit consumption deflator for year t (endogenous).

<u>Government consumption.</u> The equations given in the appendix relate the current consumption variables to GDP or government revenue and to lagged levels of government consumption. These equations remain unchanged.

<u>Exports.</u> The exports of the major crops are determined endogenously in the ASM. The exports of nonagricultural manufactured goods, other goods, and services are related to current production measure and past exports.

$$XPORT(i, t) = b_0 + b_1 \, Prod(i, t) + b_2 \, XPORT(i, t-1)$$

where XPORT(i, t) are exports of commodity i in year t

PROD(i, t) is a mesure of production for commodity i, year t.

<u>Imports.</u> The import of consumer goods, intermediate commodities for consumer goods, intermediate capital inputs have been divided into agricultural and nonagricultural parts. The levels of imports related to agriculture have been determined before the commodity demand equations were solved. The remainder of the nonagricultural imports are determined in the macro model. The disaggregated nonagricultural import equations are being refitted with the same current general form shown in the appendix. That is, imports are dependent on income, relative prices, and lagged imports.

<u>Output or value added.</u> As discussed previously, the estimates of value added from agriculture and agricultural related activities

are directly obtained the production and flow of agricultural commodities. The estimates of value added for the remaining nonagricultural items are determined on the basis of labor and capital stock in each sector. Multicollinearity between labor and capital has been a problem. The equations fitted in a value-added per worker form show increasing returns to total output from both labor and capital inputs. More work will be required but the relationship is of the form:

$$GDP(i, t) = A_0 LAB(i, t)^b \; KAP(i, t)^c \qquad i = 4, 9 \text{ sectors}$$

where GDP(i, t) is the amount of value added for sector i in year t

LAB(i, t) is the estimated employment in sector i year t (endogenous)

KAP(i, t) is an estimate of the current stock in that industry (endogenous).

The estimate of GDP is a simple summation of the 9 sector outputs.

Fixed capital formation. The total fixed capital formation in each sector was determined endogenously while the capital stock remained exogenous in the original specification of the macro model. The capital stock data was largely estimated, and data for bench mark estimates for industry capital stocks is only now becoming available.

In the current effort, the investment in each sector is being disaggregated into public investment and private investment. The public investment data is available but not tabulated. The public investment will be an exogenous policy instrument while the private or induced investment remain endogenous. This procedure by Ramangkura [19] over a different data period and on a more aggregated level was relatively successful. The capital stock will be made endogenous by relating the capital consumption allowance for each sector to the capital stock for that sector.

Private investment is formulated on the accelerator principle. Current private investment changes in accordance with changes in GDP and lagged investment.

$$PINV(i, t) = a_0 + a_1 \Delta GDP_{t,\ t-1} + a_2 PINV(i, t-1) \quad i = 1, 9 \text{ sectors}$$

PINV(i, t) is private investment in sector i, year t. Total investment in each sector is equal to private plus exogenous public investment. The total capital consumption in each sector is related to the capital stock in that sector.

$$Dep(i, t) = a_0 + a_1 KAP(i, t-1) + 1/2\ (PINV(i, t) + GINV(i, t))$$

The capital consumption allowance is estimated by summation over each sector.

$$CCA(t) = \sum_{i=1} DEP(i, t), \quad i = 1, 9 \quad \text{sectors}$$

The current capital stock can then be obtained by the relationship.

$$KAP(i, t) = KAP(i, t-1) + PINV(i, t) + GINV(i, t) - DEP(i, t)$$

Income Distribution. In the current macro model, equations to predict compensation of employees, farm income, income from property, and indirect taxes are specified. In the linkage and revision process, farm income, compensation of agricultural employees and rent from agricultural property are being determined in the agricultural sector.

More recently estimates of compensation of employees in the industrial sector have become available. These estimates and the recent labor force surveys should allow prediction of employee compensation by each sector.

The equations for predicting income from nonagricultural properties and enterprises will be refitted to the disaggregated data. Presently the variables relating to corporate taxes, corporate savings, income from government enterprises, and interest on public and consumer debt are exogenous. Again, recent work by Ramangkura [19] indicated that at least part of these variables could be endogenized. Ramankura's work also indicated that government revenues, total government expense and hence the government budget deficit could be made endogenous.

