AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 31

1. SUBJECT CLASSIFICATION	A. PRIMARY: Agriculture	AE10-0000-G704
	B. SECONDARY: Agricultural economics--Korea Rep.	

2. TITLE AND SUBTITLE
Report on the modifications of the KASS model for international trade analysis

3. AUTHOR(S)
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4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1973	16p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Mich.State

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(In KASS issue paper no.5)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAB-805

11. PRICE OF DOCUMENT

12. DESCRIPTORS
International trade
Korea Rep.
Models

13. PROJECT NUMBER

14. CONTRACT NUMBER
CSD-2975 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

26 November 1973

KASS Issue Paper 5

REPORT ON THE MODIFICATIONS OF THE KASS MODEL FOR INTERNATIONAL TRADE ANALYSIS

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The world economy interacts with an open free-market economy by setting bounds on the price levels which are obtained by the process of equating supply (both domestic and foreign) with demand (both domestic and foreign) to determine the price levels (as well as domestic consumption and amounts traded). In the analysis of trade policy questions, the effects of exchange rates, tariffs, import quotas, and minimum export targets on the domestic economy are desirable to know.

This report will separate the discussion into a section on the domestic demand and pricing mechanism and one section on the world market interactions.

Demand and Pricing Mechanism

In elementary economics we learn that price is determined when supply equals demand. In more advanced economics we study the effects of different policy instruments on supply and demand, and then use this as the basis upon which to assess their effect on the economic performance of the system. The system still requires a means to internally equate supply with demand to determine price.

This discussion of the demand component has sections describing the price determining mechanism and the revisions to the structure of the demand equation system which were necessary for it to conform with the predictions of economic theory.

Price Determining Mechanism: The KASS computer simulation model has the options of either analyzing the effects of pricing policies in which some or all commodity prices are determined outside the normal market system by decree, or allowing the prices to be set by the normal operation of the market.1/

The basic hypothesis embodied in the demand equations in the KASS model is one of constant price elasticities of demand (similar to a Cobb-Douglas functional form) with the income elasticities changing from time to time in response to the degree to which consumption targets are achieved. In addition to this specification, a national budget constraint states that urban Koreans cannot in aggregate spend more than total urban income for consumption of all commodities.

This type of specification (constant elasticities of demand) complicates the analysis more than one of purely

1/ For those commodities which have direct price elasticities of demand set equal to zero, policy-determined prices must also be specified.

linear demand equations. When all demand equations are linear, the prices and the budget constraining parameter can be derived given predetermined supply quantities, and must be simultaneously -- rather than sequentially -- determined. With the specification embodied in the KASS system of demand equations we must become involved in an iterative solution process. In order to linearize the nonlinear demand equations, the elasticities are converted to partial derivatives by multiplying each elasticity by the ratio of the previous year or iteration's per capita consumption to the previously calculated price (or per capita income as the case applies). The intercept of the relation is determined so that the linearized relation passes through the previous year or iteration's observation and possesses the assumed constant elasticities at that point. These linearized demand relations together with the budget constraint

$$Q = A_o + AE \cdot P + yb \cdot s \qquad \text{(n equations)}$$
$$Y = Q' \cdot P \qquad \text{(1 equation)}$$

or

$$\begin{pmatrix} Q - A_o \\ y \end{pmatrix} = \begin{pmatrix} AE & yb \\ Q' & o \end{pmatrix} \begin{pmatrix} P \\ s \end{pmatrix}$$

are simultaneously solved with a matrix inversion routine to determine the n prices (P) and the budget parameter (s). Q is the vector of per capita supplies and y is the per capita income. A_o is the vector of intercepts, b is the vector of income partial derivatives, and AE is the (nonsingular) matrix of the cross price derivatives.2/

Because the equilibrium prices calculated in the previous iteration are not quite the same as the equilibrium prices of the current iteration, the matrix of cross-price derivatives (and income derivatives) will change somewhat between this iteration and the next and cause the next iteration's prices to slightly differ from the current prices. This iteration process will end when all the prices differ from the previous prices by no more than 500 won per metric ton (one-half won per kilogram). The usual presumption is that convergence should be achieved in twenty iterations or less.

