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A STATUS REPORT

on the

GRAIN MANAGEMENT PROGRAM SIMULATION MODEL

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INTRODUCTION

This paper is presented in order to provide a concise but accurate report on the present state of the development of the grain management program (GMP) simulation model. This model has been designed to become an integral component of the larger Korean agricultural sector simulation (KASS) model. By doing this, many of the inputs and the loading effects for the GMP model are provided by the already existing KASS model. Furthermore, a large number of criterion variables for evaluating the impacts of various grain management programs are already present in the KASS model, e.g., farm income, urban nutrition levels, etc.

The development of the GMP component has required the design of two new subsector models: a government grain management (GGM) subsector model and a private marketing (PM) subsector model. Although influenced by government grain management operations, the PM model can operate independently of the government grain management model. For this reason, the PM model need not be associated directly with the GMP component. Rather, it can be viewed as a refinement to the KASS model necessary for incorporating the GMP component. Other refinements to the existing KASS model components were also necessary.

The farm production and urban demand components have been refined to reflect seasonal behavioral responses to changes in market prices, income, and other factors. Market pricing dynamics and transactions of controlled grains (rice and barley) have also been internalized within the KASS model in order to reflect the results of alternative price control policies and programs.

GENERAL DESCRIPTION OF THE MODEL

The general conceptualization of the GMP component model is illustrated in Figure 1. It consists of four subsector models and a market pricing and transaction mechanism which provides the linkage between these subsector models and the rest of the KASS model, i.e.,

- Government grain management subsector model
- Private marketing subsector model
- Farm production subsector model
- Urban demand subsector model
- Market pricing and transaction mechanism.

In this section, a brief nontechnical description will be given of each of the four subsector models along with the market pricing and transaction mechanism. The following sections of this paper will then deal in more detail with each model.

Government Grain Management (GGM) Subsector Model

The GGM subsector model is the instrument through which researchers and decision makers can evaluate proposed alternative grain management policies and programs. This model calculates several variables directly related to government grain management operations and also serves as an interface between these activities and the rest of the KASS model. Some of the types of policies which can be

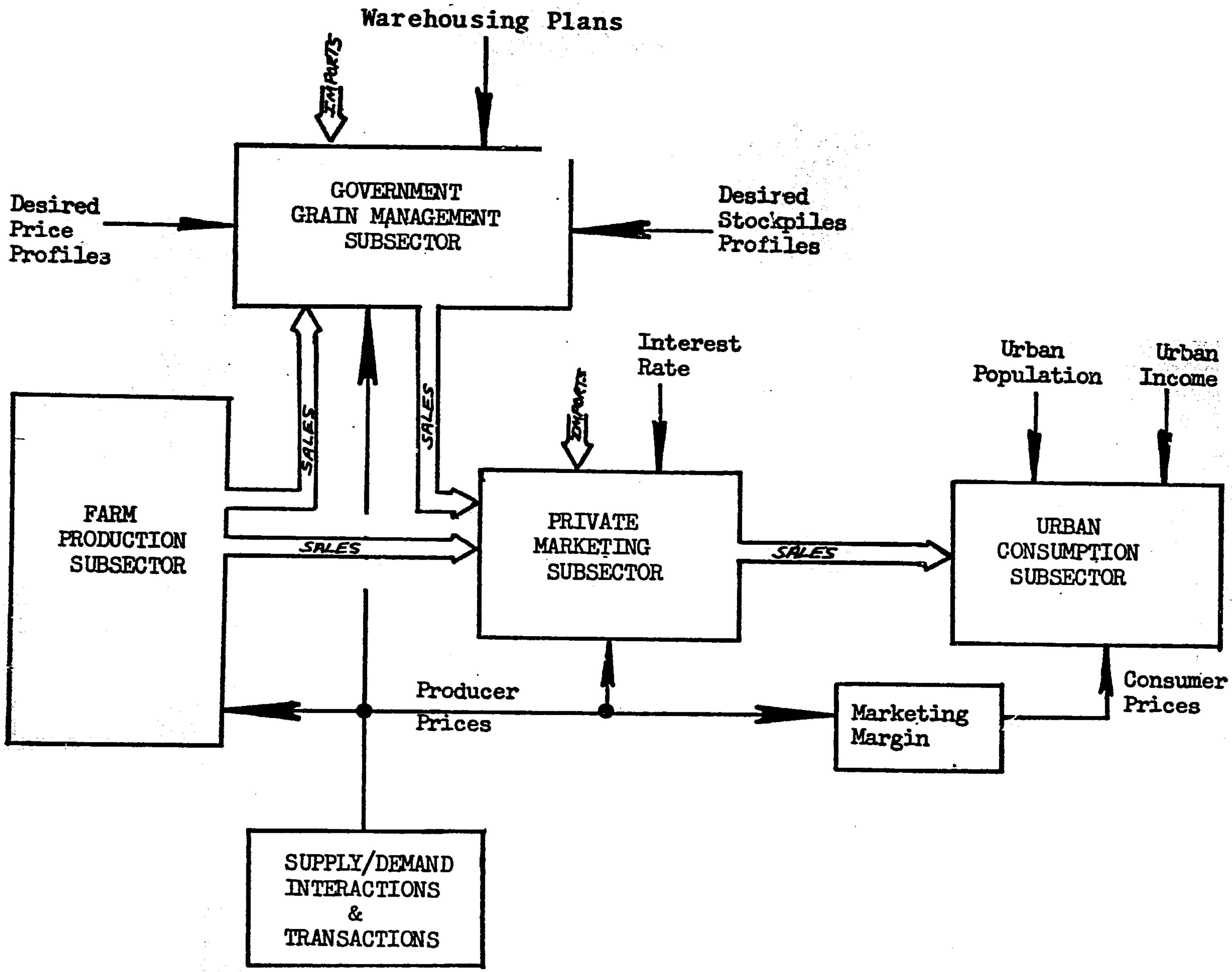


Figure 1. Grain Management Program Simulation Model
(General Outline)

addressed to the KASS model through the present version of the GGM model component are:

a) policies for controlled market pricing patterns

b) policies for government buying and selling pricing patterns

c) policies (or decision rules) governing the intensity and timing of government domestic purchases and sales for controlling market prices

d) policies governing the desired seasonal levels of reserve stocks of rice and barley

e) policies (or decision rules) governing the intensity and timing of imports to maintain desired stock levels, while at the same time utilizing these same stocks in controlling market grain prices

f) policies related to the amount of government-owned and government-leased warehousing

g) policies regarding warehouse construction and financing

h) policies regarding import financing

i) policies specifying import quotas on wheat and feedgrains

j) policies imposing tariffs on wheat and feedgrains

The GGM subsector model is designed as an automatic feedback control system. Currently, three automatic controllers are incorporated into the model: a market price controller, an import controller, and a warehousing controller. Basically, each controller periodically compares the actual observed values of the 'controlled' variables (e.g., rice and barley prices) with the current desired values. The time-series of differences between actual and desired values are called the "error signals." These error signals are used to generate appropriate corrective action to reduce the amount of error in the controlled variables. In the case of the price controller, the error signals are used to generate government domestic purchasing and sales patterns which would be necessary to maintain the desired market price behavior. There are definite trade-offs between system response (how market price actually responds to desired price signals) and the costs and impacts of various control schemes. These are system design problems which must be worked out through interactions between researchers, decision makers, and the KASS/GMP model.

Private Marketing (PM) Subsector Model

As depicted in Figure 1, the PM subsector model provides the pipeline between marketed farm production and final urban demand (or consumption). When the government is active in grain operations, a portion of farm marketings are acquisitioned through various programs based on the established government purchasing price and stored (or used) by the government. These stocks, augmented by imports, are later released onto the free market at the established government selling price through registered grain dealers.

The complexities of the actual private marketing system in Korea are greatly simplified in the PM subsector model. All private marketing channels and various levels of marketing activities are aggregated into one entity referred to as the "private market." The PM subsector model calculates several variables related to private market grain activities, such as inventory levels, warehousing, holding costs, and profits. Two very important variables generated by the PM subsector model are private market demands and marketings. The time paths of these two variables describe the role which the private market is playing in domestic grain storage.

While government grain operations (buying, storing, and selling) are motivated mainly by market price control objectives, private marketing operations are motivated by an altogether different objective--profit. The private market will exercise whatever degrees of freedom are available to it and behave in a manner which will attempt to maximize its own expected profits. The PM subsector model gives much attention to price and profit speculation, since these projections have a definite influence on marketing behavior.

Several factors have an effect on private market profit speculation: warehousing costs, storage costs, interest rates, and, of course, prices. Costs and interest rates do not tend to fluctuate throughout the profit speculated period as do prices. For this reason, market pricing patterns (and the predictability of these patterns) have the most critical influence on seasonal PM behavior. A well-controlled market price therefore can be used as a connection (or control lever) between the government grain management program and the private marketing system. Given a well-behaved (-controlled) market price pattern which is allowed to persist, the PM subsector can be motivated by normal profits to take over much, if not the entire, task of domestic grain storage, thus enabling the government to gradually reduce its grain operations for controlling prices.

