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GOVERNMENT MARKET INTERVENTION: AN ECONOMETRIC STUDY OF TANZANIAN FOOD GRAIN MARKETS

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ABSTRACT

Government intervention in food grain markets is a common feature of LDC development efforts. Intervention requires the manipulation of policy instruments, the motivation and affects of which are often complex and difficult to understand. An econometric model is used to investigate this problem for the case of maize, wheat and rice markets in Tanzania. The model contains six econometric equations for each crop, four of which are government behavioral equations. The model succeeds in explaining goverment intervention and in isolating four major constraints that impinge on its behavior in the short run. The analysis suggests that the government, through instruments at its disposal, has followed a food self-sufficiency strategy that has insulated the domestic market from the international market. A simulation analysis shows that the producer pricing component of this strategy has had a substantial impact on food grain production and external trade.

I. INTRODUCTION

Strategies to develop a domestic industrial capacity and to develop or maintain some degree of food grain self-sufficiency are common features of many LDC development plans. Policy instruments used to implement these plans include currency exchange rates, quotas, tariffs, subsidies and government investment in and control of production and marketing systems. Yet, it is only recently that economists have begun to incorporate this deep government involvement into commodity trade models of developing countries. An important contribution of Timmer and Falcon (1975a, 1975b) in their work on Asian rice economies was to demonstrate the importance of government-controlled domestic prices in explaining international trade in rice. Abbott's (1979) contribution is one of the more interesting of the recent attempts to incorporate government behavior in commodity trade models of developing countries, unfortunately, with dismal econometric results.

Tanzanian development efforts are exemplary of this deep involvement of governments in the agricultural sector, and particularly in the food grain sector. The general objective of this paper is to gain insights into this involvement by the government of Tanzania, as one case study,

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and to measure econometrically the impact of this involvement on external trade in food grains. The usefulness of the paper lies in obtaining these insights and in demonstrating the use of a method to formulate and to estimate a trade model that comprises--in addition to the usual demand and supply equations and the social accounting identity--government price-setting and stock-adjustment equations.

The paper is organized into six major sections. Background and trends in agricultural production and trade are presented in Section II. The extent of government intervention in food grain production and trade is described in Section III. This provides a foundation for Section IV where the behavioral equations for defining government intervention in food grain markets are specified. These equations, along with the retail demand and farm level supply equations, yield six equations in six endogenous variables for each of the food grain crops, maize, wheat and rice. It is shown in Section V that the model provides a good fit to the data. In the concluding sections, simulations are performed to obtain insights into the effect on and motivation for government intervention in food grain markets.

II. SETTING

Approximately 90 percent of Tanzania's total population of about 17 million reside in rural areas, comprising in the neighborhood of 2.3 million families and about 8000 villages. Hence, it is not surprising that agriculture dominates the Tanzanian economy, accounting for an average of 40 percent of GDP and an average of about 70 percent of merchandise exports. Table II-1. shows that the annual average rate of growth of the agricultural sector for the period 1968-1978 was less than the rate of

Table II-1. Gross Domestic Product, Agricultural Production and Annual Rates of Growth.

	Average (1970-1972)	Annual Rates of Growth b/ (1964-1978)
GDP, $US	1386.4 a/	5.0
GDP per capita, $US	101.7 a/	2.2
Population	13.63	2.7
Agricultural Production $US	554.56	1.9
Food Production	--	3.0
Agricultural Production/capita $US	40.7	-0.9
Food Production/capita	--	0.3

Sources: GDP and Population estimates were obtained from: IMF, International Statistics, 1978 Annual and UN, Yearbook of National Accounts Statistics, 1978.

Agricultural production estimates were obtained from USDA, ESCS, "Indicies of Agricultural Production in Africa and the Near East," Statistical Bulletins 556 and 623.

a/ GDP is calcualted as the 1970-1972 average in 1971 prices at the official rate of exchange.

b/ All annual rates in this and subsequent tables are in real terms. The rates are calculated from the regression equation $Y_t = (1+r)^t Y_o$, estimated in logarithmetic form.

growth in GDP. While GDP and GDP per capita grew at an annual average rate of 5 percent and 2.2 percent respectively, total agricultural production advanced at an annual average rate of only 1.9 percent. Agricultural production per capita actually decreased at an annual average rate of .9 percent.

The agricultural sector is characterized by small farm plots where hand methods of cultivation tend to prevail. The main food crops produced on these plots are maize, cassava, sorghum, millet and rice. Accordingly, the diet of the rural population is dominated by cereals, roots and tubers. Based on FAO estimates[1/] for the period 1972-74, these crops accounted for over 60 percent of the total consumption in terms of calories.

The major export crops produced on small farm plots include coffee, cotton, cashews, cloves, and tobacco. Sisal, tea and sugar tend to be produced on larger farms which are now, for the most part, government controlled through a parastatal affiliation. About 90 percent of the wheat crop and 10 percent of the maize crop are grown on large farms that were nationalized in the early 1970s.

The consumption, production and imports of maize, wheat and rice for the period 1964 to 1978 are shown in Table II.2. Maize production has nearly equaled maize consumption on a per annum basis during this period, while imports of wheat and rice have been necessary to satisfy the annual excess demand for these grains. Annual growth in imports of these three grains has ranged from 2.5 percent for wheat to about 8.2 for maize. Imports of maize were particularly important during the drought which occurred in 1973-75.

Table II-2. Consumption, Production and Imports of Major Food Grains, 1964 to 1978.

	Maize	Wheat	Rice
Average domestic consumption (MT per annum)	746.4	66.8	126.7
Domestic consumption per capita (kg. per person per annum)	54.3	4.9	9.2
Average domestic production (percent of domestic consumption)	96	48	82
Imports (MT per annum) Average, 1964 to 1978	43.31	36.81	23.07
Linear trend of imports	7.21	2.49	2.91

Source: USDA.

III. POLITICAL ECONOMY OF TRADE IN FOOD GRAINS

A. Government Intervention in Food Grain Markets. Public intervention in economic activity is derived from Tanzania's objectives for social and economic development which are outlined in the Arusha Declaration of 1967. Extensive public intervention in economic activity has meant effective state control over the major means of production. Rural development has been characterized by the creation of Ujamaa (Cooperative) villages while control over the major means of production has meant the nationalization of large scale industry, commerce, finance and the creation of over 300 parastatal firms (over 100 of which are directly responsible for agricultural production) and numerous crop authorities. Among the priorities set forth in the Arusha Declaration is the need for rural and agricultural development and self-reliance in national and local development efforts. In light of the droughts experienced in the early 1970's, the 1977/78-79/80 national development plan placed emphasis on the need to further increase domestic food grain crop production, namely maize and millet.[2/] This emphasis has been interpreted as one of placing greater emphasis on a policy of food self-sufficiency.[3/]

Extensive public intervention has also meant the control of commodity prices at both the farm and retail level. Parastatal processing and retailing firms and crop authorities control the marketing of most agricultural commodities from the farm gate to the retail store. Food prices are administered through various government entities. In 1973 the National Milling Corporation (NMC) took over the functions of the National Agricultural Products Board. The NMC is the parastatal responsible for purchasing farm level supplies of cereals crops. It is virtually the sole buyer of wheat. The marketing of export crops is the responsibility of the

respective crop authorities, e.g., the cotton authority, tea authority, and coffee authority, etc.