This price determining mechanism differs from the one described in Appendix D of the KASS User's Manual in two respects. First, the prices are determined at each iteration by a matrix inversion process, rather than by a mechanism that might be specified as an equilibrium-seeking adjustment in a disequilibrium model. The second difference is that the model is now calculating the budget parameter (S) simultaneously with prices, but contingent upon the price coefficients

2/ If a commodity has a policy determined price, its demand curve is eliminated from the system and $Q - A_0$ is reduced by the product of its price and the corresponding column of the former AE matrix and y is reduced by the product of this price and the per capita consumption of the commodity.

which were derived from the previous prices, rather than calculating S contingent upon previous prices but prior to calculating the current period prices, and then calculating the current prices based upon both the calculated S and price coefficients. In this way, there is complete assurance that the budget constraint will now always be satisfied.

Demand System Revisions: The empirical content of the demand equations was altered in order to allow for several of the expectations derived from consumer demand theory to be incorporated into the KASS model. The first of these is an imposition of negative definiteness upon the matrix of cross elasticities. The second incorporates the homogeneity postulate into the structure.

The basis for assuming that the cross price response matrix will be negative definite is that an income-compensated system of pure substitution demand curves will exhibit the negative definite property as a result of the second order conditions for utility maximization.[3/] Moreover, at a heuristic level of discussion, negative definiteness is "sort of" a multi-dimensional generalization of the negati

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3/ See Samuelson, P.A., Foundations of Economic Analysis; Cambridge: Harvard University Press, 1948, p. 186; or Theil, Henri, Principles of Econometrics; New York: John Wiley and Sons, 1971, Appendix A.

slope expected of a single demand curve.

The price response matrix became negative definite when the elasticity of barley consumption with respect to rice price is less than 1.08 if all other elasticities remained the same. The actual parameter value selected was 1.0 for the empirical analysis. This compares with the previous value which was 1.3.

The second change incorporates the so-called "homogeneity postulate" from demand theory into the equations. This postulate states that the demand curves of any utility maximizing individual are homogeneous of degree zero in all prices and income. This means that for each commodity, the sum of all the price elasticities (direct and cross) and the income elasticity must equal zero.[4]

To effect this change, the cross elasticity of each agricultural commodity with respect to the nonagricultural price index was defined to be the negative of the sum of all other elasticities. Previously, it had been zero in all cases. In the demand for the nonagricultural commodity, all the cross elasticities with respect to the agricultural prices were set equal to each other and equal to that proportion of the sum of the income and own price elasticities of the nonagricultural

4/ Sameulson, op.cit., p. 105.

commodity which is necessary to satisfy the postulate. Since this change has only recently been accomplished and has temporally followed the change to achieve negative definitiness in the subsystems of demand equations, it is not now known whether the whole system will retain the negative definite property after this change, although the agricultural subsystem is itself negative definite.

We will now address the changes in the model which accommodate the interaction of the world economy with the Korean market.

World Market Interactions

In a freely functioning market economy which is open to trade with the rest of the world there are two limiting domestic prices: the delivered price of imports (including freight, insurance, and tariffs) and the free-on-board (F.O.B.) price which is received for exports (which may be the "world price" or perhaps lower, reflecting the country's transportation advantage relative to its potential customers). Thus, the domestic supply curve is kinked at the import price and the domestic demand curve is kinked at the export price, as in Figure 1.