Decision makers may wish to develop policies which motivate farmers and urban consumers to take over (and benefit from) part of the grain storage function. Farm credit, interest rates, construction costs, and, again, pricing patterns are some of the instruments through which these objectives can be accomplished. Due to economies of scale, however, it may be desirable for the private market to take over most of the domestic storage function. These are policy questions for decision makers and can be studied and evaluated by means of the KASS/GMP model.

Farm Production Subsector Model

The farm production subsector model provides several criterion variables with which researchers and decision makers can evaluate the impact of various grain management policies and programs on the Korean farmer. Variables such as domestic production, seasonal farm consumption, storage, marketings, and income are generated in this subsector model.

Market Pricing and Transaction Mechanism

Market grain prices (rice and barley) are generated by this mechanism and move dynamically in response to aggregate excess demand. Positive excess demand causes prices to rise, while negative excess demand (i.e., excess supply) causes prices to fall. Since producers and consumers in Korea enjoy free market options of selling and buying through government-controlled or private marketing channels, it has been necessary to incorporate a transaction mechanism within the KASS model to reflect the allocation of domestic supply and demand between the private and government subsectors.

GOVERNMENT GRAIN MANAGEMENT SUBSECTOR MODEL

An activity analysis of the GGM subsector model is given in Figure 2. This analysis classifies each variable of the GGM model as an input, parameter, or output/criterion. It also gives a brief description, the mnemonic, and the exact units of measurement for each variable. Figure 2 will be useful to refer to when following the detailed discussion of the GGM model structure below.

The system diagram in Figure 3 gives a concise description of the structure of the GGM subsector model. Every mathematical relationship discussed in the remainder of this description of the GGM model is depicted in this diagram.

Structural Description

Automatic Control Mechanisms

The three automatic control mechanisms currently incorporated within the GGM subsector model are depicted in Figure 3. The first controller prescribes the level and timing of government domestic grain activities (buying or selling rates) necessary to maintain desired market price behavior. The second controller prescribes the level and timing of government imports necessary to maintain desired government grain reserve stock levels while, at the same time, utilizing these reserve stocks for price control.

INPUTS

GOVERNMENT GRAIN MANAGEMENT SUBSECTOR

SYSTEM PARAMETERS

OUTPUT/PERFORMANCE CRITERIA

Exogenous Inputs

$PWLD_i$ = world prices--\$/MT
RIVBOK = revenue transfers from BOK--W/yr
OGRIV = other revenue transfers--W/yr

Endogenous Inputs (from other parts of KASS model)

P_i = producer prices--W/MT
$GSLS_i$ = government domestic sales--MT/yr
$GPUR_i$ = government domestic purchases--MT/yr

Policy Inputs

PD_i = desired market prices--W/MT
PB_i = government buying prices--W/MT
PS_i = government selling prices--W/MT
$GINVD_i$ = desired government stockpile levels--MT
TCAPD = desired total government-controlled warehouse capacity--MT
GCAPD = desired government-owned warehouse capacity--MT

Feedback

P_i, $GINV_i$, $PIPINV_i$, GCAPL, QWAL, QWUC, QWAD

Expected Costs

$C101_i$ = storage and handling cost--W/MT-yr
$C102_i$ = cost of leased warehouse capacity--W/MT-yr
$C103_i$ = cost associated with selling--W/MT
$C104_i$ = cost associated with buying--W/MT
C105 = administrative cost--W/yr
C106 = construction cost of new warehouse capacity--W/MT

Average Delay Times

DELIMP = import delay
DELGR = import loan grace period--yr
DELRP = import loan repayment period--yr
DELWAL = acquisition period for leased warehousing--yr
DELWUC = construction lag time--yr
DELWRP = construction loan erpayment period--yr
DELWAD = normal warehouse depreciation period--yr

Distributions of Delay Times

KIMP, KGR, KRP, KWAL, KWUC, KWARP, KWAD

Control Gain Parameters

G101, G102, G103, G104, G105, G106, G107, G108

Interest Rates

GRINT = import loan grace period interest rate--%/yr
RINT = import loan repayment period interest rate--%/yr
RINT2 = construction loan interest rate--%/yr
RINT3 = GM account deficit/opportunity interest rate--%/yr

Other Parameters

PCTCSH = proportion of import paid in cash--%
STLOSS = government storage loss rate--%/yr
WOND = won/dollar conversion ratio--W/\$
SALVR = expected salvage value of depreciated warehouse storage area--W/MT
LBAR = proportion of warehouse capacity lost from causes other than normal depreciation--%/yr

Control Variables

$PERR_i$ = current price error (difference between desired and actual)--W/MT
$AERR_i$ = adjusted current price error--MT/yr
$LERI_i$ = current inventory level error--MT
TCERR = current total government-controlled warehouse capacity error--MT
GCERR = current government-owned warehouse capacity error--MT
A_i = unconstrained prescribed price control activities (domestic buying and selling)--MT/yr
$GDEM_i$ = constrained government domestic demand--MT/yr
$GMRTS_i$ = constrained government domestic marketings--MT/yr
$RIMPI_i$ = rate import orders are placed--MT/yr
RWALI = rate at which government warehouse leasing activities are begun--MT/yr
RWUCI = rate at which government warehouse construction is ordered--MT/yr

Operations

$GINV_i$ = government stock levels--MT
$RGINV_i$ = rate of change of government stock levels--MT/yr
$GSLOSS_i$ = rate of loss from government stocks--MT/yr
$GIMP_i$ = rate at which government imports are received--MT/yr
$PIPINV_i$ = import pipeline inventory (on order but not yet received)--MT
QWAL = current warehouse capacity being procured for leasing--MT
QWUC = current warehouse capacity under construction--MT
RWALO = rate at which leased warehouse capacity is acquisitioned--MT/yr
RWUCO = rate at which new government warehouse construction is completed--MT/yr
GCAPL = current government-leased warehouse capacity--MT
QWAD = current government-owned warehouse capacity--MT
RWADO = normal depreciation rate of government-owned warehouse capacity--MT/yr

Financing and Accounting

$RGRI_i$ = rate new import loans enter grace period--\$/yr
QGR_i = total value of import loans currently in grace period--\$
$GRIP_i$ = grace period interest payments--\$/yr
$RGRO_i$ = rate import loans leave grace period and enter repayment period--\$/yr
$TOPI_i$ = total outstanding principle on import loans in repayment period--\$
$RRPO_i$ = rate at which principle is retired on import loans--\$/yr
$PPAII_i$ = payments to principle and interest on import loans--\$/yr
RWARPI = rate of indebtedness for new warehouse construction--W/yr
TOPW = total outstanding principle on warehouse construction loans--W
RWARPO = rate at which principle is retired on warehouse construction loans--W/yr
PPAIW = payments to principle and interest on warehouse construction loans--W/yr
$FOREXD_i$ = foreign exchange deficit for imports paid in cash (dollars)--\$/yr
$FOREXW_i$ = won equivalent of $FOREXD_i$--W/yr
CHI_i = variable cost of holding inventory--W/yr
CGCAPL = cost of government-leased warehousing--W/yr
RSAL = salvage revenue from depreciated warehouse capacity--W/yr
$GREV_i$ = gross revenue flow from domestic grain activities (buying and selling)--W/yr
$GNREV_i$ = net revenue flow from domestic grain activities (includes holding costs)--W/yr
$CBAL_i$ = commodity account balances--W
$GMCF_i$ = grain management account cash flow (includes import financing)--W/yr
TGMCF = total grain management account cash flow (less warehousing costs)--W/yr
RGMBAL = grain management account flow (including fund transfers, warehousing, and managerial costs)--W/yr
GMBAL = grain management program account balance--W

Figure 2

Government Grain Management Subsector (Activity Analysis)