Retail markets for food, are for the most part, also nationalized, except for fruits and vegetables, and sales occur through government operated retail outlets. The Tanzanian Price Commission, established in 1973, is responsible for setting and enforcing retail food prices based on a cost plus method. However, consumer prices tend to be changed at more frequent intervals than producer prices. Transportation of agricultural inputs and commodities is also controlled by the public sector through public ownership of transport facilities, equipment and through licensing of private vehicles. The mechanism for setting farm level prices is different for food grain crops than for cash crops. In the case of food grains, farm prices are announced by the NMC prior to the growing season.

Tanzanian's pan-territorial pricing policy requires that official prices are applied in a uniform manner throughout the entire country, i.e., that a single price is set for a given commodity throughout the entire country and/or a single price is charged for an agricultural input regardless of the sales location. The government's willingness to purchase and supply food grains from stocks or imports throughout the year at prevailing announced prices has led to substantial deficits on the accounts of many parastatal firms, particularly the accounts of the National Milling Corporation.[4/]

B. A Model of Government Intervention in Food Grain Markets. The purpose of this section is to conceptualize a model of government intervention in food grain markets in the long run. This serves to simplify the detailed model of each food grain market presented in the next section.

The model of the intervention process is based on the maintained hypothesis that the government succeeds through intervention in maintaining the ruling of announced prices in food grain markets each year. More specifically, it is

postulated that the government has four long-run targets; the producer price, $\hat{PP}_t$, the consumer price, $\hat{CP}_t$, government held stocks, $\hat{S}_t$ and net imports $\hat{M}_t$. The conceptualization of a structural model of government behavior, where the above target prices become explicit functions of the reduced form equations of the structural model, is beyond the scope of this paper. Instead, our approach is to posit the relationship between targets and explanatory variables. To simplify the exposition, we shall proceed in two steps. In this section these relationships are posited on the assumption of a static world where the governments possess perfect knowledge of past and future events. This assumption is relaxed in the second step where at the time the government establishes targets the information available to the government and the method by which the government forecasts future events is specified. This addition changes the nature of the specification developed in this section but it does not alter the number of equations or the number of endogenous variables in the model.

The first step is to postulate that, in the long run, the government has a target producer price for each food grain, $\hat{PP}$, that varies in relation to the autarky price, SSP_t, and the world price, WP_t, as follows:

$$(3.1) \qquad \hat{PP}_t = n + \alpha.SSP_t + \beta.WP_t$$

where n, α and β are parameters to be estimated. The autarky price SSP_t, is defined as the price that would prevail at market equilibrium without government intervention. It is the intersection of the domestic supply and demand curves.

Next, it is postulated that governments long run target consumer price, $\hat{CP}_t$, varies in relation to the target producer price

$$(3.2) \qquad \hat{CP}_t = \kappa + \mu.PP_t$$

where κ and μ are parameters to be estimated. Since marketing services are supplied by the various parastatal firms and crop authorities, implicit in this formulation is a degree of subsidy or tax on these organizations.

It is pointed out above that food grain stocks are held by NMC in order to maintain spatial and temporal prices in a manner that appears approximately consistent with announced prices. To permit the market to clear at announced prices, intervention must occur through the manipulation of stocks or imports. In the case of stocks it is postulated that the government authorities long run target level of carry over stocks, $\hat{S}_t$, for the end of each year is based on their experience in previous years. The value of $\hat{S}_t$ is estimated as a linear trend of actual observed ending stock levels in previous years.

The social accounting identity is given by

$$(3.3) \qquad M_t \equiv QD_t - QP_t + S_t - S_{t-1}$$

where M_t is net imports in year t, QD_t is the domestic quantity demanded, QP_t is the quantity processed and S_t is the government carryover stocks. The assumption that the government is the only holder of carryover stocks is implied by this identity.

Given the long run targets $\hat{PP}_t$, $\hat{CP}_t$, $\hat{S}_t$, and knowledge of the domestic supply and demand curves, the long run target levels of imports is given by:

$$(3.4) \qquad \hat{M}_t \equiv \hat{QD}_t - \hat{QP}_t + \hat{S}_t - \hat{S}_{t-1}$$

which states that the government's long run pricing and stockholding decisions imply a long run target level of imports/exports.

The model of long-run government intervention developed above assumes that the government possesses perfect information when targets are announced. In reality these targets may not be observable because of short-run constraints and various other supply and demand disturbances that the government cannot forecast, and instead, must react by deviating from established targets in any given year. This problem is addressed in the next section.

IV. THE ECONOMETRIC MODEL

The supply and demand functions for each commodity are specified first. Then, the government equations are specified. Allowance is made for inflation and the assumption is relaxed that the government has perfect knowledge when it announces producer and consumer prices. Modification of the governments long-run target equations to account for the effects of short-run constraints and other contingencies completes the model.

The variables in the model are defined in Table IV-1. The subscripts, $i = 1, 2, 3$, refer to maize, wheat, and rice, respectively. The model for each commodity is a market clearing model with six equations and six endogenous variables: the quantity demanded, the quantity produced, government-announced producer and consumer prices, government-held stocks, and net imports.

A. The Supply and Demand Equations. The supply equation for each commodity is a conventional Nerlove partial adjustment model:

$$(4.1) \qquad QP_{it} = b_{io} + \sum_{j=1}^{3} b_{ij} \, (PP_{jt}/PPF_{t}) - b_{i4} \, (PPE_{t-1}/PPF_{t}) + c_{i} \, t$$

$$+ d_{i} \, QP_{i,t-1} + v_{it} \qquad , \quad i = 1, 2, 3.$$

Table IV-1. Definition of Variables.

	QUANTITIES
$*QP_{it}$	Total quantity produced of commodity i in time period t
$*QD_{it}$	Total quantity demanded of commodity i in time period t
$PCQD_t$	Per capita quantity demanded of commodity i in time period t
$*M_{it}$	Net imports of commodity i in time period t
$PL480_t$	Concessional imports (food aid) of commodity i in time period t under the United States PL480 program
$*S_{it}$	Government-held stocks of commodity i at the end of period t
UD_{it}	Unanticipated demand for commodity in period t

	PRICES
$*PP_{it}$	Government-announced producer price for quantities of commodity i delivered to government marketing boards in period t
$*CP_{it}$	Government-controlled consumer price for commodity i in period t
WP_{it}	World price of commodity i in period t, converted to units of domestic currency at the official exchange rate
SSP_{it}	The autarky price of commodity i in period t: a market-determined price at the producer level that would result under autarky

	OTHER VARIABLES
PPF_t	Producer price of fertilizer for production occurring in period t
PPE_t	An index of the producer price of export crops in period t (1971=100)
CPI_t	Consumer price index in period t (1971=100)
WPI_t	World price index in period t: World Bank "c.i.f." index of U.S. dollar prices of manufactured exports to developing countries (1971=100)
Y_t	Private consumption expenditure in period t
PCY_t	Per capita private consumption expenditure in period t
POP_t	Total population in period t
FXR_t	Government-held foreign exchange reserves at the end of period t, deflated by WPI_t

*/ endogenous variables.

