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Adjustment on Agriculture:
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by

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Multi-Market Effects
of Exchange Rate Adjustment on Agriculture:
The Case of the Philippines

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Abstract

This paper presents an analysis of the impact of a devaluation on Philippine agricultural markets using a multi-market model. The modeling technique is described and distinguished from partial and general equilibrium methods of analysis. The simulation results show that agricultural markets respond to a devaluation depending on their trade orientation and their linkages with each other. It is also shown that rural real incomes improve with a devaluation because of the income generation effects of price changes and rising export earnings. A more favorable result is obtained when devaluation is accompanied by a fertilizer subsidy.

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I. Introduction

The main source of livelihood of a significant portion of the population in a majority of less developed economies are derived from agricultural activities. And because of this, crucial and interesting policy issues arise. A basic problem faced by policymakers of these countries is to provide incentives to the sector in the short-run by implementing a properly designed agricultural policy package on the one hand and to facilitate the development process by allowing for a reasonable economic environment through adequate economy-wide policies on the other hand. For this reason, coordination and consistency between sector-specific and economy-wide policies for structural adjustment are important.

In most cases however, agricultural policy in these developing countries is seldom a part of structural adjustment policies. Moreover, design of adjustment policies often fails to take into consideration, specific policy goals for agriculture because of the very general nature of the tools available. Yet the impact of adjustment policies is crucial for the proper growth and development of the agriculture sector (Timmer, 1986).

At the core of structural adjustment packages are the macroeconomic stabilization policies and the exchange rate policy. This paper focuses on the role of the single most important macro variable affecting agricultural markets and the incomes of the population - the exchange rate.¹

The Philippine Situation

In the past decade, Philippine industrialization efforts did not bear fruit despite the series of structural adjustment programs implemented under the sponsorship of the Bretton Woods agencies. The inability of the adjustment policies to promote a viable industrial structure is mainly due to the fact that the adjustment mechanisms put in place in the 70s triggered investments with low rates of return leading to a deterioration of the infrastructure and the country's overall capital stock. This compounded the foreign debt problem which caught attention only in the early 80s as the fourth BOP crisis commenced (See De Dios, 1984). It was unfortunate that policymakers directed their attention more to the BOP problem and devoted an insignificant amount of attention to the restructuring of a weakened economy.

¹It should be noted that the dynamics of the agricultural sector can have macroeconomic consequences (Timmer, 1986) but this is not tackled in this paper.

In the absence of significant changes in the economic structure, the Philippines remains an agricultural economy. Table 1 shows that while the agriculture sector accounts for only 28 percent of real GDP, it still provides for close to half of total employment in the last half of the 80s. Furthermore, the unemployment rate has consistently increased through the years while real GDP growth is not as high as in the 70s.

Table 1

	1970	1975	80-84 Ave	85-89 Ave
Gross Domestic Product				
Agriculture	32.3%	26.8%	25.7%	28.3%
Industry	24.8%	34.1%	35.8%	32.3%
Services	42.3%	39.1%	38.5%	39.4%
Total	100%	100%	100%	100%
GDP Growth	4.8%	6.4%	1.5%	2.7%
Employment				
Agriculture	54.6%	53.7%	51.0%	47.6%
Industry	16.8%	15.2%	14.7%	14.7%
Services	28.6%	31.1%	34.3%	37.7%
Total	100%	100%	100%	100%
Unemployment Rate	-	4.2%	8.3%	9.6%

Source: ADB Key Indicators, 1989, 1990.
Philippine Statistical Yearbook, 1988, 1990

From the Table, one can only observe that the desired effects of adjustment over the period are not noticeable.

It is perhaps fair to say that the "trickle down" effect expected of adjustment was absent.

The problem that needs to be examined in this regard is not about the appropriate adjustment tools to use but rather on the way these tools are utilized to solve the foreign debt problem leaving existing institutional arrangements to adjust to the outcomes of the foreign debt strategy. A critical component of the strategy is an exchange rate policy that keeps the currency overvalued.²

Research Strategy

Except for some references on the issue³, not much is known about the microeconomic impact of adjustment policies implemented by the Philippine government particularly its implications on agricultural markets and on the incomes of different groups in society due to the lack of formal research on the topic.