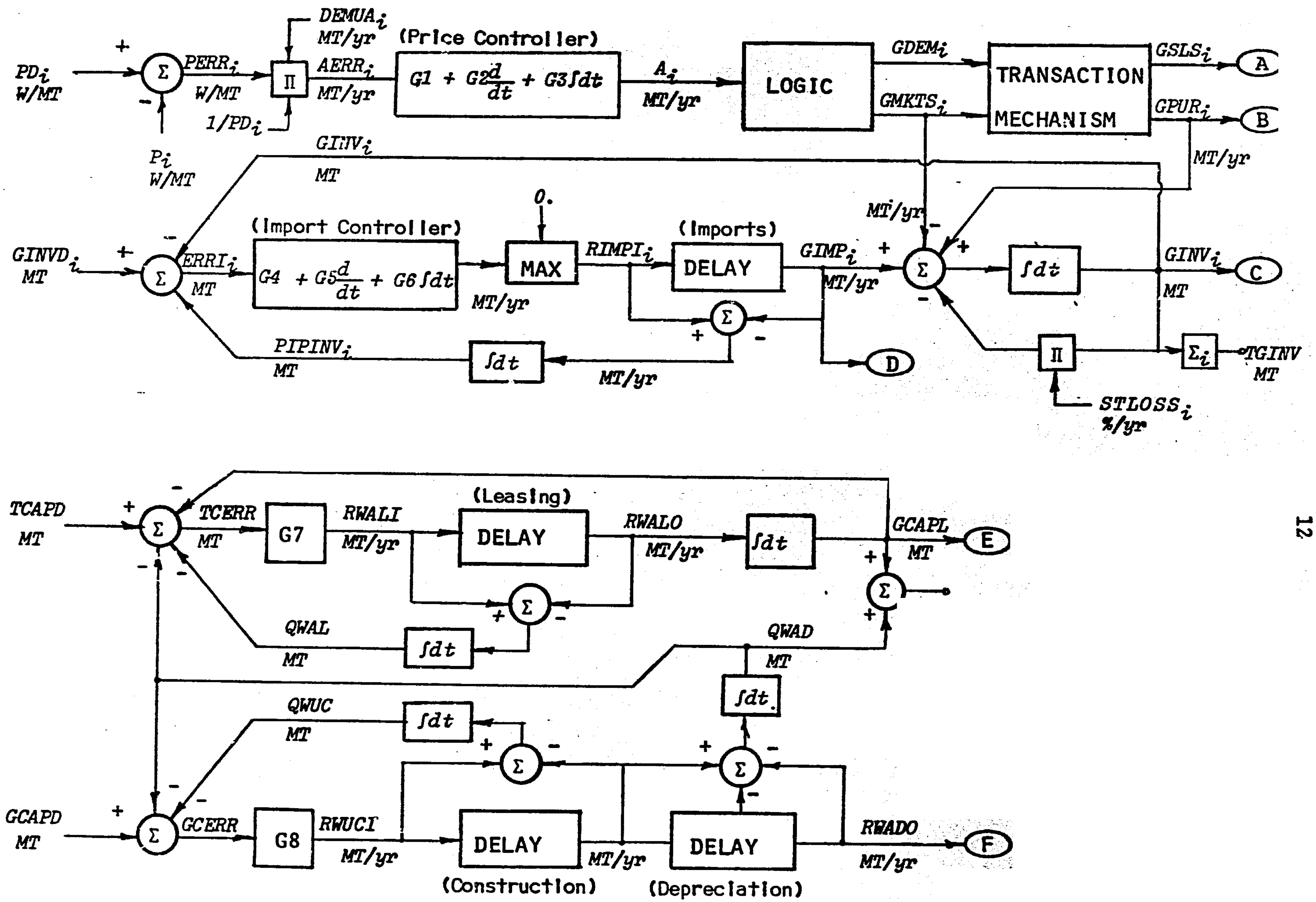


Figure 3a--Government Grain Management Subsector
(Control and Operations)

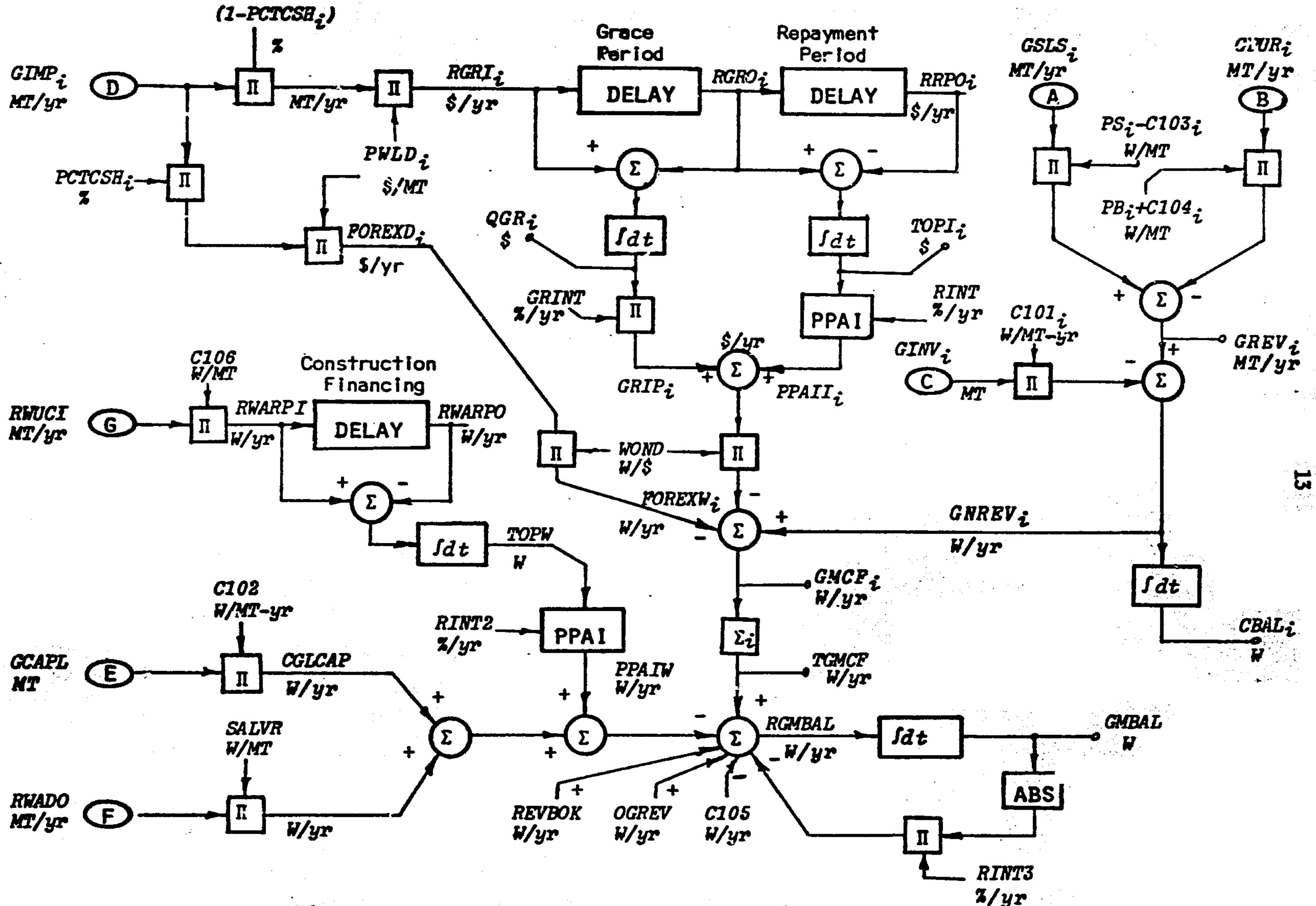


Figure 3b-- Government Grain Management Subsector
ancing and Accounting)

The third controller prescribes warehousing activities (building or leasing) necessary to realize desired warehousing plans.

The design of each of these controllers will consist of determining control functions (i.e., decision rules or policies) which are feasible and satisfactory to grain management program decision makers and, at the same time, cause desired system response.

Automatic Price Control Mechanism

The automatic price controller for the GMP subsector model is depicted in the upper left-hand corner of Figure 3. The "error" observed between desired market price and actual market price is given by

$$PERR_i(t) = PD_i(t) - P_i(t) \qquad (1)$$

where:

PERR = controlled price error--W/MT

PD = desired price--W/MT

P = actual price--W/MT

i = commodity index

t = time.

Since the output of the controller is to be (a prescription of) government domestic purchases and sales, we must first normalize the price error signal to put it into the appropriate units (i.e., MT/yr.). This is done as follows.

$$AERR_i(t) = DEMUA_i*PERR_i(t)/PD_i(t) \quad (2)$$

where:

AERR = "adjusted" error signal--MT/yr

DEMUA = average annual urban demand--MT/yr

PERR = controlled price error signal--W/yr

PD = desired market price--W/yr

general control scheme (proportional-plus-derivative-plus-integral control) is used for the automatic price controller design. This merely says that three functions of the adjusted error will influence the output of the controller: (1) the error itself, (2) its derivative (rate of change), and (3) the integral (or accumulation) of the error over time. In Figure 3, the price controller is depicted as the following function:

$$G_1 + G_2\frac{d}{dt} + G_3\int dt \quad (3)$$

G_1, G_2, and G_3 are the "gains" or weights given to each of the functions of the controller.1/ Furthermore, these

---

1/ *Since DEMUA was used to normalize the pricing error signals, the gains in the price controller specify the 'proportion of DEMUA per unit of each function.' In other words, the level of purchases (or sales) prescribed by the controller to correct a pricing error is represented by some proportion of DEMUA. Each function of the controller contributes to (or detracts from) this total proportion of DEMUA. G_1 represents the proportion of DEMUA per unit of error (PERR/PD), G_2 represents the proportion of DEMUA per unit of change in error (i.e., the slope of the error), and G_3 represents the proportion of DEMUA per unit of accumulated error.*

G's are matrices. For example,

$$G_1 = \begin{bmatrix} g_{111} & g_{112} \\ g_{121} & g_{122} \end{bmatrix} \tag{4}$$

The diagonal elements (g_{111} and g_{122}) are the direct proportional gain parameters for rice and barley price errors, respectively. The off-diagonal elements (g_{121} and g_{112}) are the compensating gain parameters which (if properly specified) will prescribe activity (buying or selling) which will cancel interactions between commodity prices. Specifically, g_{112} is the gain parameter which prescribes compensating activity in rice when correcting errors in barley price, and g_{121} is the gain parameter which prescribes compensating activity in barley when correcting errors in rice price. Another name sometimes used for the controller function (3) above is "series compensator."