Notes:
1. All variables refer to a single country.
2. Variables identified with an asterisk * are endogenous variables.
3. Quantities (with the exception of $PCQD_{it}$) are in thousand metric tons and prices in units of domestic current per metric ton of product. The per capita quantity demanded, $PDQD_{it}$, is in kilograms per person.
4. The producer price of fertilizer, PPF_t, is in units of domestic currency per metric ton of fertilizer nutrient. Private consumption expenditure, Y_t, is in units of domestic currency. Foreign exchange flows, FXF_t, and foreign exchange reserves, FXR_t, are in U.S. dollars.

The short run response to own-price is given by b_{ii} and the "long run" response by $b_{ii}/(1-d_i)$. Substitution in production with export crops is allowed. The linear time trend is a surrogate for technological change and other forces that are shifting the supply curve outwards over time.

The demand equations in the model are also conventional:

$$(4.2a) \qquad PCQD_{it} = a'_{io} + \sum_{j=1}^{3} a'_{ij}(CP_{jt}/CPI_t) + e_i\,(PCY_t/CPI_t) + u'_{it}, \text{ and}$$

$$(4.2b) \qquad QD_{it} = POP_t \cdot PCQD_{it}.$$

PCY_t is private consumption expenditure per capita, not income per capita, so that the parameter e_i is the marginal propensity to consume out of private expenditure. The system is non-linear as it stands. It is convenient for the future development of linear cross equation restrictions to transform (4.2b) into a linear system with a heteroscedastic error term as follows:

$$(4.2c) \qquad QD_{it} = a_{io} + \sum_{j=1}^{3} a_{ij}\,(CP_{jt}/CPI_t) + e_i\,(Y_t/CPI_t) + u_{it}, \text{ where}$$

$$a_{io} = a'_{io} \cdot \overline{POP},$$

$$a_{ij} = a'_{ij} \cdot \overline{POP}, \text{ and}$$

$$u_{it} = u'_{it} \cdot POP_t + a'_{io} \cdot (POP_t - \overline{POP}) + \sum_{j=1}^{3} a'_{ij} \cdot (POP_t - \overline{POP}) \cdot (CP_{jt}/CPI_t).$$

It will be noted that both producer and consumer prices in the supply and demand equations have been deflated, in the supply equation by the producer price of fertilizer, and in the demand equation by the consumer price index. More explicitly, it is assumed that both demand and supply response are homogeneous of degree zero in the relevant prices (and expenditures). The use of fertilizer prices as an index of the cost of

production follows the successful example of Timmer and Falcon[5/] in their work on the Asian rice economies.

Direct prices in each equation are treated as exogenous variables to producers and consumers since the prices are determined by the government equations. While the cross-prices of substitute grains do appear in the supply and demand equations for each commodity, they are treated as exogenous variables, to each model. Therefore, for futher ease of exposition, it is assumed that the three food grain markets are separable, i.e. that the cross-price elasticities are zero. This assumption will be relaxed when the models are estimated, but for now it makes it possible to drop the commodity subscripts, and to rewrite the supply and demand equations as follows:

$$(4.3a) \quad QP_t = b_o + b_1 (PP_t/PPF_t) - b_4 (PPE_{t-1}/PPF_t) + c\ t + d\ QP_{t-1} + v_t, \text{ and}$$

$$(4.3b) \quad QD_t = a_o - a_1 (CP_t/CPI_t) + e (Y_t/CPI_t) + u_t$$

The model for each commodity is identical, and therefore the further development of each model is conducted in terms of a single model.

B. Government Behavioral Equations: Specification. We now return to the specification of the governments four long run targets: the producer price, $\hat{PP}_t$, equation (3.1), the consumer price, $\hat{CP}_t$, equation (3.2), government-held stocks, $\hat{S}_t$, and net imports, $\hat{M}_t$, equation (3.4).

The first modification in the long-run model of government intervention, equation (3.1) to (3.4) is to allow for inflation (because such allowance is made in the supply and demand equations). In the consumer price equation, (3.2), it is convenient to deflate prices by the consumer price index, CPI_t, as follows:

$$a_1 \, (\hat{CP}_t/CPI_t) = \kappa + a_1 \cdot \mu \, (\hat{PP}_t/CPI_t), \text{ or}$$

$$(4.4) \qquad \gamma_t \cdot \hat{CP}_t = \kappa + \mu \, (Y_t \cdot \hat{PP}_t).$$

This implies that real marketing costs and real government subsidies (or taxes) to the marketing boards remain constant over time, while nominal costs and subsidies increase at the same rate as the consumer price index. The parameter taken from equation (4.3b), a_1, is the absolute value of the demand for the commodity with respect to its own price. It is introduced into the equation for reasons that will become clearer shortly. Since a_1 is a constant, it does not materially change the equation. The variable γ_t, that is, a_1/CPI_t, is a scaling factor that ceteris paribus converts nominal consumer prices into quantities of product demanded in each year.

Prices in the consumer price equation can conveniently be deflated by the consumer price index because government-set consumer prices impact only on demand. However, prices in the governments producer price equation are deflated by a weighted average of the producer price of fertilizer, PPF_t, since producer prices impact on supply, and the consumer price index, CPI_t. The CPI_t deflater is used because consumer prices impact, through the consumer price equation, on demand. An appropriate deflator is provided by the variable

$$\pi_t = a_1 \cdot \mu/CPI_t + b_1/PPF_t,$$

where b_1 is taken from the supply equation (4.3a). This deflator is completely analagous to γ_t in the consumer price equation. It is a scaling factor that converts nominal producer prices into quantities of excess demand (demand minus supply) of product in each year. The governments producer price equation is now rewritten as

$$(4.5) \qquad \pi_t \cdot \hat{PP}_t = \eta + \alpha\ (\pi_t\ SSP_t) + \beta\ (\pi_t\ WP_t).$$

The next step is to relax the assumption that the government has perfect knowledge and state how it must formulate expectations of SSP_t and WP_t. The information available to the government depends on the timing of its actions. When the government announces new producer prices, generally about halfway through period t-1, the latest information available includes S_{t-2}, FXR_{t-2}, and WP_{t-2}. Information also includes; PPE_{t-1} and QP_{t-1}, since prices in period t are set after production in period t-1 has taken place and before planting in year t begins. But the government does not know WP_{t-1}, WP_t, and Y_t. Furthermore, while it is assumed to have perfect knowledge of the deterministic components of the supply and demand equations, it does not know the random disturbances in these equations, u_t and v_t.

The expected autarky price, $E_{t-2}SSP_t$, is defined as the market-determined price at the producer level that the government would expect to prevail under autarky given the government-determined margin between consumer and producer prices in equation (4.4). It is the expected intersection of the domestic demand and supply curves with the expected random disturbances in these curves equal to zero and with expected real private consumption expenditure, $E_{t-2}(Y_t/CPI_t)$, equal to the fitted values of a linear trend. It is calculated from a simultaneous system of four equations in four unknowns including the demand equation, the supply equation, the government-determined consumer price equation (4.4) and the identity that demand equals supply. The algerbraic solution for the autarky price is given by

$$(4.6) \qquad \pi_t \cdot E_{t-2}SSP_t = a_o - a_1\ \kappa + e\ E_{t-2}(Y_t/CPI_t) - b_o + b_4\ (PPE_{t-1}/PPF_t) - c\ t - d\ QP_{t-1}.$$

The expected world price, $E_{t-2}WP_{t-1}$, was taken to be the fitted values of the following equation:

$$(4.7) \qquad WP_{t-1} = g_o + g_1 WPI_{t-1} + g_2 WP_{t-2} + g_3 WP_{t-3} + z_t.$$

The assumption is that the evolution of world prices can be represented by a stochastic second order difference equation, the deterministic components of which are known to the government. This produced remarkably good fits (R^2 ranged from .803 to .882) in spite of the fluctuations in world prices over the time period under reivew.