As the model is tentatively structured it will be possible to calculate the trade balance of net goods and services with only two items (service exports and other imports) being exogenous. Future plans call for a balance of payments sector to be incorporated into the system.

The influence of changes in agriculture on the consumer price index are partly determined. Currently price determination is limited to the agricultural sector. The price levels in the nonagricultural sector are fixed. The consumption price deflator is endogenous but depends in part on an exogenous GDP price deflator.

SUMMARY AND EXTENSION OF RESULTS

The recursive modeling system described above is designed for analysis of economic development over a relatively short (3-5 years) time horizon. The emphasis is on the analysis of development plans in the agricultural sector and on the measure of what effect these policies have on the nonagricultural sector. It is envisioned that a static analysis in which unlikely policy combinations were eliminated would precede the more extensive recursive annual analysis of a few selected policy sets.

The macro-econometric approach has an advantage in that it allows for nonlinearities and substitution between primary inputs in production. The main disadvantage is that production functions or, in this case, value-added functions represent a high level of aggregation. Planners are still faced with questions of more precisely what, when, where, and how much.

In Thailand, the regional accounts are not complete enough to support regional econometric models of the type estimated at the Kingdom level. For this reason the regional group in the DAE has been constructing input-output models which emphasize the agricultural related sectors of the economy in each region. The information is being gathered by cross-sectional survey. The National Economic and Social Development Board is cooperating to estimate the nonagricultural part of the I/O matrix. This work is not completed, but it is useful to indicate how the I/O effort can be used with the macro econometric work.

Both the model by Johansen and the Brookings have incorporated aspects of an I/O matrix in an econometric modeling process.[1] The

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[1]A short review of these models was made by Fox et al. [20].

researchers with the Brookings model used known levels of gross output (X_t) to estimate levels of final demand (F_t);

$$F_t = (I-A)\ X_t$$

The model by Johansen used a production function (Cobb Douglas) to predict gross output (Xi) or supply in each sector as a function of labor, (L) capital, (K) and technology $(e^{E}it)$.

$$X_i = A_i L^{b_i} K^{c_i} e^{E_{it}}$$

Total demand was divided into intermediate and final parts. The intermediate component of total demand for each was estimated by using I/O relationships. Total demand and total supply are related by:

$$X_i = \sum_j a_{ij}\ X_j + E_{di}$$

In the current research, the incorporation of I/O relationships would lead directly to estimates of gross sector outputs which are not provided directly by the macro model nor readily available in published sources in Thailand. Then, by equating supply and demand for each sector output, the gross output for each sector could be estimated.

$$X(i,\ t) = (I-A^*_t)^{-1}\ FD(i,\ t)$$

where: FD(i, t) is a vector of final demands

$(I-A^*_t)$ is a flow matrix modified to reflect commodity flows as determined by the ASM.

If the estimates of gross output are to be consistent with assumed changes in methods of production, the $(I-A^*_t)$ matrix must be restructured.

Researchers with the KASS project in Korea follow this procedure when linking a national I/O model with a recursive linear programming model [9].

A more powerful result can be obtained if the Johansen formulation is used to estimate gross output for the nonagricultural sectors. Gross outputs from the agricultural related sectors would still be determined in the ASM. The estimation of total supply by a production function process followed by or simultaneous with intermediate demand via an I/O process would allow the output prices for the nonagricultural sectors to be determined endogenously. In this manner the I/O approach will complement and extend the current effort.

Bibliography

1. Framingham, F., A. Stoecker, K. Khatikarn, S. Sriplung, and E. Heady. Agricultural development planning in Thailand: Some supporting analysis. Center for Rural Development, Iowa State University, DAE-CARD Sector Analysis Series: No. 4, March 1977.

2. Stephenson, J. and K. Itharattana. Macroeconometric analysis of of economic activity in Thailand. Iowa State University, DAE-CARD Sector Series: No. 6, 1977.

3. Sukidee, C. and S. Sriplung. Transportation, storage and processing model for rice. In Singapore Symposium: Agricultural Sector Analysis in Thailand. DAE-CARD Sector Analysis Series: No. 7 July 1977.