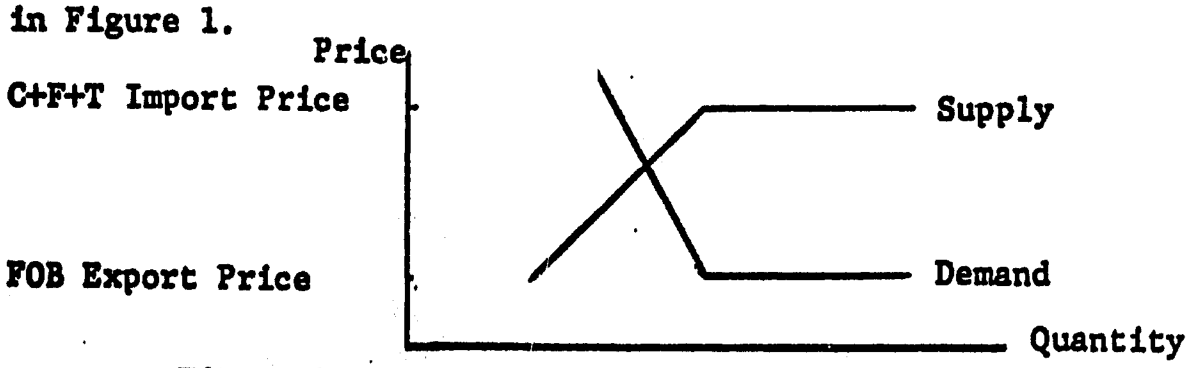

Figure 1: A Framework for Commodity Trade

As long as there are no quantitative restrictions (quotas), the behavior of the commodity's price will be predictable from Figure 1. The behavior of prices in the presence of import or export quotas is as follows.

Price is determined by domestic supply and domestic demand alone whenever it falls between the cost plus freight plus tariff (C+F+T) import price and the free-on-board (FOB) export price.

When the domestic free market price exceeds the C+F+T import price, imports, can profitably take place. If there are no quantitative restrictions (quotas), the domestic price will never exceed the C+F+T price. If the import quota exceeds the excess demand in the absence of any imports at C+F+T, either less than the quota will be imported or the importers will suffer losses on the entire imported quota. If the quota is less than the excess demand at C+F+T, and only the quota is imported, the domestic price will be pressured to rise above C+F+T, which would allow the importers to reap unearned profits.

When the domestic free market price in the absence of trade is less than the FOB price, exports can profitably take place. If there are no export quotas to be met the price will never be less than the FOB price. If the export quota exceeds the excess supply (before exports) at FOB, either less than the quota will be exported at the FOB price or the exporters will suffer losses on the entire exported quota, since the domestic price at which they buy is greater than the FOB price at which they sell. If the quota is less than the excess supply and only the quota is allowed to be exported the domestic price will be pressured to drop below FOB and the exporters will reap unearned profits on the exported quota.

In the Korean setting, the most reasonable set of assumptions regarding the operation of quantitative restrictions is that the import quotas represent absolute upper bounds on imports and export quotas represent absolute lower bounds. In this way, all the allowable deviations from the quantitative restrictions improve the trade balance.

The rather interesting distributional aspect of these assumptions, namely that importers will be expected to at least break even, and possibly obtain unearned profits, while exporters at best break even, and possibly incur forced losses due to the quotas, will not be discussed further in this report.

The way in which these assumptions are operationalized in the KASS model will now be discussed. In Figure 2, S_d is the domestic supply, which in the KASS model is predetermined and hence inelastic within any year, S_t is the total supply, which differs from the domestic supply by the amount of the import quota as long as the domestic price exceeds C+F+T. D_d is the domestic demand, but does not enter into consideration as all export quotas are expected to be at least satisfied whatever the domestic price. D_t is the total demand (domestic plus export quotas) and is kinked at FOB, reflecting the assumption that exports in excess of the quotas will occur at the FOB export price.