Upon substituting the conditional expectations for SSP_t and WP_{t-1}, equations (4.4) and (4.5) represent long run government pricing behavior, i.e., they reflect the underlying policy of the government over the entire period in question. These are the prices that the government would have set if it had experience no constraints on its behavior from year to year. But in actual experience, there are short-term constraints on government behavior that cause actual government-announced prices, actual stocks, and actual imports to diverge in any given year from the long run target level. The next task is to take these constraints into consideration.

Abbott[6/] proposed that there are three major constraints operative in most developing countries. First, if government-held stocks inherited at the end of one period are low, then the government may desire to build up stocks by one of three methods: increasing the producer price, the consumer price, or net imports above the long run target level. Secondly, the government may be facing a foreign exchange constraint. In this case, it may wish to reduce imports below the long run target level, which it can effect by increasing the producer price above the target level, by reducing stocks below its target level or both. Thirdly, the

government may receive some foreign assistance in kind, such as PL480 imports, which may reduce the level of commercial imports in a given year.[7/]

It is probable that all three constraints have been operative in Tanzania. In addition, there is a fourth contingency in the nature of unavoidable and impossible to anticipate disturbances in the supply, v_t, and demand equations, u_t, as each year unfolds. The government accommodates these disturbances by changing the level of stocks or by engaging in international trade. This permits markets to clear at announced prices.

Allowing for the conditional expectations presented above and the impact of constraints on short-term government behavior, the government equations are reformulated as follows:

$$(4.8)\quad \pi_t \cdot PP_t = \eta + \alpha\,(\pi_t \cdot E_{t-2} SSP_t) + \beta\,(\pi \cdot E_{t-2} WP_{t-1}) + \psi_2\,(\tilde{S}_t - S_{t-2}) + \delta_2\,(\tilde{FXR}_t - FXR_{t-2}) + w_{1t},$$

$$(4.9)\quad \gamma_t \cdot CP_t = \kappa + \mu\,(\gamma_t \cdot PP_t) + \psi_1\,(\tilde{S}_t - S_{t-1}) + \delta_1\,(\tilde{FXR}_t - FXR_{t-1}) - \omega\, PL480_t + w_{2t},$$

$$(4.10)\quad S_t - S_{t-1} = \xi - \sigma\,(\pi \cdot WP_t) + \theta_1\,(\tilde{S}_y - S_{t-1}) + \theta_2\,(\tilde{S}_t - S_{t-2}) - \zeta_1(\tilde{FXR}_t - FXR_{t-1}) - \zeta_2\,(\tilde{FXR}_t - FXR_{t-2}) + \lambda\, PL480_t - \phi\, UD_t + w_{3t}, \text{ and}$$

$$(4.11)\quad M_t = \hat{QD}_t - \hat{QP}_t + \nu - \upsilon\,(\pi_t \cdot WP_t) + \chi_1\,(\tilde{S}_t - S_{t-1}) + \chi_2\,(\tilde{S}_t - S_{t-2}) - \varepsilon_1\,(\tilde{FXR}_t - FXR_{t-1}) - \varepsilon_2\,(\tilde{FXR}_t - FXR_{t-2}) + \iota\, PL480_t + \rho\, UD_t + w_{4t}.$$

where UD is the only variable that remains to be defined. The removal of "^" implies that all variables are observable. These are the final government behavioral equations. All the government parameters are postulated to be greater than or equal to zero (with the possible exception of the constant intercepts, η, κ, ξ, and ν). Note that Roman letters have been used in the supply and demand equations, and that Greek letters have been reserved for all the government behavioral parameters.

The variable UD_t, appearing in the stock and net import demand equations, measures the unanticipated demand and supply shocks. Recalling that $PP_t = E_{t-2}PP_t$ and $CP_t = E_{t-1}CP_t$, it follows from the supply and demand equations, that this is given by

$$UD_t = QD_t - E_{t-1}QD_t - (QP_t - E_{t-2}QP_t),$$

which equals

$$UD_t = u_t + e\,(Y_t/CPI_t - E_{t-1}(Y_t/CPI_t)) - v_t. \tag{4.12}$$

The unanticipated demand contains three components: the error term in the demand equation, the error term in the supply equation, and the expenditure elasticity of demand times the deviation of real private consumption from its previously expected value.

The government must respond to UD_t by adjusting stocks or external trade. If UD_t is positive but very small, it seems likely that the government will respond in the least cost way which is to reduce stocks somewhat. But stocks can never fall below zero, so that if UD_t is very large, the government will be forced to acquire additional imports to meet the demand at the prevailing prices. Therefore, the response of both stocks and imports to unanticipated demand and supply shocks is likely to

be non-linear. Equations (4.10) and (4.11) incorporate a linear approximation to this response with both the parameters, ϕ and ρ, postulated to fall somewhere between zero and unity.

The stock and foreign exchange constraints are represented as deviations from a linear trend where $\tilde{S}_t$ and $\tilde{FXR}_t$ are the fitted values of their respective linear trends over the estimation period. Deviations from trend of stocks or foreign exchange reserves are postulated, as represented in the equations, to induce governments to deviate from their own long run targets.

All four equations have two parts, the first part representing long-term government behavior, and the second part representing deviations from this long-term behavior owing to the operation of short-term constraints. To prevent the short-term constraints from affecting the estimated values of the long-term parameters, or the constant intercepts, η and κ, the mean of the five independent variables that appear on the right hand side of the producer and consumer price equations are normalized to zero over the period of estimation. This normalization procedure does not change any of the estimated parameters (except the constant intercepts) because the specification of all equations is linear. Furthermore, it makes no difference whether the stock constraint in the produce price equation, for example, is represented as $(\tilde{S}_t - S_{t-2})$, $(\tilde{S}_{t-1} - S_{t-2})$, or $(\tilde{S}_{t-2} - S_{t-2})$, since the fitted trend is linear.

All four equations have error terms that represent unexplained government behavior from year to year. Because the government is intervening in food grain markets in four ways simultaneously, the unspecified forces that underlie the four error terms--such as a drought in one year--are likely to be similar, resulting in nonzero correlations between the four disturbances.

C. Government Behavioral Equations: Identification of Parameters. The four government variables are overdetermined and the government behavioral parameters are overidentified as the model now stands. To handle this problem, cross-equation restrictions are imposed on the parameters in the government equations--restrictions implied by the demand and supply equations and the identity--that will uniquely determine the government variables. The unique advantage of this approach is that one can also test the null hypothesis that the restrictions are true. Since all the exogenous variables that appear on the right hand side of equations (4.8) to (4.10) also appear in the net import demand equation, the restrictions were calculated by inserting the other three government equations plus the demand and supply equations into the social accounting identity (3.3) and then solving for net imports as a function of all the exogenous variables and the error terms.