A systematic analysis of the microeconomic impact of adjustment can proceed using an applied general equilibrium (AGE) model which incorporates a monetary sector with the

²Overvaluation of the currency from the viewpoint of the policy maker is desirable to the extent that foreign debt payments in domestic currency terms are smaller than at free market rates.

³See for example, Montes (1988) and a few references cited in this paper.

exchange rate playing a central role. An alternative treatment of the research problem is to identify the important segment of the economy and employ a simpler method - the multi-market modeling procedure.

This paper presents the initial output of a research that adopts the alternative strategy. It also introduces the multi-market method that has been used by other researchers evaluating sector-specific policies and shows the preliminary results of an empirical investigation on the consequences of a devaluation on the Philippine agriculture sector using a multi-market model.

The second section discusses the multi-market technique. The third section briefly gives an account of the structure of the Philippine agricultural economy through a multi-market model. The model developed in this section is flexible enough to be used for other purposes. In this paper however, the model is used to examine the implications of changes in the nominal exchange rate on the agriculture sector in conjunction with selected sector-specific policies. The fourth section presents the results of counterfactual experiments using the model developed. The fifth section concludes.

II. The Multi-Market Modeling Method

Multi-market analysis is a method by which the effects of sector-specific policies on production and consumption decisions, income distribution, foreign exchange earnings and the government's role can be evaluated. Multi-market analysis unlike partial equilibrium analysis, takes into consideration the interaction between closely related markets within a sector while assuming away other sectors in the economy.

While it is one step ahead of partial equilibrium analysis, it is a few steps behind AGE analysis since it focuses itself within the boundaries of the sector being analyzed.

The multi-market technique offers distinct advantages over the extremes of partial and general methods of quantitative analysis. This method was developed partly in response to the need to make systematic the analysis of an important sector given the data constraints faced by the analyst. While its data requirements are small compared to that of an AGE model, it can account for the spillover effects among interrelated markets by allowing for substitution in production and consumption - a luxury not available when one conducts an analysis based on a partial equilibrium framework.

A multi-market model is useful in organizing a set of accounts that permits a clear view of policy issues. It also allows the user to observe the trade-offs or complementarity between policies implemented simultaneously.

A multi-market model is a convenient medium by which policy dialogues can be conducted between the operational economist and the policymaker. Because it avoids the complexity of AGE models, this model can readily be implemented in a personal computer which makes it accessible and which can provide quick responses to important policy issues confronting the policymaker.

The method has been applied most successfully by the World Bank to assist borrower countries in examining agricultural pricing policies. Applications of multi-market analysis for some countries were done by Braverman and Hammer in collaboration with economists of the countries involved (See the papers by Braverman et al in the references).

The modeling process begins by identifying the structure of the agriculture sector, and gathering information on institutional arrangements within the sector. Institutional details vary widely across countries so that

no model should be the same for any two countries.¹ The method proceeds with the specification of the market equilibrium conditions which incorporates the information gathered. Equations showing the income generation effects of price changes are also specified since incomes appear on the demand side. These are then totally differentiated and solved for equilibrium prices and incomes.²

Limitations of the Methodology

While the multi-market model offers a wide array of uses, it certainly has some limitations. This class of models is related more to AGE analysis rather than to econometric methods. As such, it can not be used to generate forecasts of variables of interest.

Related to this, the policy simulations that can be done are limited to small changes in policy. It therefore can only show the direction of change of the endogenous variables. This is because differentiating excess demand

¹The process of constructing a multi-market model is however the same. Appendix A gives an illustration of a general model without institutional details to highlight the basic data requirements of a multi-market model.

²The first applications of the model required the specification of production and utility functions and adopted calibration techniques of AGE modeling to fit the data with model specifications (see for example, Braverman et al, 1987a). Since then, the technique evolved such that it avoids this procedure by starting out with the market equilibrium conditions or excess demand equations (See Braverman et al, 1986, 1987b, 1987c).

equations imply that the model can only allow for infinitesimal changes in the variables in the system. Extensions to the case where drastic policy changes are permitted is discussed in Braverman et al, 1987b.