Price Control Activity Constraints

The output of the controller has been referred to as "prescribed activity." Actual feasible activity will depend on a number of logical factors:

a) to buy, the government must have financial resources available

b) to buy, the government must have storage space available

c) to sell, the government must, of course, have stocks available.

The logic function depicted in Figure 3 provides these constraints to government price control activities.

Automatic Import Control Mechanism

The government must draw on its stocks when engaging in price control activities. If it also desires to maintain a reserve stock level, it must augment its stocks with imports.

The automatic import controller is much simpler than the price controller described above. The error signal consists of

$$ERRI_i(t) = GINVD_i(t) - GINV_i(t) - PIPINV_i(t) \quad (5)$$

where:

ERRI = controlled inventory error--MT

GINVD = desired government stock levels--MT

GINV = current government inventory--MT

PIPINV = imports on order which are not yet delivered--MT.

The same general control scheme (proportional-plus-derivative-plus-integral control) is used for the automatic import controller. In Figure 3, the import controller is depicted as the following function.

$$G_4 + G_5 \frac{d}{dt} + G_6 \int dt \quad (6)$$

G_4, G_5, and G_6 are the gains or weights given each of the functions of the controller. There are no coupling effects, therefore the G's in (6) are, at most, diagonal matrices. It is very possible that the same gains can be used for all controlled commodities, meaning that the G's in (6) may simply be scalar parameters.

Import Activity Constraint

Currently, the model does not allow exports. There will be periods during the year when stock levels exceed the desired reserve levels set by the government. If this constraint was not in the model, exports would be triggered every time stock levels exceeded the desired reserve levels. This constraint is modeled as follows.

$$RIMPI_i(t) = MAX(RIMPI_i(t), 0.) \quad (7)$$

wnere:

RIMPI = rate import orders are placed--MT/yr

MAX (a,b) = maximum function.

Automatic Warehousing Control Mechanism

The government provides for the storage of controlled grains through both leased and government-owned warehousing. Given a warehousing plan, the automatic warehouse control mechanism will prescribe the activities required to meet this plan. These activities will consist of the rates (and timing) at which government warehouse construction is started and the rates (and timing) of government warehouse leasing.

Two error signals are measured by the warehousing control mechanism: the error in total government-controlled warehouse capacity (TCERR), and the error in government-owned warehouse capacity (GCERR).

$$TCERR(t) = TCAPD(t)-GCAPL(t)-QWAD(t)-QWAL(t) \quad (8)$$

$$GCERR(t) = GCAPD(t)-QWAD(t)-QWUC(t) \quad (9)$$

where:

TCERR = total warehouse capacity error--MT

GCERR = government-owned warehouse capacity error--MT

TCAPD = desired total capacity--MT

GCAPD = desired government-owned capacity--MT

GCAPL = government-leased capacity--MT

QWAD = government-owned capacity--MT

QWAL = current amount of capacity being acquisitioned--MT

QWUC = government warehouse capacity under construction--MT

Since there are two error signals involved, there are also two control functions. A proportional control scheme is used for each of the warehousing control functions.

Government Grain Management Operations

Domestic Buying and Selling

The 'prescribed' government demands and marketings are the output of the automatic price control mechanism discussed earlier. Given that logical conditions allow for the prescribed price control activities, these signals become actual government demands and/or marketings. The transaction mechanism receives these signals and returns the actual resulting government domestic purchases and/or sales.

Government Inventory Levels

Equation (10) expresses the dynamics of government grain stock levels.

$$GINV_i(t+DT)=GINV_i(t)+DT*(GIMP_i(t)+GPUR_i(t)-GMKTS_i(t)-GSLOSS_i(t)) \quad (10)$$

where:

GINV = government stocks of commodity i--MT

GIMP = government imports of commodity i--MT/yr

GMKTS = government sales--MT/yr

GPUR = government purchases--MT/yr

GSLOSS = government storage losses--MT/yr

DT = basic time increment used in the simulation --.025 yr

Government storage losses in Equation (10) are computed as

$$GSLOSS_i(t) = STLOSS*GINV_i(t) \quad (11)$$

where STLOSS is the proportion of storage lost or damaged per year.

Imports

The rate at which import orders are placed is the output of the import controller which was discussed earlier.

The model uses a distributed delay to simulate the lags involved in processing import orders and transporting grain to Korean ports and then to government warehouses. This delay is simulated by a call to subroutine DELDT.

CALL DELDT ($RIMPI_i$,$GIMP_i$,$RINIMP_i$,$DELIMP_i$,IDTIMP,DT,KIMP) (12)

where:

RIMPI = rate at which orders are placed for imports --MT/yr

GIMP = rate at which imports arrive at government warehouses--MT/yr

RINIMP = an array of KIMP intermediate rates--MT/yr

DELIMP = importation delay--years (the average elapsed time between ordering of imports and arrival of grain at government warehouses)

IDTIMP = internal DELDT parameter

KIMP = a parameter that determines the shape of the probability distribution function for the import delay (applies to individual units of grain as they arrive at government storage facilities)

DT = time increment used in the simulation--.025 yr

The amount of grain which has been ordered but not yet received is represented by the storage in this delay.

$$PIPINV_i(t) = DELIMP_i*IDTIMP*\sum_{j=1}^{KIMP} RINIMP_{ij}(t)/KIMP \quad \text{1/} \qquad (13)$$

Warehousing

The warehouse leasing and construction order rates are the outputs of the warehousing controller which was discussed earlier.

It is assumed that there is lag in acquisitioning leased government warehouse capacity. This phenomenon is simulated by a call to the DELDT subroutine.

```
CALL DELDT (RWALI,RWALO,RINWAL,DELWAL,IDTWAL,DT,KWAL)      (14)
```

where:

RWALI = rate at which warehouse leasing activities are begun--MT/yr

RWALO = rate at which leased warehouse capacity is acquisitioned--MT/yr

RINWAL = an array of KWAL intermediate rates--MT/yr

DELWAL = average length of leased warehouse acquisition period--years

KWAL = parameter which determines the probability distribution of the acquisition period.

The storage in this delay (QWAL) represents the amount of leased capacity currently in the process of being acquisitioned.

$$QWAL(t) = DELWAL*IDTWAL*\sum_{j=1}^{KWAL} RINWAL_j(t)/KWAL \qquad (15)$$

1/ *This equation denotes the exact manner in which the storage in a delay is calculated. This method is more precise than simply integrating input rate minus output rate as depicted in Figure 3.*

The current amount of leased warehouse capacity is calculated by the following equation.

$$GCAPL(t+DT) = GCAPL(t)+DT*RWALO(t) \quad (16)$$

where:

GCAPL = government-leased warehouse capacity--MT

RWALO = see (14)--MT/yr

DT = time increment of model--.025 year

Government warehousing construction lag periods are simulated by another call to subroutine DELDT.

CALL DELDT (RWUCI,RWUCO,RINWUC,DELWUC,IDTWUC,DT,IWUC) (17)

where:

RWUCI = rate at which government warehousing construction is ordered--MT/yr

RWUCO = rate at which new government warehousing construction is completed--MT/yr

RINWUC = array of KWUC intermediate rates--MT/yr

DELWUC = average construction lag time--year

KWUC = parameter which determines probability distribution of construction lag times.

The storage in this delay (QWUC) represents the amount of government warehouse capacity under construction.

$$QWUC_i(t) = DELWUC*IDTWUC \sum_{j=1}^{KWUC} RINWUC_j(t)/KWUC \quad (18)$$

As soon as government warehouse construction is completed, it can be used for storage. This new capacity also begins its depreciation period at this time. A non-conservative delay (one in which storage is lost throughout the delay period) is used to simulate the depreciation of warehousing capacity. The reason for using this special delay in this case is because not all warehouse capacity remains for the purpose of grain storage throughout the depreciation life. Fire and other losses may also occur at <u>any</u> time during the depreciation period. This depreciation and loss phenomenon is simulated by a call to subroutine DELDTX.

CALL DELDTX (RWUCO,RWADO,RINWAD,LBAR,DELWAD,IDTWAD,DT,KWAD) (19)

where:

RWUCO = rate at which new government warehouse construction is completed--MT/yr

RWADO = rate at which warehouse capacity is decreased due to normal depreciation--MT/yr

RINWUC = an array of KWAD intermediate rates--MT/yr

LBAR = proportion of the amount of warehouse grain storage capacity which is lost from causes other than normal depreciation--%/yr

DELWAD = average normal depreciation period--year

KWAD = parameter which determines the probability distribution of the depreciation period.

The amount of current government-owned warehouse capacity (QWAD) is equal to the storage in the above depreciation delay.

$$QWAD(t) = DELWAD*IDTWAD*\sum_{j=1}^{KWAD} RINWAD_j(t)/KWAD \quad (20)$$

Financing and Accounting

Revenues

The major revenue flows in the GGM subsector are from the purchases and sales of domestic grains.

$$GREV_i(t) = GSLS_i(t)*(PS_i(t)-C103_i)-GPUR_i(t)*(PB_i(t)+C104_i) \quad (21)$$

where:

GREV = gross revenue flow (+ or -) from domestic grain activities--W/yr

GSLS = current government sales--MT/yr

GPUR = current government purchases--MT/yr

PB = government-established buying price--W/MT

PS = government-established selling price--W/MT

C103 = cost associated with selling--W/MT

C104 = cost associated with buying--W/MT

Net revenue flows from domestic purchases and sales are defined as

$$GNREV_i(t) = GREV_i(t)-CHI(t) \quad (22)$$

where:

GNREV = net revenue flow from domestic grain activities--W/yr

GREV = see (21) above--W/yr

CHI = cost of holding inventory--W/yr computed in (35) below .