After some algerbra, this calculation yields:

$$
\begin{aligned}
(4.13) \quad M_t = {} & \nu + (1-\alpha)\cdot(\pi_t \cdot E_{t-2} SSP_t) - \beta\,(\pi_t \cdot E_{t-2} WP_{t-1}) - \sigma\,(\pi_t \cdot WP_t) \\
& + (\theta_1-\psi_1)\cdot(\tilde{S}_t - S_{t-1}) + (\theta_2-\psi_2)\cdot(\tilde{S}_t - S_{t-2}) \\
& - (\zeta_1+\delta_1)\cdot(\tilde{FXR}_t - FXR_{t-1}) - (\zeta_2+\delta_2)\cdot(\tilde{FXR}_t - FXR_{t-2}) \\
& + (\lambda+\omega)\ PL480_t + (1-\phi)\ UD_t + w_{3t} - w_{1t} - w_{2t}
\end{aligned}
$$

These are precisely the cross-equation restrictions in the four equations that are necessary in order to identify exactly the government behavioral parameters given the supply equation, the demand equation, and the social accounting identity.

The complete model for a single commodity in a single country is summarized in Table IV-2, where the supply and demand equations are listed in the top half of the table and the government behavioral equations with

Table IV-2. Complete model for a single commodity: Summary

a. Supply and demand equations

	Constant	PP_t/PPF_t	CP_t/CPI_t	PPE_{t-1}/PPF_t	t	Y_t/CPI_t	QP_{t-1}	Error term
QP_t	b_o	b_1	-	$-b_4$	c	-	d	v_t
QD_t	a_o	-	$-a_1$	-	-	e	-	u_t

b. Government behavioral equations

	Constant	$\pi_t \cdot E_{t-2}SSP_t$	$\pi_t \cdot E_{t-2}WP_{t-1}$	$\pi_t \cdot WP_t$	$\gamma_t \cdot PP_t$	$(\tilde{S}_t - S_{t-1})$	$(\tilde{S}_t - S_{t-2})$	$(\tilde{FXR}_t - FXR_{t-1})$	$(\tilde{FXR}_t - FXR_{t-2})$	$PL480_t$	UD_t	Error term
$\pi_t \cdot PP_t$	η	α	β	-	-	-	ψ_2	-	δ_2	-	-	w_{1t}
$\gamma_t \cdot CP_t$	κ	-	-	-	μ	ψ_1	-	δ_1	-	$-\omega$	-	w_{2t}
$(S_t - S_{t-1})$	ξ	-	-	$-\sigma$	-	θ_1	θ_2	$-\zeta_1$	$-\zeta_2$	λ	$-\phi$	w_{3t}
M_t	ν	$(1-\alpha)$	$-\beta$	$-\sigma$	-	$(\theta_1-\psi_1)$	$(\theta_2-\psi_2)$	$-(\zeta_1+\delta_1)$	$-(\zeta_2+\delta_2)$	$(\lambda+\omega)$	$(1-\phi)$	$(w_{3t}-w_{1t}-w_{2t})$

Notes: 1. See Table IV-1 for definition of variables.

2. The variables, π_t and γ_t, are scaling factors that convert nominal producer and consumer prices, respectively, into metric tons of grain in each year. They are defined as follows:

$$\pi_t = a_1 \cdot \mu / CPI_t + b_1 / PPF_t \quad , \quad \text{and} \quad \gamma_t = a_1 / CPI_t$$

They are also price deflators that depend on the level of prices in each year as represented by PPF_t and CPI_t.

3. See equations (4.6), (4.7), and (4.12) for the definitions of $E_{t-2}SSP_t$, $E_{t-2}WP_{t-1}$, and UD_t, respectively.

cross-equation restrictions are listed in the lower half. Imposing these restrictions while estimating the four equations simultaneously will of course change the estimated values of the parameters. The more interesting question is whether these changes are statistically significant.

In summary, the model is a dynamic model that takes into account the information available to the government when it makes its decisions, and incorporates government expectations about future events. The dynamic nature of the model is as follows. At the beginning of each period, the government has announced a new set of producer and consumer prices that prevail throughout the entire period. Domestic producers and consumers respond to these prices. Markets clear at the ruling prices by government intervention which takes the form of adjustments in government stock levels and by engaging in international trade. The key feature of the model is that, while government intervention in the form of prices, changes in stocks, and international trade remains exogenous to producers and consumers, it is treated as endogenous to the model and as influenced in a systematic way by the state of the world in each year as viewed by the government. This state of the world includes world prices, government-held stocks and foreign exchange reserves inherited from previous periods, PL480 imports, and unanticipated demand and supply shocks as each year unfolds, all of which are exogenous variables to the government. Short-term constraints mask long-term behavior. By incorporating both into the equations, it becomes possible to separate the two econometrically to determine endogenously the degree to which the domestic market has been separated from the international market on the average over the period of estimation, and to isolate this long-term impact of government policy on trade.

D. Estimation Problems and Procedures. Most of the data to estimate the model were collected at USDA in Washington, D.C., from USDA data banks, government of Tanzania documents, and IMF publications. Production and trade data refer to crop years beginning in each calendar year. Stock data refer to the end of each crop year. Consumption was constructed as a residual from the identity, the production, trade, and stock data and refers to annual disappearance in each year.

All producer prices are the government-announced prices prior to planting in each crop year. Consumer prices are those collected by the Bureau of Statistics that were used in the calculation of the consumer price index for Dar-es-Salaam.

Private consumption expenditure, population, the consumer price index, foreign exchange reserves, and world prices were all taken from the IMF, International Financial Statistics, 1978 annual. World prices were export prices, f.o.b. gulf ports U.S.A. for maize and wheat, and f.o.b. Bangkok, Thailand, for rice.

In each model, the supply and demand equations were estimated first. Because the Slutsky relationship in demand theory imposes cross-equation restrictions on the cross-price coefficients in the demand equations, these were estimated simultaneously with these restrictions imposed, using Zellner's seemingly unrelated regression technique.[8/] The three equations were also estimated without the restrictions imposed and the likelihood ratio was calculated to determine if the restrictions significantly affected the estimated parameters.

The four government equations in each commodity model were also estimated simultaneously with the cross-equation restrictions imposed in order to identify exactly the government parameters. To keep the

restrictions linear, they were imposed at the mean values of the variables POP, CPI and PPF. With the stock equation (S_t-S_{t-1}) transformed to $-(S_t-S_{t-1})$, this procedure also imposed the restrictions on the error terms.

Finally the parameters, κ and μ, are required to calculate the expected autarky price $E_{t-2}SSP_t$, but they can only be estimated in the complete model once $E_{t-2}SSP_t$ has been calculated. Therefore an iterative procedure was adopted. Initial values of κ and μ were derived from a single equation estimation of the consumer price equation. These were used to calculate $E_{t-2}SSP_t$ from which new estimates of κ and μ were derived from the four-equation simultaneous estimation. This procedure was continued until μ converged to within one percent, which was generally achieved after about three iterations. Once the final estimates of κ and μ were obtained, the four government equations were also estimated without the cross-equation restrictions imposed. Then the Lagrange multiplier test was performed to test whether the restrictions significantly affected the estimated parameters.[9/]

V. ECONOMETRIC RESULTS

A. Demand and Supply Equations. Results from fitting the per capita demand functions for maize, wheat and rice appear in Table V-1. Since the critical chi-square value for three degrees of freedom is 7.81, the restrictions imposed by the Slutsky conditions are not rejected at the .05 level of significance.