4. Fox, K.A. A sub-model of the agricultural sector. The Brookings Quarterly Econometric Model of the United States eds. James S. Duesenberry et al. pp. 409-61 Chicago Rand McNally and Co., 1965.

5. Chen, D.T. The Wharton agricultural model: Structure, specification, and some simulation results. American Journal of Agricultural Economics Vol. 59 No. 1, pp. 198-116, Feb. 1977.

6. Roop, Joseph M. and Randolph H. Zeitner. Agricultural Activity and the General Economy: Some Macro Model Experiments. American Journal of Agricultural Economics, Vol. 59 No. 1 pp. 117-125, Feb. 1977.

7. Hein, D. Price determination process for agricultural sector models. AJAE 56: 126. 1977.

8. Byerlee, D. and A.N. Halter. A macro-economic model for agricultural sector analysis, AJAE 56: 521. 1974.

9. Korean Agricultural Sector Study. Model conception and system overview, Chapter 1, In the Korean Agricultural Sector System of Models, Special Report 13 (DRAFT). 1976.

10. Abkin, M. The National Economy Model of KASM: Technical Documentation and Users Guide. Department of Agricultural Economics, Michigan State University, KASS Special Report 18 (DRAFT). 1976.

11. Duloy, J.H. and D. Norton. Prices and incomes in linear programming models. AJAE 57: 591. 1975.

12. Sahi and W.J. Craddock. Estimation of flexibility coefficients for recursive programming models-alternative approaches, AJAE 56: 344-350. 1974.

13. Just, R. An investigation of the importance of risk in farmer's decisions. AJAE, 56: 14. 1974.

14. Frisch, R. A complete scheme for computing all direct and cross-demand elasticities in a model with many sectors. Econometrica 27: 177. 1959.

15. Dadgostar, B.; Ellingson, W.; Heady, E.O.; and R. Hoffmann. Consumer demand for food commodities in Thailand. DAE-CARD Sector Analysis Series: No. 10, March 1978.

16. Blakeslee, L. Kenaf demand in Thailand. Division of Agricultural Economics and Iowa State Team, Series No. 4. Feb. 1975.

17. National Account Division. Instructions: Revision of National Income Statistics. National Account Division, Office of National Economic Development Council. April 1970.

18. National Accounts Division, NESDB. National Income of Thailand. National Accounts Division, Office of the National Economic and Social Development Board. 1976 edition.

19. Ramangkura, Virabongsa. The Chulalongkorn econometric model. Economic Research Unit, Faculty of Economics, Chulalongkorn University. Dec. 1976.

20. Fox, K.; Sengupta, J.; and E. Thorbeck. The theory of quantitative economic policy. North Holland Publishing Co.: Amsterdam. 1973.

THE EQUATIONS OF MODEL II

PRIVATE CONSUMPTION EXPENDITURE EQUATIONS

(1) $$\frac{FBT_t}{N_t} = \underset{(4.139)}{235.490} + \underset{(4.010)}{0.174}\frac{PDY_t}{N_t} + \underset{(2.886)}{0.418}\frac{FBT_{t-1}}{N_{t-1}}$$ $\bar{R}^2$ = .991, D.W. = 2.196

(2) $$\frac{RFLHHO_t}{N_t} = \underset{(3.606)}{67.160} + \underset{(3.476)}{0.029}\frac{PDY_t}{N_t} + \underset{(1.740)}{0.328}\frac{RFLHHO_{t-1}}{N_{t-1}}$$ $\bar{R}^2$ = .979, D.W. = 2.083

(3) $$\frac{COPE_t}{N_t} = \underset{(-0.688)}{-16.213} + \underset{(1.409)}{0.039}\frac{PDY_t}{N_t} + \underset{(2.236)}{0.608}\frac{COPE_{t-1}}{N_{t-1}}$$ $\bar{R}^2$ = .963, D.W. = 1.455

(4) $$\frac{FFHHE_t}{N_t} = \underset{(5.123)}{111.567} + \underset{(4.432)}{0.025}\frac{PDY_t}{N_t} + \underset{(1.027)}{0.122}\frac{FFHHE_{t-1}}{N_{t-1}} - \underset{(-5.998)}{117.789}\frac{PFFHHE_t}{P_t}$$ $\bar{R}^2$ = .970, D.W. = 2.187