Import Financing

Import Loan Repayment

The model policy parameter PCTCSH describes the proportion of imports that are paid for on a cash basis. The rate at which indebtedness is acquired is therefore:

$$RGRI_i(t) = GIMP_i(t)*(1-PCTCSH_i)*PWLD_i(t) \quad (23)$$

where:

RGRI = the rate at which new loans are acquired and "enter" a grace period--$/yr

GIMP = rate at which imports arrive at their destination--MT/yr

PCTCSH = proportion of $GIMP_i$ paid for in cash (a number between zero and one)

PWLD = the world price of commodity i (delivered at a Korean port)--$/MT

The grace period is simulated by a call to the DELDT subroutine:

$$CALL\ DELDT\ (RGRI_i, RGRO_i, RINGR_i, DELGR, IDTGR, DT, KGR) \quad (24)$$

where:

RGRI = rate new loans enter a grace period--$/yr

RGRO = rate loans leave the grace period and enter a repayment phase--$/yr

RINGR = an array of KGR intermediate rates--$/yr

KGR = average length of grace period for loans--year

Grace period interest payments are calculated as follows:

$$GRIP_i(t) = GRINT*QGR_i(t) \tag{25}$$

where:

GRIP = grace period interest payments--\$/yr

QGR = total value of loans in grace period--\$

GRINT = grace period interest rate--%/yr

At the expiration of the grace period, loans enter the repayment phase. The loan repayment phase is simulated by another call to the DELDT subroutine.

$$CALL\ DELDT\ (RGRO_i, RRPO_i, RINRP_i, DELRP, IDTRP, DT, KRP) \tag{26}$$

where:

RGRO = see above--\$/yr

RRPO = rate at which principle is retired on import loans--\$/yr

DELRP = average length of loan repayment phase--yr

KRP = parameter which determines the probability distribution of individual loan payoff periods.

In order to compute payments to principle and interest on outstanding loans, it is important to compute the total amount of unpaid principle which is in the process of repayment. This variable is the storage of the above delay.

$$TOPI_i(t) = DELRP*IDTRP*\sum_{j=1}^{KRP} RINRP_{ij}(t)/KRP \tag{27}$$

Given $TOPI_i(t)$, the payments to principle and interest, (PPAII), are computed as:

$$PPAII_i(t) = -RINT*TOPI_i(t)e^{RINT*DELRP})/(1-e^{RINT*DELRP} \tag{28}$$

where:

PPAII = payment to principle and interest for outstanding loans in the repayment phase --\$/yr

TOPI = total outstanding principle on import loans --\$

RINT = interest rate during repayment period--%/yr

DELRP = length of the repayment period--year

e = base of natural logarithms.

Cash Payments for Imports

The foreign exchange deficit representing cash payments for imports is computed as follows.

$$FOREXD_i(t) = GIMP_i(t)*PCTCSH_i*PWLD_i(t) \quad (29)$$

where:

FOREXD = foreign exchange deficit for imports paid in cash--\$/yr

GIMP = government imports of commodity i--MT/yr

PCTCSH = proportion of $GIMP_i$ paid for in cash

PWLD = world price of commodity i delivered to Korean ports--\$/MT

Given $FOREXD_i$, the won cost of imports paid for in cash is

$$FOREXW_i(t) = FOREXD_i(t)*WOND \quad (30)$$

where:

FOREXW = won value of foreign exchange deficit for cash payments on imports--W/yr

FOREXD = see above--\$/yr

WOND = won/dollar exchange rate--W/$.

Warehouse Construction Financing

Defrayments on the principle and interest of government warehouse construction costs are simulated in the same manner as import loan repayments. The rate of indebtedness for warehouse construction is given by

RWARPI(t) = C106*RWUCI(t) (31)

where:

RWARPI = rate of indebtedness for new warehousing construction being started--W/yr

C106 = average construction cost of new warehouse capacity--W/MT

RWUCI = rate at which new warehouse construction is started--MT/yr .

The repayment period for warehouse construction loans is simulated by a call to subroutine DELDT.

CALL DELDT (RWARPI,RWARPO,RINWRP,DELWRP,IDTWRP,DT,KWARP) (32)

where:

RWARPI = see above--W/yr

RWARPO = rate at which the principle on construction loans is paid off--W/yr

RINWRP = array of KWARP intermediate rates--W/yr

DELWRP = average length of construction loan repayment period--year

KWARP = parameter which determines the probability distribution of the construction loan repayment period.

The amount of unpaid principle on construction loans (TOPW) is given by the storage in the above delay.

$$TOPW(t) = DELWRP*IDT*\sum_{j=1}^{KWARP} RINWRP_j/KWARP \qquad (33)$$

$$PPAIW(t) = -RINT2*TOPW(t)*e^{RINT2*DELWRP}/(1-e^{RINT2*DELWRP}) \qquad (34)$$

where:

PPAIW = payment to principle and interest for outstanding warehouse construction loans --W/yr

TOPW = total outstanding principle on warehouse construction loans--W

RINT2 = interest rate on construction loans--%/yr

DELWRP = average length of construction loan repayment period--year

e = base of natural logarithms.

Inventory Holding Costs

The costs of holding government inventory are computed as:

$$CHI_i(t) = C101_i*GINV_i(t) \qquad (35)$$

where:

CHI = cost of holding inventory--W/yr

C101 = average cost of holding inventory--W/MT-yr

GINV = current government inventory--MT

Warehouse Leasing Expenditures

Expenditures on government-leased warehousing are given by

$$CGLCAP(t) = C102*GCAPL(t) \qquad (36)$$

where:

CGLCAP = expenditure on government-leased warehousing--W/yr

GCAPL = government-leased warehouse capacity--MT

C102 = average cost of leased warehouse capacity --W/MT-yr .

Accounting

Of course, a very important set of criterion variables for evaluating the impacts of alternative grain management policies or programs is grain management account balances.

Commodity cash balances are calculated as follows:

$$CBAL_i(t+DT) = CBAL_i(t)+DT*GNREV_i(t) \qquad (37)$$

where:

CBAL = commodity account balances--W

GNREV = net revenue flow from domestic grain activities; see equation (22)--W/yr

DT = time increment for the model--.025 year

Further commodity specific accounting follows:

$$GMCF_i(t) = GNREV_i(t) - FOREXW_i(t) - PPAII_i(t) * WOND \quad (38)$$

where:

GMCF = commodity specific account flow including import financing--W/yr

GNREV = see above--W/yr

FOREXW = won value of foreign exchange deficit for cash payments on imports--W/yr

PPAII = payment to principle and interest on import loans--$/yr

WOND = won/dollar conversion rate--W/$

The above account flows are summed over commodities:

$$TGMCF(t) = \sum_i GMCF_i(t) \quad (39)$$

The flow (+ or -) of funds in the grain management program account balance is given by the following equation.

$$RGMBAL(t) = TGMCF(t) + REVBOK(t) + OGREV(t) + SALVR * RWDHO(t) - CGLCAP(t) - PPAIW(t) - RINT3 * ABS(GMBAL(t)) - C105 \quad (40)$$

where:

RGMBAL = rate at which grain management account balance is changing--W/yr

TGMCF = account flow due to grain operations--W/yr

REVBOK = revenue transfers from BOK--W/yr (exogenous to model)

OGREV = other revenue transfers--W/yr (exogenous to model)

SALVR = salvage rate for government-owned warehousing --W/MT

RWADO = rate at which government warehousing capacity is decreased due to normal depreciation--MT/yr

CGLCAP = expenditure on government-leased warehousing --W/yr

PPAIW = payment to principle and interest on warehouse construction loans--W/yr

RINT3 = account deficit/opportunity interest rate--%/yr

C105 = grain management administrative expenditure --W/yr

The grain management program balance (GMBAL) is calculated as follows:

GMBAL(t+DT) = GMBAL(t)+DT*RGMBAL(t) 41)

PRIVATE MARKETING SUBSECTOR

This section will give a brief description of the mathematical structure of the PM subsector model. Lacking in this account will be a technical description of the PM speculative behavioral mechanism. Such a description is provided in KASSIM Working Paper 73-1 and, because of its lengthiness, will not be repeated here.

An activity analysis of the ordinary (i.e., without speculative behavior) PM subsector model is given in Figure 4. This analysis classifies each variable of the PM model as an input, parameter, or output/criterion. It also gives a brief description, the mnemonic, and the exact units of measure for each variable. The system diagram in Figure 5 gives a concise description of the mathematical structure of the ordinary PM subsector model.