The demand functions fit the data remarkably well. All signs are correct except the cross-price effects between maize and rice (-.1367) and (-.0396), although, they are not significantly different from zero in

Table V-1. Per capita consumption elasticities, Tanzania, 1964 to 1977

	Consumer prices			Private consumption expenditure	Expenditure proportion	R^2
	Maize meal	Wheat flour	Milled rice			
Maize	-.8978 (-5.88)	.0299 (0.52)	-.0396 (-0.50)	.8478 (3.42)	.0924	.767
Wheat	.1765 (0.37)	-2.6043 (-5.32)	.6363 (1.51)	1.4637 (2.52)	.0118	.761
Rice	-.1367 (-0.58)	.2378 (1.55)	-1.0453 (-4.83)	1.0990 (2.97)	.0332	.703

The likelihood ratio for the cross-equation restrictions imposed by the Slutsky relationship is 5.78 on 3 degrees of freedom, which represents a probability of greater than 10 percent.

Notes:

1. The actual equations estimated were linear; the elasticities have been calculated at the mean. T-statistics are shown in parentheses below the elasticities.

2. The consumer prices that appear as independent variables in the equations are generally those reported by the Central Bureau of Statistics that were used in the calculation of the consumer price index for Dar-es-Salaam. There is a large element of control over these prices as the government generally enforces maximum retail prices for staple grains.

3. The three equations were estimated simultaneously using Zellner's seemingly unrelated regression technique, while at the same time imposing the cross-price restrictions derived from the Slutsky relationship.

either case. All direct price and income expenditure effects are significant.

Both the direct price and expenditure elasticities are the largest for wheat followed by rice and maize respectively. This is not surprising and it is consistent with observations in other countries. This ranking of price and expenditure elasticities suggests that wheat is a prestige food grain relative to the other grains while rice is preferred relative to maize. Nevertheless, the expenditure elasticity for maize is also large, suggesting that it is preferred to roots and tubors. As income increases, demand for these grains will increase relative to maize, or conversely, differential changes in income, say between rural and urban areas, will cause differential rates of growth in food grain demand. Unfortunately, Tanzania is not a low cost producer of wheat. Hence rising incomes, especially in urban areas, will likely increase the import demand for wheat.

Results from fitting the total and marketed production equation for maize, wheat and rice to the data appear in Table V-2. The equations provide a reasonably good fit to the data with significant direct price effects and expected signs obtained in all cases.

In the case of the total production equations, the partial adjustment coefficient suggests fairly rapid adjustment in the quantities of maize and rice produced to price changes. Wheat, which is produced almost exclusively on government farms, appears to respond the slowest of the three crops to price changes. The annual rate of growth in wheat production also lags behind the rate of growth in the production of the other crops, with rice showing the most rapid growth rate. The results also suggest that maize competes for resources used in the production of export crops; a one

Table V-2. Short run supply elasticities, Tanzania, 1964 to 1978

	Producer prices						R^2
	Maize	Wheat	Rice	Export crops	Annual growth rate (percent)	Partial adjustment coefficient (1-d)	
TOTAL PRODUCTION							
Maize	.359 (1.50)	-	-	-.199 (-1.08)	2.91 (2.70)	.849 (5.05)	.737
Wheat	-.650 (-1.16)	.989 (1.97)	-	-	1.03 (0.40)	.673 (2.90)	.562
Rice	-.328 (-1.55)	-	.426 (2.39)	-.027 (-0.10)	5.12 (5.07)	1.177 (8.76)	.804
MARKETED PRODUCTION							
Maize	2.290 (3.26)	-	-	-1.571 (-2.79)	-1.78 (-0.63)	.918 (5.38)	.530
Rice	-.954 (-1.77)	-	2.290 (6.11)	-.803 (-1.58)	0.83 (0.46)	1.077 (7.00)	.818

Notes:

1. The actual equations estimated were linear; the elasticities have been calculated at the mean. T-statistics are shown in parentheses below the elasticities.

2. The maize, wheat, and rice prices that appear as independent variables in the equations are government-announced prices prior to planting in each year. The price of export crops is a Paasche index of government-announced producer prices for coffee and cotton.

3. Marketed production of maize and rice and total production of wheat correspond to purchases by the National Milling Corporation in each year. In the case of maize and rice, the total and marketed production equations were estimated simultaneously, for improved efficiency, using Zellner's seemingly unrelated regression technique.

percent increase in the price index of export crops results in an average of about .2 percent decrease in the production of maize. The results also suggest that maize competes for resources with both wheat and rice.

Also consistent with expectations are the relatively large direct price elasticities associated with the marketed production of maize and rice, and again, evidence (-.954) which indicates that maize and rice competes for the same resources. Marketed maize production is also responsive to the price of export crops, decreasing by about 1.6 percent per a one percent increase in the price index of export crops. The same relationship for rice is about .8 percent. Since the majority of maize and rice produced are on small farm plots, these results suggest that those plots yielding a surplus over household consumption needs, and perhaps sales in unofficial markets, are responsive to the relative terms of trade between food and import crops. Indeed, virtually no lag exists in their supply adjustment response to price changes from year to year. Also revealing is the virtually zero annual growth rate in marketed production of maize and rice. Since marketed production corresponds to purchases by NMC, this result suggests either that the marketed surplus of maize and rice over farm household needs has been stagnant or that marketed production has been bypassing official channels.

B. Government Behavioral Equations. The estimated government behavioral equations are presented in Tables V-3, V-4, and V-5, one table for maize, wheat, and rice, respectively. The actual equations estimated, with the cross-equation restrictions imposed, are shown in the bottom half of each table and the estimated elasticities, calculated at the means, in the top half.

Table V-3. Government behavioral equations, Tanzania, Maize model, 1964 to 1977

a. Elasticities, calculated at the mean

	$E_{t-2}SSP_t$	$E_{t-2}WP_{t-1}$	WP_t	PP_t	$(\tilde{S}_t-S_{t-1})$	$(\tilde{S}_t-S_{t-2})$	$(\tilde{FXR}_t-FXR_{t-1})$	$(\tilde{FXR}_t-FXR_{t-2})$	$PL480_t$	UD_t
PP_t	.680**	.671**	-	-	-	-.034	-	.057*	-	-
CP_t	-	-	-	.999**	.011	-	.003	-	-.078**	-
(S_t-S_{t-1})	-	-	1.853#	-	.579**	-.043	.218	.730##	-.445##	-.533**
M_t	5.833	-11.448**	1.238	-	.253	.548	.113	-.484	.678**	1.340**

b. Actual estimated equations, with cross-equation restrictions (t-statistics in parentheses below coefficients)