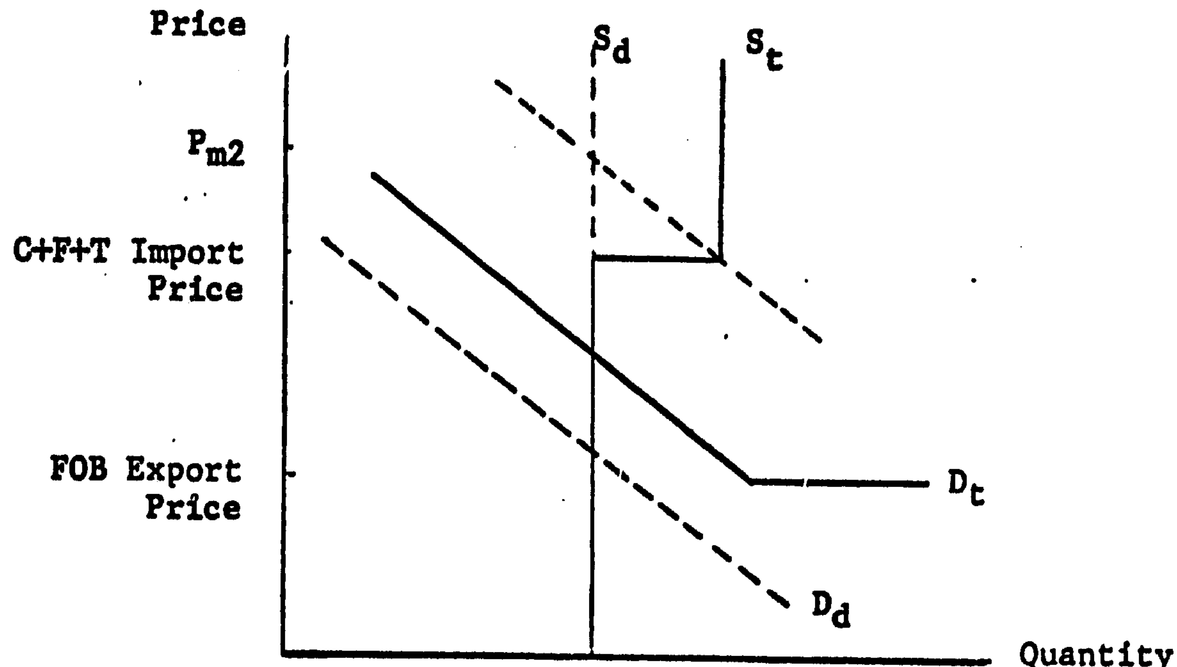

Figure 2: Framework for Trade in the KASS Model

If, when domestic supply is equated with the sum of domestic demand and the export quota, the resulting price is less than the FOB export price, the domestic equilibrium price is set equal to the FOB price, by increasing exports at the expense of domestic consumption. This action necessarily will affect the price of other commodities and the budget parameter in the general equilibrium adjustment.

When the equation of domestic supply with total demand results in a price between FOB and C+F+T, this equilibrium price is not altered.

When the price resulting from the equation of domestic supply with total demand results in a price between C+F+T and P_{m2}, the domestic price is set equal to C+F+T, and imports less than or equal to the import quota occur. These imports will also affect the prices of all other commodities, since the total supply of commodities is increased. The difference between P_{m2} and C+F+T in a one-commodity model is given by

$$\frac{\text{Import Quota}}{\frac{dQs}{dP} - \frac{dQd}{dP}}, \quad \text{where } \frac{dQ_s}{dP} \text{ is the (partial)}$$

derivative of supply with respect to price (which is zero in the KASS model) and $\frac{dQd}{dP}$ is the derivative of demand with respect to price.

For all higher prices, the domestic price is obtained by setting the total demand equal to the domestic supply plus the import quota. Since each demand equation is part of a larger system, all endogenous prices will be adjusted if the domestic price exceeds the P_{m2} limit. 5/ This general

5/ The adjustment is equal to the import quota multiplied by the respective column of the inverse of the matrix mentioned in the previous section. The budget parameter (S) is also affected by this adjustment.

equilibrium adjustment could either enhance or partially frustrate, depending on the cross-elasticities of demand, the achievement of the desired results which have only been illustrated using a one commodity partial-equilibrium type of analysis.

The computing sequence in the KASS model has been revised somewhat in order to facilitate this analysis as well as to make the assumptions relating to the open economy analysis of Korean agriculture more explicit.

The calculation of import and export prices has been removed from the national criterion (CRTNAT) subroutine to a point in the computing sequence prior to the price determination mechanism. 6/ Moreover, the world prices are now being stored as dollar values in the PWLDDS array for the years 1970, 1975, 1980, and 1985. The dollar price in any year (PWLDD) is the linear interpolation of the stored prices. 7/ Transportation costs (TRCST) are now being stated in dollar per metric ton terms. Tariff rates are specified

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6/ This is currently located in the DEMAND subroutine, but will likely become a subroutine in its own right.