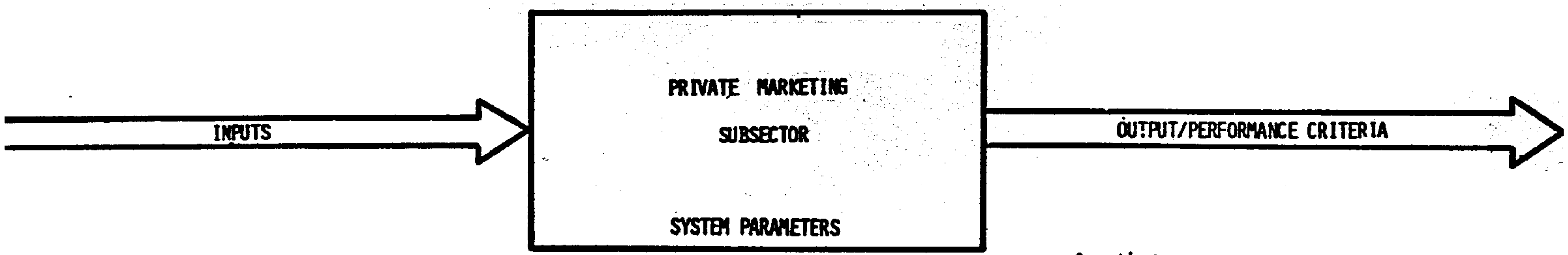
Structural Description

Private Market Grain Operations

PM Inventory

The dynamics of PM inventories are described by the following equation.

$$PINV_i(t+DT) = PINV_i(t) + DT*(PPUR_i(t) - PSLS_i(t) - PSLOSS_i*PINV_i(t)) \quad (42)$$



$PPUR_i$ = private purchases--MT/yr
$PSLS_i$ = private sales--MT/yr
P_i = producer prices--W/MT
CPU_i = consumer prices--W/MT

<u>Costs</u>
01_i = storage and handling cost--W/MT-yr
02 = average fixed cost of PM storage capacity--W/MT-yr
03_i = cost associated with selling--W/MT
04_i = cost associated with buying--W/MT

<u>her Parameters</u>
$LOSS_i$ = PM storage loss rate--%/yr
NT = PM interest rate--%/yr

<u>Operations</u>
$PINV_i$ = PM inventory levels--MT
TPINV = total PM inventory (overall commodities)--MT
PCAP = PM storage capacity--MT
$PMKTS_i$ = PM marketings--MT/yr
$PDEM_i$ = PM demands--MT/yr

<u>Accounting</u>
$AVCHPI_i$ = average variable cost of holding PM stocks--W/MT
$VCHPI_i$ = variable cost of holding PM inventory--W/yr
FCHPI = total fixed cost of PM storage capacity--W/yr
$FCHPIC_i$ = fixed cost of PM storage capacity (commodity specific)--W/yr
TCHPI = total cost of holding private inventory--W/yr
PREV = gross PM revenue flow from domestic grain activities--W/yr
PMP = current PM profit--W/yr
APMP = accumulated (or annual) PM profit--W
TPMP = current total PM profit (over all commodities)--W/yr

Figure

Private Marketing Subsector
(Activity Analysis)

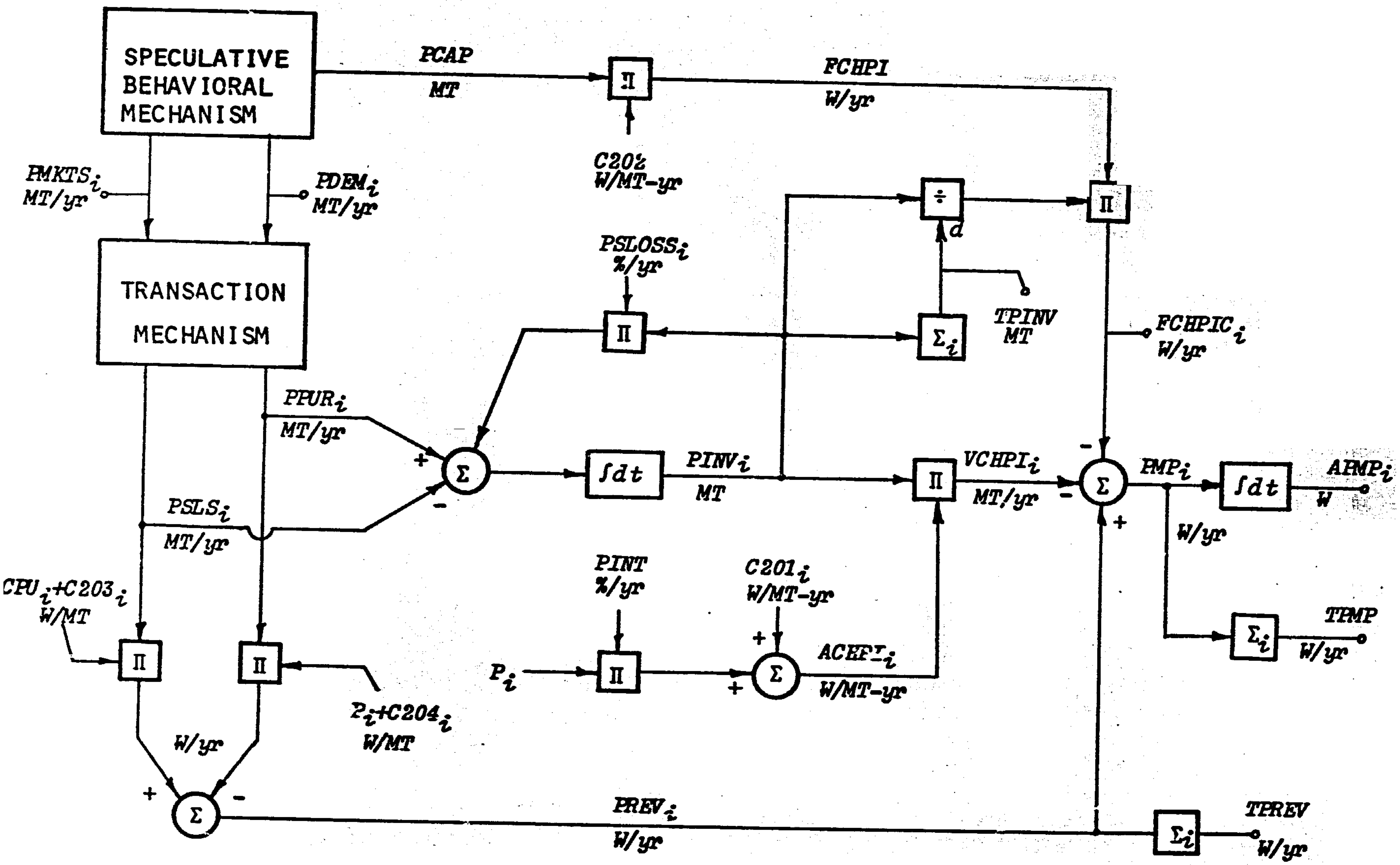


Figure 5--Private Marketing Subsector

where:

PINV = PM inventory--MT

PPUR = PM purchases

PSLS = PM sales

PSLOSS = PM storage loss rate--%/yr

DT = time increment--.025 yr

i = commodity index.

Aggregate PM grain stockpiles are calculated by the following summation:

$$TPINV(t) = \sum_i PINV_i(t) \qquad (43)$$

Financing and Accounting

Revenues

The major revenue flows in the PM subsector model are from the purchases and sales of domestic grains.

$$PREV_i(t) = PSLS_i(t)*(CPU_i(t)-C203_i)-PPUR_i(t)*(P_i(t)+C204_i) \qquad (44)$$

where:

PREV = gross PM revenue flow (+ or -) from domestic grain activities--W/yr

PSLS = current PM sales--MT/yr

PPUR = current PM purchases--MT/yr

CPU = urban consumer price--W/MT

P = producer price--W/MT

C203 = cost associated with buying--W/MT

C204 = cost associated with selling--W/MT.

Total revenue flow (TPREV) from all commodities handled by the PM subsector model is given by

$$TPREV(t) = \sum_i PREV_i(t) \tag{45}$$

Inventory Holding Costs

The average variable cost of holding private grain stocks is given by

$$AVCHPI_i(t) = PINT_i * P_i(t) + C201_i \tag{46}$$

where:

$AVCHPI_i(t)$ = average variable cost of holding private stocks--W/MT-yr

PINT = PM interest rate--%/yr

P = producer price--W/MT

C201 = storage and handling cost--W/MT-yr

The variable cost of holding PM inventory is given by

$$VCHPI_i(t) = AVCHPI_i(t) * PINV_i(t) \tag{47}$$

where:

VCHPI = variable cost of holding PM inventory --W/yr

AVCHPI = see above--W/MT-yr

PINV = private inventory level--MT.

The fixed cost of maintaining present PM storage capacity is given by

$$FCHPI(t) = C202*PCAP(t) \tag{48}$$

where:

FCHPI = total fixed cost of maintaining current PM storage capacity--W/yr

C202 = average fixed cost of PM storage capacity --W/MT-yr

PCAP = current PM storage capacity--MT.