	Constant	$\pi \cdot E_{t-2}SSP_t$	$\pi \cdot E_{t-2}WP_{t-1}$	$\pi \cdot WP_t$	$\gamma \cdot PP_t$	$(\tilde{S}_t-S_{t-1})$	$(\tilde{S}_t-S_{t-2})$	$(\tilde{FXR}_t-FXR_{t-1})$	$(\tilde{FXR}_t-FXR_{t-2})$	$PL480_t$	UD_t	R^2
$\pi \cdot PP_t$	-142.1 (-4.15)	.665 (3.84)	.528 (3.48)	-	-	-	-1.283 (-1.32)	-	2.311 (2.04)	-	-	.961
$\gamma \cdot CP_t$	0.9 (0.02)	-	-	-	2.596 (27.28)	.294 (0.62)	-	.075 (0.14)	-	-6.964 (-5.75)	-	.956
(S_t-S_{t-1})	-54.3 (-2.22)	-	-	.053 (2.54)	-	.846 (5.45)	-.063 (-0.28)	.328 (1.51)	1.161 (4.77)	-2.123 (-3.19)	-.216 (-4.20)	.810
M_t	262.3 (3.91)	.335 (1.93)	-.528 (-3.48)	.053 (2.54)	-	.552 (1.24)	1.220 (1.49)	.254 (0.48)	-1.150 (-1.16)	4.841 (3.83)	.784 (15.23)	.579

The Lagrange multiplier statistic for the cross-equation restrictions is 22.13 on 9 degrees of freedom, which is significant at the 5 percent level.

Notes:
1. See Table IV-1 for definition of the variables.
2. See Table IV-2 for the definition of π and γ which are scaling factors that convert producer and consumer prices, respectively, into metric tons of grains.
3. In table a. above, the elasticities corresponding to (S_t-S_{t-1}), $(\tilde{S}_t-S_{t-1})$, $(\tilde{S}_t-S_{t-2})$, $(\tilde{FXR}_t-FXR_{t-1})$, $(\tilde{FXR}_t-FXR_{t-2})$, and UD_t have been calculated at the mean of the absolute value because the actual means are zero or very close to zero.
4. In table a. above, a single asterisk * indicates a coefficient of the right sign and significant at the 5 percent level, and a double asterisk ** at the 1 percent level. The symbol # indicates a coefficient of the wrong sign and significant at the 5 percent level, and the symbols ## at the 1 percent level.

Table V-4. Government behavioral equations, Tanzania, Wheat model, 1964 to 1977

a. Elasticities, calculated at the mean

	$E_{t-2}SSP_t$	$E_{t-2}WP_{t-1}$	WP_t	PP_t	$(\tilde{S}_t-S_{t-1})$	$(\tilde{S}_t-S_{t-2})$	$(\tilde{FXR}_t-FXR_{t-1})$	$(\tilde{FXR}_t-FXR_{t-2})$	$PL480_t$	UD_t
PP_t	1.267**	-.306##	-	-	-	-.001	-	.020	-	-
CP_t	-	-	-	.856**	.046	-	.129**	-	.019	-
(S_t-S_{t-1})	-	-	.312	-	1.858**	-.316	1.306##	.240	.302*	.199##
M_t	-.322	1.449##	.073	-	.219**	-.070	-.299**	-.040	-.020	.364**

b. Actual estimated equations, with cross-equation restrictions (t-statistics in parentheses below coefficients)

	Constant	$\pi \cdot E_{t-2}SSP_t$	$\pi \cdot E_{t-2}WP_{t-1}$	$\pi \cdot WP_t$	$\gamma \cdot PP_t$	$(\tilde{S}_t-S_{t-1})$	$(\tilde{S}_t-S_{t-2})$	$(\tilde{FXR}_t-FXR_{t-1})$	$(\tilde{FXR}_t-FXR_{t-2})$	$PL480_t$	UD_t	R^2
$\pi \cdot PP_t$	27.6 (0.75)	1.057 (30.17)	-.347 (-5.11)	-	-	-	-.014 (-0.04)	-	.161 (0.74)	-	-	.929
$\gamma \cdot CP_t$	291.2 (3.18)	-	-	-	2.446 (34.16)	.812 (1.83)	-	.959 (5.88)	-	.781 (1.22)	-	.910
(S_t-S_{t-1})	-0.5 (-0.15)	-	-	.016 (1.00)	-	1.642 (8.05)	-.296 (-1.75)	.484 (7.82)	.094 (0.86)	.605 (2.29)	.146 (3.56)	.764
M_t	-6.8 (-1.36)	-.057 (-1.62)	.347 (5.11)	.016 (1.00)	-	.830 (2.88)	-.282 (-1.23)	-.475 (-4.25)	-.067 (-0.54)	-.176 (-0.43)	1.146 (28.01)	.890

The Lagrange multiplier statistic for the cross-equation restrictions is 14.07 on 9 degrees of freedom, which is not significant at the 5 percent level.

Notes: See Table

Table V-5. Government behavioral equations, Tanzania, Rice model, 1964 to 1977

a. Elasticities, calculated at the mean

	$E_{t-2}SSP_t$	$E_{t-2}WP_{t-1}$	WP_t	PP_t	$(\tilde{S}_t-S_{t-1})$	$(\tilde{S}_t-S_{t-2})$	$(\tilde{FXR}_t-FXR_{t-1})$	$(\tilde{FXR}_t-FXR_{t-2})$	$PL480_t$	UD_t
PP_t	.885**	.114	-	-	-	.015	-	.020	-	-
CP_t	-	-	-	.916**	.016	-	.050	-	.002	-
(S_t-S_{t-1})	-	-	-.219	-	.450**	.629**	.068	-.308*	.251**	-.309**
M_t	1.601	-.725	-.125	-	.174	.265*	-.220	-.301**	.136	.678**

b. Actual estimated equations, with cross-equation restrictions (t-statistics in parentheses below coefficients)

	Constant	$\pi \cdot E_{t-2}SSP_t$	$\pi \cdot E_{t-2}WP_{t-1}$	$\pi \cdot WP_t$	$\gamma \cdot PP_t$	$(\tilde{S}_t-S_{t-1})$	$(\tilde{S}_t-S_{t-2})$	$(\tilde{FXR}_t-FXR_{t-1})$	$(\tilde{FXR}_t-FXR_{t-2})$	$PL480_t$	UD_t	R^2
$\pi \cdot PP_t$	0.8 (0.02)	.779 (6.90)	.071 (1.12)	-	-	-	.188 (0.56)	-	.135 (0.88)	-	-	.903
$\gamma \cdot CP_t$	184.1 (2.40)	-	-	-	3.175 (35.96)	.169 (0.92)	-	.265 (1.99)	-	.067 (0.10)	-	.945
(S_t-S_{t-1})	4.9 (1.44)	-	-	-.011 (-1.13)	-	.524 (8.74)	.710 (5.29)	.040 (0.65)	-.190 (-2.56)	1.176 (3.77)	-.207 (-5.04)	.745
M_t	4.8 (0.56)	.221 (1.96)	-.071 (-1.12)	-.011 (-1.13)	-	.353 (1.81)	.521 (2.24)	-.225 (-1.41)	-.325 (-3.66)	1.109 (1.35)	.793 (19.34)	.921

The Lagrange multiplier statistic for the cross-equation restrictions is 45.19 on 9 degrees of freedom, which is significant at the 5 percent level.