7/ Previously, the KASS model used the Alternative III won prices as the won equivalent of the C+F+T world prices for all commodities delivered to Korea.

as ad valorem percentages. The exchange rate (WOND) is now explicitly entering the analysis. Thus, the import and export prices are calculated as:

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PWLDIM(J) = (PWLDD(J) + TRCST(J)) * (1.+TARIFF(J)) * WOND
PWLDEX(J) = (PWLDD(J)) * WOND
```

for the J-th commodity.

The current data values which enter into the international trade analysis are presented in Table 1. These include the stored dollar prices, the transportation costs, and tariff rates. The exchange rate is now being set at 400 won per U.S. dollar. For comparison, the world prices implicit in the KASS Alternative III analysis are also presented. These current values still have to be viewed as rather tentative conjectures rather than finalized values.

Effects of These Changes

When all of the changes as outlined herein are accomplished, the KASS model will be able to calculate a series of "self-sufficiency" prices for Korean agriculture as well as to analyze the effects of changes in the tariff rate or quotas for either imports or exports of any particular agricultural commodity.

Work is currently in progress which will link the recursive linear programming resource allocation component

Table 1: Data for International Trade Analysis

Commodity	---- World Price Assumptions PWLDDS($/MT) 1970	1975	1980	---- 1985	Transportation Cost	Tariff Rate
Rice	250.	250.	200.	200.	25.00	.16
Barley	80.	100.	80.	80.	25.00	.20
Wheat	75.	200.	130.	130.	25.00	.20
Other Grains	100.	150.	100.	100.	25.00	.00
Fruits	250.	250.	250.	250.	25.00	.00
Pulses	235.	350.	275.	275.	25.00	.00
Vegetables	225.	225.	225.	225.	25.00	.00
Potatoes	250.	250.	250.	250.	25.00	.00
Tobacco	770.	770.	770.	770.	25.00	.00
Forage	77.	77.	77.	77.	25.00	.00
Silk	1200.	1200.	1200.	1200.	25.00	.00
Industrial Crops	400.	400.	400.	400.	25.00	.00
Beef	1750.	1500.	1600.	1700.	25.00	.00
Milk	175.	275.	275.	275.	25.00	.00
Pork	900.	850.	850.	850.	25.00	.00
Chicken	1250	1050.	1000.	1000.	25.00	.00
Eggs	675.	625.	500.	450.	25.00	.00
Fish	700.	700.	650.	600.	25.00	.00
Ag. Residual						
KASS Alternative III Price Data at 400 W/$ Exchange Rate						
Rice	207.5	180.0	197.5	197.5		
Barley	115.0	112.5	112.5	112.5		
Wheat	70.0	75.0	75.0	75.0		
Other Grains	92.5	72.5	72.5	80.0		
Fruits	220.0	205.0	212.5	242.5		
Pulses	237.5	237.5	237.5	237.5		
Vegetables	200.0	172.5	192.5	225.0		
Potatoes	257.5	257.5	257.5	257.5		
Tobacco	770.0	770.0	770.0	770.0		
Forage (Feed Grains)	77.0	77.0	77.0	77.0		
Silk	1152.5	1152.5	1152.5	1152.5		
Industrial Crops	397.5	397.5	397.5	397.5		
Beef	1732.5	1357.5	1357.5	1357.5		
Milk	275.0	275.0	275.0	275.0		
Pork	845.0	845.0	845.0	845.0		
Chicken	1237.5	1040.0	1012.5	1002.5		
Eggs	667.5	632.5	480.0	435.0		
Fish	487.5	487.5	487.5	487.5		
Ag. Residual						

to the main KASS model. By so doing, the response (albeit with a one-year lag) of the supply of Korean agricultural products to a world prices will be able to be analyzed. This will enable us to determine the allocation of Korean (and World) agricultural resources to the production of commodities for Korean consumption.