(5) $$\frac{SERV_t}{N_t} = \underset{(2.830)}{140.900} + \underset{(4.709)}{0.026}\frac{GDP_t}{N_t} - \underset{(-2.003)}{76.005}\frac{PSERV_t}{P_t}$$ $\bar{R}^2$ = .881, D.W. = 1.778

(6) $$\frac{TC_t}{N_t} = \underset{(0.026)}{0.891} + \underset{(27.580)}{0.097}\frac{PDY_t}{N_t} - \underset{(-2.324)}{68.402}\frac{PTC_t}{P_t}$$ $\bar{R}^2$ = .993, D.W. = 2.701

(7) $$\frac{RE_t}{N_t} = \underset{(-0.453)}{-14.220} + \underset{(35.427)}{0.069}\frac{GDP_t}{N_t} - \underset{(-1.157)}{37.394}\frac{PRE_t}{P_t}$$ $\bar{R}^2$ = .992, D.W. = 2.613

GOVERNMENT CONSUMPTION EQUATIONS

(8) $$GADJP_t = \underset{(-0.842)}{-426.585} + \underset{(3.291)}{0.439}\,GREV_{t-1} + \underset{(1.848)}{0.352}\,GADJP_{t-1}$$ $\bar{R}^2$ = .977, D.W. = 3.068

(9) $$GSERV_t = \underset{(-2.400)}{-321.027} + \underset{(2.649)}{0.011}\,GDP_t + \underset{(5.416)}{0.759}\,GSERV_{t-1}$$ $\bar{R}^2$ = .989, D.W. = 2.410

(10) $$GTC_t = \underset{(3.110)}{83.626} + \underset{(17.079)}{0.908}\,GTC_{t-1}$$ $\bar{R}^2$ = .960, D.W. = 1.711

EXPORT EQUATIONS		$\bar{R}^2$	D.W.
(11)	$XRICE_t = \underset{(-1.574)}{-3397.596} \underset{(-1.403)}{- 0.144} XPRICE_t \underset{(3.004)}{+ 0.402} RICE_{t-1} \underset{(3.064)}{+ 0.792} XRICE_{t-1} \underset{(-3.380)}{-2786.198} D73_t$	.634	1.708
(12)	$XRUB_t = \underset{(-2.397)}{-195.712} \underset{(3.662)}{+ 0.027} XPRUB_t \underset{(18.543)}{+ 1.414} RUB_t \underset{(-4.854)}{-.380} XRUB_{t-1}$	.995	2.455
(13)	$XMZE_t = \underset{(1.373)}{228.865} \underset{(6.286)}{+ 1.060} MZE_{t-1} \underset{(1.668)}{+ 1.069} DXPBPZ_t \underset{(-1.277)}{-0.252} XMZE_{t-1}$	.876	1.728
(14)	$XTAP_t = \underset{(-0.897)}{-106.297} \underset{(2.718)}{+ 0.405} TAP_t \underset{(3.390)}{+ 0.752} XTAP_{t-1}$	.915	1.917
(15)	$XMFG_t = \underset{(-2.472)}{-1109.251} \underset{(3.188)}{+ 0.146} MGDP_t \underset{(1.074)}{+ 0.268} XMFG_{t-1}$	.962	1.451
(16)	$XOTH_t = \underset{(-0.224)}{-117.471} \underset{(1.745)}{+ 0.015} GDP_{t-1} \underset{(2.802)}{+ 0.692} XOTH_{t-1}$	.828	1.620
(17)	$XSERV_t = \underset{(-0.471)}{-282.921} \underset{(2.308)}{+ 0.246} SERGDP_t \underset{(2.171)}{+ 0.307} XSERV_{t-1} \underset{(5.946)}{+ 2857.120} D666_t^{*}$	.982	2.588