The parameter requirements of multi-market models are as difficult to obtain as in AGE models. Own and cross elasticity estimates are subject to measurement errors and are not easily derived. Because of this, close interaction between the user and the field experts may be necessary when putting the model into operation in case a sensitivity analysis is called for. In relation to this, a drawback of this method is that as in AGE models, the danger of abuse is present because the parameters or elasticities can be changed at will by the user.

III. The Philippine Agricultural Economy in a Multi-Market Framework

A distinct feature of Philippine agriculture is the existence of an important food sector side by side with a traditional agricultural export crop sector. The former includes rice, corn, livestock/poultry and fish while the latter consists of sugar and coconut. These commodities account for approximately 80 percent of total agricultural production value.

The multi-market model in this section shows the interrelationships and the trade orientation of the six commodities above plus a fully imported food commodity - wheat. There are two groups, the urban and the rural consumer and an aggregate supply for each commodity. Fertilizer, which is an important imported input to rice, corn and sugar, is included in the modeling exercise to capture the effects of currency realignment on these markets.

Shown below are the market clearing conditions for each commodity. For all commodities, supply (given on the left-hand side of each equation) is a function of the producer prices of rice and corn, the domestic prices of livestock, fish, the average prices of coconut, sugar and fertilizer and the non-agricultural price. All urban and rural consumer demands at the right-hand side of the equations are

a function of consumer and domestic (those without asterisks in the equations) prices of the commodities including that of wheat and nominal incomes. Variable names are listed in Appendix B.

The Food Crop Sub-Sector

Rice, the most important food crop, is the staple food of the majority of the population. Equation (1) below describes the market for rice. The producer price of rice which clears the market differs from the consumer price by a marketing margin which is assumed fixed. Problems with the sufficiency in rice supply has led the government to turn to the world market to meet domestic demands.

The import policy and the marketing activities of the National Food Authority (NFA) are the means by which the government implements its pricing policy. It has however been ineffective in this regard (See Wallace et al, 1989, for a detailed analysis). NFA operations include procurement and disbursement of rice at a support price for farmers and a release price for consumers. At present NFA participation has been limited to only 6 percent of the market due to a meager budget allocation. Because of this,

a detailed specification of NFA activities while possible, is not necessary for the purposes of this paper.⁴

$$q_r(p_r, p_c, p_l, p_u, p_s, p_f, p_z, p_o) = q_r^U(p_r^*, p_c^*, p_l^*, p_u^*, p_s^*, p_f, p_w, p_o, m^U) \\ + q_r^R(p_r^*, p_c^*, p_l^*, p_u^*, p_s^*, p_f, p_w, p_o, m^R) - I_r \quad (1)$$

where

$$p_r^* = p_r + t_r$$

$$p_z = \pi p_z^d + (1 - \pi) p_z^I \quad ; \quad \pi = q_z^d / q_z \quad ;$$

$$p_z^I = e p_z^b$$

The role of fertilizer in rice and corn production is significant to the extent that in 1987 the government initiated a program, the Rice Productivity Enhancement Program, which subsidized the fertilizer use of rice and corn farmers by half the cost. It should be noted however that a significant portion of fertilizer supply is imported. In the model, producers are faced with a weighted average of prices (p_z) of domestically produced and imported fertilizer as shown above.

Corn is also a staple food but only in some parts of the country. The importance of this crop lies in the fact that it is a major input as feeds to the livestock sector.

⁴One of the effects of market intervention is to decrease the trade margins. An indirect way of simulating NFA activities is to alter tr in the model.

The structure of the corn market shown in equation (2) below is quite different to that of the rice market because of this. Imports are also used to meet domestic demand.

$$\begin{aligned}
 q_C(p_r, p_c, p_L, p_u, p_s, p_f, p_z, p_o) = & q_C^U(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f^*, p_w, p_o, m^U) \\
 & + q_C^R(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f^*, p_w, p_o, m^R) \\
 & + q_C^L(p_r^*, p_c^*, p_L) - I_C
 \end{aligned} \quad (2)$$

where $p_c^* = p_c + t_c$

The third term on the right hand side is the demand for corn as feeds to the livestock sector. One of the arguments in the demand function is the price of rice since a small portion of rice output is also used as feeds. The difference between farmgate prices and consumer prices is accounted for by trade and transport margins. The current policy issue in the livestock industry is the insufficient corn supply due to the disincentives brought by a number of regulations pertaining to corn transportation and marketing (See Clarete, 1991).