In order to preserve commodity specific calculations, this fixed cost of PM capacity is charged proportionately to each commodity.

$$FCHPIC_i(t) = (PINV_i(t)/TPINV(t))*FCHPI(t) \tag{49}$$

where:

FCHPIC = commodity specific fixed cost of maintaining current PM storage capacity--W/yr

PINV = current PM inventory level--MT (of commodity i)

TPINV = total PM stockpile of grains--MT

FCHPI = see above--W/yr.

Finally, the total cost associated with holding a certain level of PM stocks consists of the variable cost of holding this amount plus the fixed cost.

$$TCHPI_i(t) = VCHPI_i(t)+FCHPIC_i(t) \tag{50}$$

where:

TCHPI = total cost of holding PM inventory--W/yr

VCHPI = variable cost--W/yr

FCHPIC = fixed cost--W/yr.

Profit

Current PM profits are calculated as follows:

$$PMP_i(t) = PREV_i(t) - TCHPI_i(t) \tag{51}$$

where:

PMP = current PM profit--W/yr

PREV = current PM gross revenue flow (+ or -) from domestic grain activities--W/yr

TCHPI = total cost of holding PM inventory--W/yr.

Important performance criteria for the PM subsector model are the accumulated (or annual) profits.

$$APMP_i(t+DT) = APMP_i(t) + DT*PMP_i(t) \tag{52}$$

where:

APMP = accumulated (or annual) profit--W

DT = time increment--.025 yr

PMP = current profit--W/yr.

Total PM profit across all commodities (TPMP) is given by

$$TPMP(t) = \sum_i PMP_i(t). \tag{53}$$

Private Market Speculative Behavioral Mechanism

The PM speculative behavioral mechanism will serve as the nerve center for the PM subsector component of the GMP model. It is through this mechanism that the PM subsector model will sense the impacts of various grain management policies and respond to new profit opportunities. Decisions regarding the amount and timing of purchases and sales of foodgrain will come from this mechanism. Priority decisions which determine how available storage capacity will be allocated among competing commodities will be made here. Decisions which will determine the growth or decline of total storage capacity will also be made. All decisions (except those reflecting government decrees) are made with one objective: to maximize PM subsector profits. Whether these decisions do maximize profits or even assure the survival of the PM subsector will depend on several things: (1) how accurate market speculators (modeled) are in projecting future market information; (2) how "predictable" future market information actually is; and (3) the degree to which PM speculators are restrained from engaging in profit maximizing activities.

FARM PRODUCTION AND URBAN DEMAND SUBSECTOR MODELS

In order to effectively interface the GMP component model with the existing KASS model, some refinements and modifications were necessary in the existing farm production component and the urban demand component. These components are described in Appendix A of the KASS report and again in the User's Manual (Special Report No. 9). With the refinements described below, these two KASS model components serve as the required farm production and urban demand subsector models of the GMP component.

Structural Description

Dr. Moon, Pal Yong, of the Korean Development Institute, has been investigating some of the seasonal foodgrain demands and marketings in Korea.[1/] A review of the econometric model used in Dr. Moon's study indicated that, with some minor adjustments and "re-assumptions," it could be fully incorporated into the KASS model. Although the model was not originally developed for prediction purposes, it seems capable of generating credible seasonal responses for farm consumption, farm marketings, and urban demand. This capability is precisely what is required from the farm production and urban demand subsector models of the GMP

1/ *Moon, Pal Yong, An Econometric Analysis of Foodgrain Demand and Marketings; Partial Vs. Total Response Analysis, Korean Development Institute, Seoul, 1972.*

component. Of course, independent research into these response patterns will be undertaken to verify the applicability of the Moon model in this context.

Dr. Moon's model consists of eight simultaneous equations: six behavioral equations and two market-clearing identities. The six behavioral equations describe the seasonal farm demand, farm sales, and urban consumption demand for rice and barley in Korea. The two market-clearing identities were included to complete the above system. Since TSLS was used to estimate the above coefficients, the market identities have no effect on the estimation of the six behavioral equations.

If we replace the two static market equilibrium identities in the above system by the (yet-to-be-described) dynamic relationships between prices and excess demands, the above model is transformed from a static system of simultaneous equations into a dynamic system of recursive equations.

Moon's system of seasonal response equations is given on the following page. Notice that in the farm sales and urban demand equations, prices are the only endogenous variables appearing on the right-hand side. If, in the KASSIM model, prices at time t are calculated based on price and excess demands at time t-DT, we have, by definition, a reduced form for endogenous prices at time t. The values of prices at time t can then be used in the farm sales and urban demand at time t. Finally, values of prices and farm sales at time t can be used in the farm demand equations to obtain a reduced form for farm demand at time t.

Moon's Seasonal Response Model

(Farm Demand)

$$q_R^{FD} = b_{10} + b_{11}P_R + b_{12}D_1P_R + b_{13}D_2P_R + b_{14}P_B + b_{15}P_W + b_{16}q_{Rt-1}^{FK} + b_{17}(P_Rq_R^{FS} + P_Bq_B^{FS} + Y_{NRB}) + b_{18}D_1 + b_{19}D_2 \quad (54)$$

$$q_B^{FD} = b_{20} + b_{21}P_B + b_{22}D_1P_B + b_{23}D_3P_B + b_{24}P_R + b_{25}P_W + b_{26}q_{Bt-1}^{FK} + b_{27}(P_Rq_R^{FS} + P_Bq_B^{FS} + Y_{NRB}) - b_{28}D_1 + b_{29}D_3 \quad (55)$$

(Farm Sales)

$$q_R^{FS} = b_{30} + b_{31}P_R + b_{32}D_1P_R + b_{33}D_2P_R + b_{34}L_{t-1} + b_{35}E + b_{36}q_{Rt-1}^{FK} + b_{37}(P_Rq_{Rt-1}^{FK} + P_Bq_{Bt-1}^{FK} + Y_{NRB}) + b_{38}D_1 + b_{39}D_2 \quad (56)$$

$$q_B^{FS} = b_{40} + b_{41}P_B + b_{42}D_1P_B + b_{43}D_3P_B + b_{44}L_{t-1} + b_{45}E + b_{46}q_{Bt-1}^{FK} + b_{47}(P_Rq_{Rk-1}^{FK} + P_Bq_{Bt-1}^{FK} + Y_{NRB}) + b_{48}D_1 + b_{49}D_3 \quad (57)$$

(Urban Demand)

$$q_R^{UD} = b_{50} + b_{51}P_R + b_{52}D_1P_R + b_{53}D_2P_R + b_{54}P_B + b_{55}P_W + b_{56}P_RY_U + b_{57}Y_U + b_{58}D_1 + b_{59}D_2 \quad (58)$$

$$q_B^{UD} = b_{60} + b_{61}P_B + b_{62}D_1P_B + b_{63}D_3P_B + b_{64}P_R + b_{65}P_W + b_{66}P_BY_U + b_{67}Y_U + b_{68}D_1 + b_{69}D_3 \quad (59)$$

Variable Definitions for Moon's Model [1/]

Endogenous Variables:

q_R^{FD} = farm per capita consumption of rice — kg/#-mo

q_B^{FD} = " " " " barley — kg/#-mo

q_R^{FS} = farm per capita sales of rice — kg/#-mo

q_B^{FS} = " " " " barley — kg/#-mo

q_R^{UD} = urban per capita consumption of rice — kg/#-mo

q_B^{UD} = " " " " barley — kg/#-mo

P_R = monthly average wholesale price of rice deflated by the index of nongrain wholesale prices WPI_n — W/kg

P_B = monthly average wholesale price of barley deflated by WPI_n — W/kg

Exogenous Variables:

P_W = monthly average wholesale price of wheat flour deflated by WPI_n — W/22 kg (bag)

q_{Rt-1}^{FK} = farm per capita stock of rice at end of previous month — kg/#

q_{Bt-1}^{FK} = farm per capita stock of barley at end of previous month — kg/#

Y_{NRB} = farm per capita income originating from non-rice-barle sources deflated by index of prices paid by farmers (PPFI) — W/#-mo

---

1/ *The original coefficients of Moon's model have been transformed so that KASS units of measure can be used. The units indicated here are the original units.*

Variable Definitions (cont'd)

L_{t-1} = farm per capita liabilities as of the end of the previous month deflated by PPFI — W/#

E = farm per capita cash expenditures for clothing, education, etc., deflated by PPFI — W/#-mo

Y_U = urban per capita disposable income deflated by the index of urban consumer prices — W/#-mo

D_1 = 1 if October - January period
= 0 otherwise

D_2 = 1 if February - May period
= 0 otherwise

D_3 = 1 if June - September period
= 0 otherwise

MARKET PRICING AND TRANSACTION MECHANISM

Market Pricing Dynamics

Market price responses of controlled grains (currently rice and barley) have been internalized within the KASS model. These prices serve as an important linkage for interaction among the four subsector models of the GMP component. (Market prices cause responses in the behavioral patterns of each subsector, and, at the same time, the behavioral patterns of each subsector cause responses in market prices.)