IMPORT EQUATIONS		$\bar{R}^2$	D.W.
(18)	$IMP1_t = \underset{(10.478)}{11429.275} \underset{(3.787)}{+ 0.026} PDY_{t-1} \underset{(-6.860)}{- 8553.100} \frac{M1P_t}{PGDP_t}$	.792	2.284
(19)	$\frac{IMP2_t}{N_t} = \underset{(-1.755)}{-19.7} \underset{(17.586)}{+ .0909} \frac{PDY_t}{N_t} \underset{(-8.024)}{- 82.000} \frac{M2P_t}{PGDP_t}$	.966	2.336
(20)	$\frac{IMP3_t}{N_t} = \underset{(-3.936)}{-51.100} \underset{(9.327)}{+ 0.0471} \frac{PDY_t}{N_t}$	.887	1.937
(21)	$\frac{IMP4_t}{N_t} = \underset{(6.029)}{241.400} \underset{(6.996)}{+ 0.1556} \frac{PDY_{t-1}}{N_{t-1}} \underset{(-9.139)}{- 400.000} \frac{M4P_t}{PGDP_t} \underset{(1.699)}{+ 0.1629} \frac{IMP4_{t-1}}{N_{t-1}}$	.967	1.624

GROSS FIXED CAPITAL FORMATION EQUATIONS ($\bar{R}^2$, D.W.)

(22)
$$AGINV_t = \underset{(0.464)}{126.607} + \underset{(2.707)}{0.071}\,(GDP_t - GDP_{t-1}) + \underset{(3.726)}{0.114}\,(GDP_{t-1} - GDP_{t-2}) + \underset{(3.619)}{0.451}\,AGINV_{t-1}$$
$\bar{R}^2$ = .895, D.W. = 2.033

(23)
$$MANINV_t = \underset{(-1.603)}{-589.457} + \underset{(2.167)}{0.073}\,(GDP_t - GDP_{t-1}) + \underset{(3.124)}{0.130}\,(GDP_{t-1} - GDP_{t-2}) + \underset{(13.826)}{0.872}\,MANINV_{t-1}$$
$\bar{R}^2$ = .986, D.W. = 1.833

(24)
$$CONSINV_t = \underset{(-0.578)}{-75.999} + \underset{(2.397)}{0.035}\,(GDP_t - GDP_{t-1}) + \underset{(3.142)}{0.056}\,(GDP_{t-1} - GDP_{t-2}) + \underset{(4.423)}{0.575}\,CONSTNV_{t-1}$$
$\bar{R}^2$ = .937, D.W. = 3.251

(25)
$$TCINV_t = \underset{(1.751)}{749.259} + \underset{(2.060)}{0.087}\,(GDP_t - GDP_{t-1}) + \underset{(8.309)}{0.744}\,TCINV_{t-1}$$
$\bar{R}^2$ = .895, D.W. = 2.047

(26)
$$WRTINV_t = \underset{(1.840)}{386.916} + \underset{(1.707)}{0.118}\,(WRTOUT_t - WRTOUT_{t-1}) + \underset{(2.295)}{0.208}\,(WRTOUT_{t-1} - WRTOUT_{t-2}) + 0.770\,WRTINV_{t-1}$$
$\bar{R}^2$ = .940, D.W. = 2.449

(27)
$$SERVINV_t = \underset{(-0.434)}{-156.963} + \underset{(1.281)}{0.046}\,(GDP_t - GDP_{t-1}) + \underset{(2.111)}{0.088}\,(GDP_{t-1} - GDP_{t-2}) + \underset{(6.602)}{0.746}\,SERVINV_{t-1}$$
$\bar{R}^2$ = .942, D.W. = 2.720

(28)
$$OTHINV_t = \underset{(0.372)}{184.627} + \underset{(1.555)}{0.087}\,(GDP_t - GDP_{t-1}) + \underset{(3.588)}{0.228}\,(GDP_{t-1} - GDP_{t-2}) + \underset{(7.703)}{0.679}\,OTHINV_{t-1}$$
$\bar{R}^2$ = .967, D.W. = 2.401

OUTPUT EQUATIONS

(29)
$$\ln\left(\frac{AGOUT_t}{AGLAB_t}\right) = \underset{(10.559)}{3.385} + \underset{(13.872)}{0.427}\,\ln KAG_t$$
$\bar{R}^2$ = .941, D.W. = 2.393