Other than this problem of increasing cost of feeds and the ineffective interventions (also by the NFA) in the corn market, the Philippines can be considered self-sufficient in livestock and poultry products. Imports of these products are negligible and are omitted in the model. No distinction is made between producer and consumer prices. In the same

way, the fish market clears through a domestic price. The fishing industry has recently started exporting tuna and tuna products and ranks third in agricultural export earnings in 1988. Fish export supply is a function of the domestic currency equivalent of the world price. The equilibrium conditions for these markets are:

$$q_L(p_r, p_c, p_L, p_u, p_s, p_f, p_z, p_o) = q_L^U(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f^*, p_w, p_o, m^U) + q_L^R(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f^*, p_w, p_o, m^R) \quad (3)$$

$$q_f(p_r, p_c, p_L, p_u, p_s, p_f, p_z, p_o) = q_f^U(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f^*, p_w, p_o, m^U) + q_f^R(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f^*, p_w, p_o, m^R) + X_f(p_f^x) \quad (4)$$

where $p_f^x = ep_f^b$

Wheat is fully imported and is included as an important component of the whole food market. A simple description of the market is given below:

$$I_w(p_w^I) = q_w^U(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f^*, p_w, p_o, m^U) + q_w^R(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f^*, p_w, p_o, m^R) \quad (5)$$

where $p_w^I = ep_w^b$. The domestic price clears the market.

The Export Crop Sub-Sector

Prior to the assumption to power of the present government, parastatals controlled all activities of the

export crop sector.¹ Since then, these controversial agencies have been reorganized and their activities curtailed. Thus, two agricultural export crop markets are specified in a simple way. Both crops are produced for domestic consumption and for exports. Producers are assumed to be faced with a weighted average of consumer and export prices in domestic currency terms. The equilibrium conditions and price relations are shown in equations (6) and (7):

$$q_u(p_r, p_c, p_L, p_u, p_s, p_f, p_z, p_o) = q_u^U(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f, p_w, p_o, m^U) + q_u^R(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f, p_w, p_o, m^R) + X_u(p_u^x) \quad (6)$$

where $p_u = \beta_u p_u^* + (1 - \beta_u) p_u^x$; $\beta_u = (q_u^U + q_u^R) / q_u$

$$p_u^x = e p_u^b$$

$$q_s(p_r, p_c, p_L, p_u, p_s, p_f, p_z, p_o) = q_s^U(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f, p_w, p_o, m^U) + q_s^R(p_r^*, p_c^*, p_L^*, p_u^*, p_s^*, p_f, p_w, p_o, m^R) + X_s(p_s^x) \quad (7)$$

where $p_s = \beta_s p_s^* + (1 - \beta_s) p_s^x$; $\beta_s = (q_s^U + q_s^R) / q_s$

$$p_s^x = e p_s^b$$

Export supplies are assumed to be a function of the world price in domestic currency terms. Consumer prices

¹These are the United Coconut Oil Mills (UNICOM) and the National Sugar Trading Company (NASUTRA).

serve to equilibrate the markets. It should be noted that aside from rice and corn, a significant user of fertilizer inputs is the sugar industry.

Urban and Rural Incomes

Urban (m^U) and rural (m^R) nominal incomes are derived from the production of the six agricultural commodities and from non-agricultural activities. Non-agricultural incomes are assumed fixed. The income equations are:

$$m^U = \sum_i \theta_i p_i q_i - \theta_z p_z q_z + m^U_0 ; i = r, c, L, u, s, f \quad (8)$$

$$m^R = \sum_i (1-\theta_i) p_i q_i - (1-\theta_z) p_z q_z + m^R_0 ; i = r, c, L, u, s, f \quad (9)$$

where θ_i s are the shares of the urban population in the production value of commodity i and θ_z is the fraction of the total input value used in agricultural production by the urban population. The third term at the right-hand side of (8) and (9) are the non-agricultural incomes. A more elaborate income generation equation, if data were readily available, is a breakdown of agricultural incomes into wage, non-wage incomes and agricultural rents.