The pricing mechanism currently being tested for application in the KASS model generates wholesale market prices as a function of excess demand.

$$WP_i(t+DT) = WP_i(t)+DT*C_i*WP_i(t)*(TD_i(t)-TM_i(t))/TD_i(t) \quad (60)$$

where:

WP = wholesale market price--W/MT

DT = time increment of the KASS model--.025 yr

C = an empirically determined parameter which describes the speed at which wholesale prices respond to excess demands--no units

TD = total aggregate demand (per DT)--MT

TM = total aggregate (and residual) marketings --MT

The total aggregate demand in (60) is defined as

$$TD_i(t) = (PDEM_i(t)+GDEM_i(t)+UDEM_i(t))*DT \quad (61)$$

where:

PDAI = private market subsector demand--MT/yr

GDEM = government subsector demand--MT/yr

UDEM = urban subsector demand--MT/yr.

The total aggregate (and residual) marketings are calculated according to Equation (62) below. The 'residuals' in this equation are defined as all past marketings which have not yet cleared the market. These residuals are computed by the transaction mechanism to be discussed shortly.

$$TM_i(t) = FMRES_i(t)+PMRES_i(t)+GMRES_i(t) \quad (62)$$

where:

TM = total aggregate (and residual) markets--MT

FMRES = farm marketing residuals--MT
see (65) below

PMRES = private marketing residuals--MT
see (66) below

GMRES = government marketing residuals--MT
see (67) below

Producer and consumer prices are derived from the wholesale price of Equation (60) by the following transformations.

$$P_i(t) = (1/(1+MMW_i*MM_i))*WP_i(t) \quad (63$$

$$CPU_i(t) = ((1+MM_i)/(1+MMW_i*MM_i))*WP_i(t) \quad (64$$

where:

P = producer price--W/MT

CPU = consumer price--W/MT

WP = wholesale price--W/MT

MM = producer-to-consumer marketing margin--%

MMW = proportion of MM taken by producer-to-wholesaler margin--%

Transaction Mechanism

Since the GMP model is separable into four entities (government, farmers, private market, and urban consumers), it is desirable to maintain as much information about the activities of each of these individual entities (or subsectors) as possible. The allocation of domestic supply and demand among the subsectors has a very important impact on the performance of each subsector model.

Marketing Residuals

It is assumed that marketings are not reversible processes; once a certain amount of grain is marketed, it will remain on the market until purchased. When market demand (per unit time) for the grain exceeds the amount on the market, there will be no residual. However, when the reverse is true and there are excess marketings (over demand) for a given time period, the residuals accumulate on the market and are added to marketings of subsequent periods. This phenomenon is modeled for the farm, private, and government subsectors as follows.

$$FMRES(t+DT) = FMRES(t)+DT*(FMKTS(t)-FSLS(t)) \quad (65)$$

$$PMRES(t+DT) = PMRES(t)+DT*(PMKTS(t)-PSLS(t)) \quad (66)$$

$$GMRES(t+DT) = GMRES(t)+DT*(GMKTS(t)-GSLS(t)) \quad (67)$$

where:

FMRES
PMRES = market residual supplies of respective
GMRES subsectors--MT

FMKTS
PMKTS = current marketing rates of respective
GMKTS subsectors--MT/yr

FSLS
PSLS = current sales rates of respective sub-
GSLS sectors--MT/yr

Market Transactions

The calculation of market transactions begins with the following two purchasing equations.

$$PPUR_i(t) = MIN(PDEM_i(t),CMP_i*PRFM_i*FMRES_i(t)/DT) \quad (68)$$

$$GPUR_i(t) = MIN(GDEM_i(t),(1-CMP_i*PRFM_i)*FMRES_i(t)/DT) \quad (69$$

where:

PPUR = private marketing purchases--MT/yr

GPUR = government purchases--MT/yr

MIN(a,b) = minimum function

PDEM = private market demand--MT/yr

GDEM = government demand--MT/yr

PRFM[1/] = an empirical parameter reflecting the natural proportion in which farm marketings are distributed between private and government marketing channels--no units

CMP[2/] = a government 'countermeasure' policy parameter affecting the natural proportion of private/ government marketing--no units

FMRES = farm marketing residual (including current marketing)--MT

DT = time increment of the model--.025 year

After completing these initial purchasing transactions, a check is made to see if any excess market demands exist, and if there is a potential for a secondary transaction during the same time period.

$$EPD_i(t) = PDEM_i(t) - PPUR_i(t) \quad (70)$$

$$EGD_i(t) = GDEM_i(t) - GPUR_i(t) \quad (71)$$

where:

EPD = excess private market demand--MT/yr

EGD = excess government market demand--MT/yr

1/ *The parameter PRFM may be computed as an empirical function of a number of factors affecting farm choices of markets. These might be relative differences between government-established buying price and market prices, the relative levels of market activities (e.g., sizes of demands) of the government private subsectors, etc.*

2/ *Currently, the parameter CMP in the purchasing equations above is set equal to 1. That is, no government 'countermeasure' policies are in effect which will change the propensity of Korean farmers to react in their choices of markets.*

Four possible situations exist:

Situation	Excess Demand From Private Market?	Excess Demand From Government Market?	Possible Secondary Transaction?
1	Yes	Yes	No
2	No	No	No
3	Yes	No	Yes
4	No	Yes	Yes

In the first two situations, there exists no potential for a secondary transaction. However, in the last two situations, the chance of a secondary transaction does exist.

Situation (3):

In this case, there is an excess demand in the private market and, most likely, a farm marketing residual on the government market. If it is assumed that residual farm marketings may flow from the government to the private subsector, a secondary transaction can now take place in the same time period. Private purchases are augmented by this second transaction:

$$PPUR_i(t) = PPUR_i(t) + MIN(EDP_i(t), FMRES_i(t)/DT - PPUR_i(t) - GPUR_i(t) \qquad (72)$$

Situation (4):

In this case, there is an excess demand in the government market channel and, most likely, a farm marketing residual in the private market. If a secondary transaction is allowed, government purchases will be augmented by the following equation:

$$GPUR_i(t) = GPUR_i(t) + MIN(EGD_i(t), FMRES_i(t)/DT - PPUR_i(t) - GPUR_i(t)) \quad (73)$$

Farm Sales are defined as

$$FSLS_i(t) = GPUR_i(t) + PPUR_i(t) \quad (74)$$

The calculation of other sales transactions begins with the following two equations:

$$PSLS_i(t) = MIN(PMRES_i(t)/DT, PRUD_i{*}UDEM) \quad (75)$$

$$GSLS_i(t) = MIN(GMRES_i(t)/DT, (1-PRUD_i(t)){*}UDEM) \quad (76)$$

where:

PSLS = private subsector sales--MT/yr

GSLS = government subsector sales--MT/yr

MIN(a,b) = minimum function

PMRES = private marketing residual supply--MT

GMRES = government marketing residual supply--MT

PRUD[1/] = an empirical parameter reflecting the natural proportion in which urban demand is distributed between private and government marketing outlets

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1/ *This parameter may be computed as an empirical function of a number of factors affecting the consumer's choice of markets. These factors might be relative differences between government-established selling prices and prevailing market consumer prices, the relative level of marketing activities, etc.*

A government countermeasure parameter similar to CMP in the

UDEM = current urban demand--MT/yr

After completing these initial sales transactions, a check is made to see if any excess urban demand remains, and if there is the possibility of any secondary transactions during the same time period.

$$EUDP_i(t) = PRUD_i*UDEM_i(t)-PSLS_i(t) \quad (77)$$

$$EUDG_i(t) = (1.-PRUD_i)*UDEM_i(t)-GSLS_i(t) \quad (78)$$

where:

EUDP = excess urban demand in private subsector --MT/yr

EUDG = excess urban demand on government subsector --MT/yr

PRUD = see above--no units

UDEM = urban demand--MT/yr

PSLS = private sales resulting from first transaction calculation--MT/yr

GSLS = government sales resulting from first transaction calculation--MT/yr

Again, as in the case of farm-to-market transactions, four possible transactions exist:

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purchasing equations discussed earlier can be incorporated into (75) and (76). This parameter would reflect government countermeasure policies such as taxations, or publicity campaigns which changed the propensity of urban consumers to react in their choices of markets. This parameter would affect the market choices of consumers, but not the total amount of urban demand. If the latter type of parameter is desired in the model, it should be incorporated into the urban demand component and not in the transaction mechanism. Such a parameter could be used to reflect government policies to supress urban consumption of certain commodities (e.g., riceless days, etc.).

Situation	Excess Urban Demand on Private Market?	Excess Urban Demand on Government Market?	Possible Secondary Transaction?
1	Yes	Yes	No
2	No	No	No
3	Yes	No	Yes
4	No	Yes	Yes

Situation (3):

In this case, there is an excess urban demand on the private market, and, most likely, a government marketing residue on the consumer market. If it is assumed that consumers will shift their excess demands between markets (in the absence of adequate supply), a secondary transaction can now take place in the same time period. Government sales are augmented by this secondary transaction.

$$GSLS_i(t) = GSLS_i(t) + MIN(GMRES_i(t)/DT - GSLS_i(t), EUDP_i(t)) \quad (79)$$

Situation (4):

In this case, there is an urban demand on the government market, and, most likely, a private marketing residual on the consumer market. If a secondary transaction is allowed, private market sales will be augmented by the following equation:

$$PSLS_i(t) = PSLS_i(t) + MIN(PMRES_i(t)/DT - PSLS_i(t), EUDG_i(t)) \quad (80)$$