(30)
$$\ln\left(\frac{MGDP_t}{MANLAB_t}\right) = \underset{(13.258)}{3.606} + \underset{(24.244)}{0.644}\,\ln KMAN_t$$
$\bar{R}^2$ = .980, D.W. = 0.979

	$\bar{R}^2$	D.W.
(31) $\frac{CONSOUT_t}{CONLAB_t} = \underset{(2.141)}{19780.387} - \underset{(-2.896)}{0.726}\ KCONS_t + \underset{(5.331)}{0.779}\ \frac{CONSOUT_{t-1}}{CONLAB_{t-1}}$	.908	1.030
(32) $\ln \frac{(WRTOUT_t)}{(WRTLAB_t)} = \underset{(-2.146)}{-1.329} + \underset{(18.164)}{1.059}\ \ln KWRT_t$	.965	0.904
(33) $\ln \frac{(SERGDP_t)}{(SERLAB_t)} = \underset{(41.185)}{6.441} + \underset{(17.378)}{0.266}\ \ln KSERV_t$	.962	0.553
(34) $\ln \frac{(TCOUT_t)}{(TCLAB_t)} = \underset{(24.977)}{6.726} + \underset{(13.148)}{0.318}\ \ln KTC_t$	.935	2.110
(35) $\ln \frac{(OTHOUT_t)}{(OTHLAB_t)} = \underset{(11.266)}{3.162} + \underset{(25.007)}{0.616}\ \ln KOTH_t$	.981	0.718

INCOME DISTRIBUTION EQUATIONS

	$\bar{R}^2$	D.W.
(36) $COMP_t = \underset{(-5.875)}{-11929.889} + \underset{(4.780)}{2.027}\ OTHAG_t + \underset{(3.397)}{5.372}\ NAGLAB_t$	.985	1.104
(37) $FY_t = \underset{(7.078)}{537442.001} - \underset{(-3.679)}{2.761}\ OTHAG_t - \underset{(-7.047)}{617994.000}\ RAGTLAB_t - \underset{(-1.881)}{0.862}\ XRICE_t$	.943	1.808
(38) $YUE_t = \underset{(2.302)}{29541.813} + \underset{(3.190)}{0.569}\ GDP_t - \underset{(-1.896)}{17.337}\ NAGLAB_t$	.972	1.927
(39) $YPROP_t = \underset{(-3.381)}{-111036.547} + \underset{(7.473)}{0.711}\ MGDP_t + \underset{(3.443)}{135660.782}\ RAGTLAB_t$	.988	2.489
(40) $IDTAX_t = \underset{(-0.098)}{-76.798} + \underset{(16.082)}{0.115}\ GDP_t$	.955	1.755

MONETARY AND PRICE EQUATIONS

	$\bar{R}^2$	D.W.
(41) $CHP_t = \underset{(4.404)}{2057.450} + \underset{(21.992)}{0.073}\ GDPCP_t$	.976	1.314
(42) $DDHP_t = \underset{(3.037)}{1162.477} + \underset{(16.696)}{0.067}\ XNAGCP_t$	.959	0.962

Equation	$\bar{R}^2$	D.W.
(43) $TDHP_t = \underset{(-7.993)}{-12844.045} + \underset{(20.887)}{0.238}\ GDPCP_t$	.973	0.940
(44) $PGDP_t = \underset{(23.111)}{0.676} + \underset{(9.353)}{0.000018}\ M1_t + \underset{(6.841)}{0.141}\ M3P_t$	.969	1.738
(45) $P_t = \underset{(3.713)}{0.423} + \underset{(3.126)}{0.00001}\ M1 + \underset{(2.446)}{0.408}\ PGDP_t + \underset{(2.610)}{0.068}\ M3P_t$	.990	1.812

IDENTITIES

(46) $$\frac{TPCE_t}{N_t} = \frac{FBT_t}{N_t} + \frac{RFLHHO_t}{N_t} + \frac{COPE_t}{N_t} + \frac{FFHHE_t}{N_t} + \frac{SERV_t}{N_t} + \frac{TC_t}{N_t} + \frac{RE_t}{N_t}$$