Following the procedure in the Appendix, the nine equations above are differentiated, transformed into percentage rates of change form, and solved using linear

algebra for prices and incomes. The endogenous variables are:

$$P_R, P_C, P_L, P_U^*, P_S^*, P_f, P_W, m^U, m^R$$

Cost of living indices are computed for both the rural and urban populations as follows:

$$C^k = \pi_1 \left(-\frac{P_i^n}{P_i^0} \right)^{a_i^k} \quad ; \quad k = U, R$$

where P_i^0 are the base prices, P_i^n are the new prices and a_i^k are the shares of income spent on good i by consumer k . Changes in real incomes are then computed as the difference between changes in nominal incomes and changes in the cost of living index.

IV. Effects of Exchange Rate Changes

The results presented are limited to counterfactual experiments concerning a nominal devaluation of the currency singly and in combination with sector-specific agricultural policies. The base data are first discussed followed by the simulation results.

Base Data

The base year for the model is 1988. The data for quantities produced, consumed, imported and exported and their corresponding prices were obtained from the Department of Agriculture and the NEDA Agriculture Staff.⁶ Table 2 shows the base quantity and price data. The study makes use of elasticity estimates for rural and urban demands obtained from a study by Bouis (1989). Supply elasticities are however a problem. The supply elasticities were estimated econometrically using time series data provided by the NEDA Agriculture Staff. Ordinary least squares were used in the estimation and only the estimates which coincide with known supply behavior were used.

⁶Where necessary, quantities were converted to equivalent units for consistency. For example, one ton cane of sugar is equal to 0.082 tons of sugar in 1988.

Table 2
Base Data, 1988

QUANTITIES (thousand metric tons)							
	produc- tion	consumption		ex- feeds	ex- ports	im- ports	change in stocks
		urban	rural				
rice	5867	2438	3120	548	-	182	-57
corn	4428	383	865	3142	-	25	63
livestock*	1671	1081	590	-	-	-	-
coconut**	1248	113	203	-	932	-	-
sugar	1368	758	468	-	143	-	-
fish	2270	1215	1007	-	47	-	-
wheat	-	41	17	-	-	58	-
PRICES (pesos/metric ton)							
	pro- ducer	con- sumer	world (\$/MT)	world	ave- rage		
rice	5140	6870	301	6348	-		
corn	2730	4620	108	2278	-		
livestock	-	31450	-	-	-		
coconut	-	15402	620	13084	13672		
sugar	-	8170	422	8900	8246		
fish	-	18550	2388	50367	-		
wheat	-	4759	226	4759	-		
fertilizer	-	4833	136	2875	3681		

Source: NEDA Agriculture Staff
Department of Agriculture

* excludes dairy and egg production
** converted to coconut oil equivalent

Because of these limitations, the study has to content itself with the assumption of no substitution in production between most sectors at the moment until estimates of these can be derived. Income and expenditure patterns were derived from the 1988 Family Income and Expenditure Survey (FIES). Appendix C shows the income parameters derived from the 1988 FIES and the elasticities which were used in the model.

Simulation Results

This section presents the multi-market effects of a 15 percent nominal devaluation using the model described above. The first column of Table 3 shows the base values. The second column presents the results of a devaluation alone. It can be seen that all prices increased with a devaluation. A small increase in rural real incomes is noted because of the income generation effects of price changes and rising export earnings. Urban incomes declined by 0.98 percent. This result should be interpreted with caution since a large proportion of urban income is derived from non-agricultural activities which is fixed in the model.

The decline in the production of rice, corn and sugar is due to the fertilizer cost which rose due to the devaluation. For sugar, the stimulus of a devaluation was not sufficient to compensate for the increased input cost. Livestock output also fell as the price of corn inputs

increased. Corn inputs to livestock declined by 1.21 percent. Only fish and coconut registered increases in output - an expected result because of their export orientation and negligible or no reliance at all on imported inputs. Overall total demand for these commodities also declined. Total export earnings increased by 3.00 percent.