(47) $$TGCE_t = GADJP_t + GSERV_t + GTC_t$$

(48) $$TX_t = XRICE_t + XRUB_t + XMZE_t + XTAP_t + XMFG_t + XOTH_t + XSERV_t$$

(49) $$\frac{TIMP_t}{N_t} = \frac{IMP1_t}{N_t} + \frac{IMP2_t}{N_t} + \frac{IMP3_t}{N_t} + \frac{IMP4_t}{N_t} + \frac{IMP5_t}{N_t} + \frac{IMPSERV_t}{N_t}$$

(50) $$TINV_t = AGINV_t + MANINV_t + CONSINV_t + TCINV_t + WRTINV_t + SERVINV_t + OTHINV_t + DINV_t$$

(51) $$TYUE_t = FY_t + YUE_t$$

(52) $$M1_t = CHP_t + DDHP_t$$

(53) $$2GDP_t = TPCE_t + TGCE_t + TX_t - TIMP_t + TINV_t + SD_t + AGOUT_t + MGDP_t + CONSOUT_t + WRTOUT_t + SERGDP_t + TCOUT_t + OTHOUT_t$$

(54) $$2NY = GDP_t + NFYPROW_t - IDTAX_t - CCA_t + COMP_t + TYUE_t + YROP_t + CORPSAV_t + DTCORP_t + GGY_t - INTPD_t - INTCD_t$$

(55) $$PDY_t = NY_t - DTHH_t + TRANIN_t - TRANOUT_t$$

LIST OF VARIABLES

(Note: All variables are in millions of baht, 1962 prices, unless otherwise noted.)

(1) AGINV = Fixed Capital Formation in Agriculture
(2) AGLAB = Number of Workers in Agriculture (1,000's of workers)
(3) AGOUT = Total Output in Agriculture
(4) CCA = Capital Consumption Allowance
(5) CHP = Currency in Hand of the Public
(6) COMP = Conpemsation of Employees
(7) CONLAB = Millions of Workers in Construction
(8) CONSINV = Gross Fixed Capital Formation in Construction
(9) CONSOUT = Construction Output
(10) COPE = Clothing and Other Personal Expense
(11) CORPSAV = Saving of Corporations and Government Enterprises
(12) CROPOUT = Crop Output
(13) D66* Dummy Variable, 1962-65 = 0; 1966-74 = 1
(14) D73 = Dummy Variable, 1973 = 1; all other years = 0
(15) DDH = Demand Deposits in Hands of the Public
(16) DINV = Change in Inventories
(17) DTCORP = Direct Taxes on Corporations
(18) DTHH = Direct Taxes on Households
(19) DXPBPMZ = Differences Between Export Price and Bangkok Wholesale Price of Maize (number of baht)
(20) FBT = Consumption of Food, Beverages, and Tobacco
(21) FFHHE = Consumption of Furniture, Furnishings, and Household Equipment
(22) FY = Farm Income
(23) GADJP = Government Expenditures on Administration, Defence, Justice and Police
(24) GDP = Gross Domestic Product
(25) GDPCP = Gross Domestic Product in Current Prices
(26) GGY = General Government Income from Property and Enterpreneurship
(27) GREV = Government Revenue
(28) GSERV = Government Expenditures on Services
(29) GTC = Government Expenditures on Transportation and Communication
(30) IDTAX = Indirect Taxes
(31) IMPI = Imports of Consumer Goods, Passenger Cars and Tires
(32) IMP2 = Imports of Intermediate Goods (Chiefly for Consumer Goods), Chassis and Bodies, and Fertilizers and Pesticides
(33) IMP3 = Imports of Fuel and Lubricants
(34) IMP4 = Imports of Capital Goods (not including Fertilizers and Pesticides), Buses and Trucks, and Intermediate Goods (Chiefly for Capital Goods)
(35) IMP5 = Total Merchandise Imports in Balance of Payments - (IMP1 + IMP2 + IMP3 + IMP4)
(36) IMPSERV = Imports of Service