An interesting exercise would be to suppose that the government tries to cushion the impact of a devaluation by keeping the domestic fertilizer price constant at the base level. Assume also that funds for the fertilizer subsidy are available. The results of this simulation is shown in the third column of the Table.

Compared to the results on column 2, significant improvements can be seen in the real incomes of the rural population though the income growth of the urban population remains negative. Price increases are smaller when a devaluation is accompanied by the subsidy. Furthermore, all outputs except that of livestock increased.

Table 3
Simulation Results

	base value	15% Deva- luation	with fertilizer subsidy
PRICES/KILO AND INCOMES			
rice retail price	6.37	4.05%	0.61%
corn retail price	4.62	6.79%	0.52%
livestock	31.45	2.71%	0.41%
coconut	15.40	6.08%	3.40%
sugar	8.17	4.54%	0.54%
fish	18.55	0.26%	0.24%
wheat	4.76	4.80%	3.25%
urban income (real)	466	-0.98%	-0.15%
rural income (real)	359	0.01%	0.39%
PRODUCTION (thousand metric tons)			
rice	5867	-0.33%	0.27%
corn	4428	-1.06%	0.22%
livestock	1671	-1.90%	-0.10%
coco	1248	1.25%	1.17%
sugar	1368	-1.96%	0.37%
fish	2270	0.06%	0.06%
TOTAL DOMESTIC DEMAND (thousand metric tons)			
rice	5558	-0.35%	0.28%
corn	1248	-3.52%	0.55%
livestock	1671	-1.90%	-0.10%
coco	317	-3.92%	-4.22%
sugar	1225	-2.54%	0.06%
fish	2223	-0.00%	-0.01%
wheat	58	-3.00%	-3.00%
corn inputs to livestock	3142	-1.21%	0.01%
EXPORTS (Mil \$)	751	3.00%	3.00%
IMPORTS (mil P)			
rice	1155	15.00%	15.00%
corn	57	15.00%	15.00%
wheat	276	11.55%	11.55%

This result is mainly due to a decrease in livestock demand. It may be noted that this decrease in demand is due to a price elastic demand and negligible linkages in consumption with other commodities. On the supply side, the cushioning effect of the subsidy on the corn sector is not sufficient to lift the livestock sector to a higher output level. This result shows that the corn sector role as feed provider cannot be ignored.

V. Concluding Remarks

This paper has shown the effects of a devaluation on agricultural markets using a multi-market model. The counterfactual experiments show that agricultural markets respond to a devaluation depending on their trade orientation and their linkages with each other.

It is also shown that a devaluation improves rural real incomes. A more favorable result is obtained when devaluation is accompanied by a fertilizer subsidy which maintains fertilizer price at the base level.

Attempts to improve the model should include estimation of cross supply elasticities. The model above is fully operational and is installed in a personal computer. An update of the base data would however be necessary for actual field applications.

The model can be extended by attaching a small macroeconomic model which, for example, makes the exchange rate and non-agricultural prices and incomes adjust to other macro variables as money supply, the budget deficit or the interest rate. By this, the microeconomic impact of macroeconomic stabilization policies can be explored more fully.

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Appendix A

This Appendix presents the algebra of a multi-market model at a fairly general level. The purpose is to show the input requirement and calculating procedure. For simplicity it is written without the institutional details.

The core equations of a multi-market model are shown in equation (1). The left hand side is total supply of the i th agricultural product from s regions. The right hand side is the sum of the demands of L consumers plus the net foreign demand for the i th commodity:

$$1) \quad \sum_{r=1}^s q_i^r = \sum_{k=1}^L q_i^k + x_i ; i = 1, \dots, n$$

Differentiating (1) and rearranging these transforms the equilibrium conditions in terms of percentage rates of change¹:

$$2) \quad \sum_{r=1}^s \phi_i^r \hat{q}_i^r = \sum_{k=1}^L \phi_i^k \hat{q}_i^k + \phi_i^x \hat{x}_i ; i = 1, \dots, n$$

$$\text{where } \phi_i^r = q_i^r / \sum_{r=1}^s q_i^r,$$

$$\phi_i^k = q_i^k / \sum_{r=1}^s q_i^r,$$

$$\phi_i^x = x_i / \sum_{r=1}^s q_i^r$$

$$\text{and } \sum_{r=1}^s \phi_i^r = \sum_{k=1}^L \phi_i^k + \phi_i^x = 1$$

Equation (3) is the supply of the i th commodity from the r th region while (4) shows the demands for the i th commodity by the k th consumer:

¹Variables with $\hat{}$ indicate percentage rates of change, e.g., $v = dv/v$.

$$3) \quad q_i^r = q_i^r(p_1, \dots, p_n)$$

$$4) \quad q_i^k = q_i^k(p_1, \dots, p_n, m^k)$$

where $p_1, \dots, p_n$ are the prices of the commodities and m^k is the income of the k th consumer. The supply function is assumed to arise from profit maximization so that (3) may be thought of as the derivative of the profit function with respect to output price. Demand for the i th commodity may be thought of as arising from utility maximization.

The incomes of the k th consumer are derived from agricultural production and non agricultural activities:

$$5) \quad m^k = \sum_{j=1}^n \theta_{ij}^k p_j \sum_{r=1}^S q_j^r + m_0^k \quad ; k = 1, \dots, L$$

where the θ parameters are the shares of consumer k on the production value of commodity i . It should be noted that the specification of the income equations can be further broken down into profit and wage incomes. In this case a mapping from size to functional distribution is necessary.

Differentiating (3) and (4), and substituting in (2) yields the equations used in the computation procedure:

$$6) \quad (\sum_{r=1}^S \sum_{j=1}^n \theta_{ij}^r \Gamma_{ij}^r - \sum_{k=1}^L \sum_{j=1}^n \theta_{ij}^k \epsilon_{ij}^k) \hat{p}_j - \sum_{k=1}^L \theta_{i1}^k \mu_{i1}^k \hat{m}^k = \hat{\phi}_i^x x_i$$

where

$$\Gamma_{ij}^r = \frac{\partial q_i^r}{\partial p_j} - \left(-\frac{p_j}{q_i^r} \right);$$

$$\epsilon_{ij}^k = \frac{\partial q_i^k}{\partial p_j} - \left(-\frac{p_j}{q_i^k} \right); \quad \mu_{i1}^k = \frac{\partial q_i^k}{\partial m^k} - \left(-\frac{m^k}{q_i^k} \right)$$

are supply, demand and income elasticities respectively.

Differentiating (5), setting $dq_i = 0$ and rearranging transforms the income equations into percentage rates of change,

$$7) \quad \hat{m}^k = -\frac{1}{m^k} \left(\sum_{j=1}^n \sum_{r=1}^R \theta_{jr}^k p_j q_j^r \right) \hat{p}_j = -\frac{m_o^k}{m^k} \hat{m}_o^k$$

and shows the income generation effects of changes in agricultural prices.

Equations (6) and (7) form a system of $n + L$ linear equations with the same number of unknowns, p_i and m^k . The exogenous variables for this generic model are the non-agricultural incomes, m_o^k and net foreign demands, x_i . This system of equations is of the form,

$$Np = Bx$$

where p is a vector of endogenous variables, x is a vector of exogenous variables and N and B are coefficient matrices.

Inverting N , the solution is :

$$\hat{p} = N^{-1} B \hat{x}$$

From (6) and (7), one could see that the model requires base data for prices, quantities, incomes, own and cross elasticities of supply and demand, income elasticities and distribution parameters.