(37) INTCD = Interest on Consumer Debt
(38) INTPD = Interest on Public Debt
(39) KAG = Capital Stock in Agriculture
(40) KCONS = Capital Stock in Construction
(41) KMAN = Capital Stock in Manufacturing
(42) KOTH = Capital Stock in Other
(43) KSERV = Capital Stock in Service
(44) KTC = Capital Stock in Transportation and Communication
(45) KWRT = Capital Stock in Wholesale and Retail Trade
(46) M3P = Price Deflator for Fuel and Lubricants
(47) MANINV = Gross Fixed Capital Formation in Manufacturing
(48) MANLAB = Workers in Manufacturing (millions of workers)
(49) MIP/PGDP = Ratio of Price Deflator for IMP1 to the GDP Price Deflator
(50) M2P/PGDP = Ratio of Price Deflator for IMP2 to the GDP Price Deflator
(51) M4P/PGDP = Ratio of Price Deflator for IMP4 to the GDP Price Deflator
(52) MGDP = Manufacturing Output
(53) MZE = Output of Maize
(54) N = Population (millions of persons)
(55) NAGLAB = Number of Workers in Nonagriculture (1,000's of workers)
(56) NAGINV = Fixed Capital Formation on Nonagriculture
(57) NFYPROW = Net Factor Income Payment from the Rest of the World
(58) NY = National Income
(59) OTHAG = Output of Agricultural Products, Other than Crops
(60) OIHINV = Gross Fixed capital Formation in Other
(61) OTHLAB = Millions of Workers in Other
(62) OTHOUT = Output of Other Products
(63) PDY = Personal Disposable Income
(64) PFFHHE/P = Ratio of Price Deflator for FFHHE to the Price Deflator for All Consumption
(65) PRE/O = Ratio of Price Deflator for RE to the Price Deflator for All Consumption
(66) PSERV/P = Ratio of Price Deflator for SERV to the Price Deflator for All Consumption
(67) PTC/P = Ratio Deflator for TC to the Price Deflator for All Consumption
(68) RAGTLAB = Ratio of Agricultural Labor to Total Labor Force
(69) RE = Consumption Expenditures on Recreation and Entertainment
(70) RFLHHO = Consumption Expenditures on Rent, Fuel, Light, and Household Operation
(71) RICE = Output of Rice
(72) NATLAB = Ratio of Nonagricultural Labor to Total Labor Force
(73) RUB = Output of Rubber
(74) SD = Statistical Discrepancy
(75) SERGDP = Output of Services
(76) SERV = Consumption Expenditures on Services

(77) SERVINV = Gross Fixed Capital Formation in Services
(78) SERLAB = Millions of Workers in Services
(79) TAP = Output of Tapioca
(80) TC = Consumption Expenditures of Transportation and Communication
(81) TCINV = Gross Fixed Capital Formation in Transportation and Communication
(82) TCLAB = Millions of Workers in Transportation and Communication
(83) TCOUT = Output of Transportation and Communication
(84) TDH = Time Deposits in Hands of the Public
(85) TGCE = Total Government Consumption Expenditures
(86) TIMP = Total Imports
(87) TINV = Total Fixed Capital Formation
(88) TPCE = Total Personal Consumption Expenditures
(89) TRANIN = Net Transfers to Households from Government and ROW
(90) TRANOUT = Net Transfers from Households to Government and ROW
(91) TX = Total Exports
(92) TYUE = Total Income for Unincorporated Enterprises
(93) WRTINV = Gross Fixed Capital Formation in Wholesale and Retail Trade
(94) WRTLAB = Millions of Workers in Wholesale and Retail Trade
(95) WRTOUT = Output of Wholesale and Retail Trade
(96) XMFG = Exports of Manufactured Goods
(97) XMZE = Exports of Maize
(98) XNAGCP = Nonagricultural Output in Current Prices
(99) XOTH = Exports of Other Goods
(100) XPRICE = Export Price of Rice (Baht per Metric Ton)
(101) XPRUB = Export Price of Rubber (Baht per Metric Ton)
(102) XRICE = Exports of Rice
(103) XRUB = Exports of Rubber
(104) XSERV = Exports of Services
(105) XTAP = Exports of Tapioca
(106) YPROP = Income from Property
(107) YUE = Income from Unincorporated Enterprises Other than Farms

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