Appendix B

Variable names

Prices

p_r - wholesale price of rice	p_r^* - retail price of rice
p_c - producer price of corn	p_c^* - retail price of corn
p_L - price of livestock	p_w - domestic price of wheat
p_u - ave price of coconut	p_u^* - consumer price of coconut
p_s - ave price of sugar	p_s^* - consumer price of sugar
p_f - price of fish	p_o - non-agricultural price
p_z - ave fertilizer price	e - exchange rate (P/\$)
p_z^d - price of domestically produced fertilizer	
p_z^I - price of imported fertilizer	
p_w^I - import price of wheat in domestic currency	
p_u^x - export price of coconut in domestic currency	
p_s^x - export price of sugar in domestic currency	
p_f^x - export price of fish in domestic currency	
p_w^b - import price of wheat in foreign currency	
p_u^b - export price of coconut in foreign currency	
p_s^b - export price of sugar in foreign currency	
p_f^b - export price of fish in foreign currency	

Quantities

q_r - rice supply	q_c - corn supply
q_r^U - urban rice demand	q_c^U - urban corn demand
q_r^R - rural rice demand	q_c^R - rural corn demand
q_c^L - corn demand by the livestock sector	
q_L - livestock supply	q_f - fish supply
q_L^U - urban livestock demand	q_f^U - urban fish demand
q_L^R - rural livestock demand	q_f^R - rural fish demand
q_s - sugar supply	q_u - coconut supply
q_s^U - urban sugar demand	q_w^U - urban wheat demand
q_s^R - rural sugar demand	q_w^R - rural wheat demand
q_u^U - urban coconut demand	q_u^R - rural coconut demand
X_u - coconut exports	X_f - fish exports
X_s - sugar exports	I_w - wheat imports
I_r - rice imports	I_c - corn imports
m^U - urban income	m^R - rural income
t_r - trade and transport margins in rice	
t_c - trade and transport margins in corn	

Appendix C

Table C.1
ELASTICITIES

SUPPLY								
	rice	corn	lives	coco	sugar	fish	fert	
rice	0.33	0.00	0.00	0.00	0.00	0.00	-0.31	
corn	0.00	0.25	0.00	0.00	0.00	0.00	-0.58	
livestock	0.00	-0.22	0.23	0.00	0.00	0.00	0.00	
coco	0.00	0.00	0.00	0.10	0.00	0.00	0.00	
sugar	0.00	0.00	0.00	0.00	0.17	0.00	-0.43	
fish	0.00	0.00	0.00	0.00	0.00	0.23	0.00	
DEMAND								
URBAN	rice	corn	lives	coco	sugar	fish	wheat	income
rice	-0.52	0.06	0.06	0.11	0.05	0.02	0.07	0.01
corn	1.05	-1.31	0.06	0.16	0.06	0.03	0.09	-0.31
livestock	0.09	0.00	-1.07	0.01	0.01	0.01	0.01	0.61
coco	0.48	0.02	0.01	-1.28	0.04	0.01	0.04	0.52
sugar	0.24	0.01	0.05	0.06	-1.04	0.01	0.03	0.42
fish	-0.06	-0.00	0.00	-0.01	-0.00	-1.06	-0.00	0.82
wheat	0.29	0.02	0.03	0.05	0.02	0.00	-1.07	0.48
RURAL	rice	corn	lives	coco	sugar	fish	wheat	income
rice	-0.57	0.13	0.02	0.08	0.04	0.01	0.03	0.12
corn	1.45	-1.53	0.03	0.14	0.07	0.03	0.04	-0.44
livestock	0.04	0.00	-1.08	0.00	0.01	0.00	0.01	0.81
coco	1.11	0.20	0.01	-1.58	0.06	0.01	0.03	0.07
sugar	0.42	0.06	0.02	0.05	-1.17	0.01	0.02	0.45
fish	-0.14	-0.02	0.00	-0.01	-0.01	-1.07	-0.00	1.03
wheat	0.38	0.04	0.01	0.04	0.02	0.00	-1.10	0.48
				coco	sugar	fish	wheat	
Trade elasticities				0.2	0.2	0.2	-0.2	

Source: Demand - Bouis, H. (1991)
 Supply - Econometric estimates

Table C.2
INCOMES (in percent)

Shares in agricultural income			
	crop farming	live- stock	fish
urban	0.106	0.225	0.194
rural	0.894	0.775	0.806
total	1.000	1.000	1.000
Incomes by source			
	agri cultural	non-agri cultural	total
urban	0.0508	0.9492	1.0000
rural	0.4020	0.5980	1.0000

Source of basic data: 1988 Family Income and Expenditure Survey, National Statistics Office