Notes: See Table V-3

The overall model explains 58 percent of the variation in maize imports over the period, 89 percent of the variation in wheat imports, and 92 percent of the variation in rice imports. Not including the intercepts, there are 22 separate parameters in each model. In the maize model, there are only 5 incorrect signs; and of the 12 variables that are significantly different from zero at the 5 percent level, 9 have the expected signs. In the wheat model, there are 11 wrong signs; but 8 of the 11 variables that are significantly different from zero have the expected signs. In the rice model, there are only 2 wrong signs; and all ten of the variables that are significantly different from zero have the expected signs.

In the maize model (Table V-3), the government-announced producer price has been equally a function of the expected autarky and world prices. The estimated elasticity of net imports to the expected world price is -11.45, which implies that small changes in the world price can transform Tanzania from a net importer to a net exporter, or vice versa. This seems reasonable since external trade in maize has averaged only 4 percent of domestic consumption over the entire period.

When stocks of maize are low at the end of one period, the primary response of the government is to import more in the next period in order to build up stock, and the secondary response is to raise consumer prices. When foreign exchange reserves are low, the government will generally reduce imports by increasing producer prices, but this response is not significant.

The government's response to PL480 imports is to lower consumer prices and to increase imports. In this instance, food aid is demand-creating; it does not simply substitute one-for-one with commercial imports. The government's response to unanticipated positive demand and supply shocks

is primarily to import (78 percent of the response), and secondarily to reduce stocks (22 percent). This is exemplory of a government that uses international trade as a buffer stock in order to moderate domestic price changes. The government has not been able to use stocks alone to accommodate demand and supply shocks because the average level of stocks over the period (50.3 thousand metric tons) has been less than the average demand and supply shocks (85.1 thousand metric tons). Production has been very unstable from year to year.

In the wheat model (Table V-4), the government-announced producer price has been primarily a function of the expected autarky price; the estimated response to expected world prices has actually been negative. This perverse response can arise because of collinearity between the expected autarky and world prices. However, examination of the partial correlation coefficients suggests that this collinearity does not change the major conclusion that the primary response is to the self-sufficiency price. When stocks of wheat are low, the government builds up stocks equally by importing in the next period, and by raising consumer prices. When foreign exchange reserves are low, the government imports significantly less in the next period, primarily by increasing consumer prices and secondarily by increasing producer prices. Unlike the case of maize, the government's response to PL480 imports is insignificant, but similar to maize, the overwhelming response to unanticipated demand and supply shocks is to import more.

In the rice model (Table V-5), the government-announced producer price has been primarily a function of the autarky price. There is a slight, but insignificant response of the correct sign to world prices. When stocks are low, the government responds primarily by importing more in the next period, and secondarily by increasing consumer and producer prices.

When foreign exchange reserves are low, the government imports less in the next period by reducing stocks and by increasing both consumer and producer prices. The response of total net imports to PL480 imports is positive but insignificant from zero. Unlike the case of maize, PL480 imports do not appear to be demand-creating because the major response is to such food aid is to build up domestic stocks. As in the case of both maize and wheat, the major response of the government to unanticipated demand and supply shocks is to import more (79 percent of the response) and secondarily to reduce government stocks (21 percent).

In summary, the models have succeeded in capturing significant short-term responses by the government, and in isolating four major constraints that impinge upon government behavior -- government-held stocks, foreign exchange reserves, PL480 imports, and unanticipated demand and supply shocks. Some of these responses are very consistent for all three commodities. The general response to low levels of stocks is to import more in the next period; to foreign exchange reserves, to adjust domestic prices; and to unanticipated demand and supply shocks, to equilibrate domestic demand and supply by engaging in international trade. The only significant response to total net imports to PL480 imports occurs in the maize model.

Most importantly, the models have succeeded in separating long-term government pricing behavior from selected short-term constraints. Over the long run, by which is meant the underlying policy of the government over the entire period in question, domestic consumer and producer prices have moved more or less in tandem, although there has been some tendency to reduce the margin between consumer and producer prices in the case of wheat and rice. Also, the major determinant of domestic producer prices has

been the expected autarky price. World prices have had a secondary influence. It is not regarded as a coincidence that the more important the crop to domestic consumption, the more important has been the influence of world prices, since in this case, deviations of domestic prices from world prices are more costly for the government to maintain.

Finally, the government equations were also estimated without the restrictions imposed. The restrictions are expected to be accepted because they are imposed so as to be consistent with the social accounting identity on average over the period of estimation. The Lagrange multiplier test implies that the restrictions are not accepted in two cases, i.e., that the restrictions on the maize and rice equation in the government model may be violated in any particular year. An interpretation of this result is that, over the period of estimation, the government may not have been consistent in its reaction to the exogenous variables in government equations for maize and rice.

VI. THE IMPACT OF GOVERNMENT PRICING POLICIES ON EXTERNAL TRADE IN FOOD GRAINS

It has been pointed out that Tanzania is a net importer of all three grains and that net imports have been increasing over time. It is reasonable to ask whether this picture has been caused by the underlying state of development in Tanzania or whether it has been caused by specific government policies in the food grain sector.

Because all the independent variables in the producer and consumer price equations except $E_{t-2}SSP_t$, $E_{t-2}WP_{t-1}$, and PP_t were normalized to a mean of zero, the estimated long run target producer and consumer prices are given by

$$\hat{PP}_{it} = \eta_i + \alpha_i E_{t-2}SSP_t + \beta_i E_{t-2}WP_{t-1}, \text{ and}$$

$$\hat{CP}_{it} = \kappa_i + \mu_i \hat{PP}_{it}, \quad i = 1, 2, 3,$$

where η_i, α_i, β_i, κ_i, and μ_i are the estimated coefficients in each model. Calculating the values of $\hat{PP}_{it}$ and $\hat{CP}_{it}$ for the period of the study provides a description of long run government pricing policy. These results are summarized in Table VI-1. For ease of exposition, the expectation operator, E_{t-2}, has been dropped from the autarky and world price variables listed in the table.

The first feature of government policy that emerges from the table is that the margin between consumer and producer prices differs little from margins maintained on average in four other countries in East Africa.[10/] Margins are larger for rice and wheat than for maize since more of the product is lost in processing (35 percent in the case of rice, 25 percent for wheat, and 10 percent for maize). It has been observed that the National Milling Corporation has been running a persistent deficit in recent years.[11/] This would seem to imply that the NMC is providing an inefficient service.

The impact of long-run pricing policy on producer prices is shown in part b. of the table. Even at the official exchange rate, the rate of taxation on the producers of export crops has been large (about 32 percent over the period) and it has been increasing over time. In 1977, the margin was estimated to be about 47 percent. Given a more realistic exchange rate for the Tanzanian shilling, this rate would be even greater.

Furthermore, maize production has been taxed on average over the period by about 24 percent, once again at the official exchange rate; wheat production has been subsidized by about 15 percent; and rice production taxed by about 36 percent. However, in all cases, the rate of taxation has been decreasing (or the rate of subsidy increasing) over time. If observed trends have continued to the present, the rate of taxation on maize production

Table VI-1. Description of government pricing policies, Tanzania, 1964 to 1977

a. Consumer prices

Commodity	Ratio	Mean	Linear trend	Overall mean of four countries 1/
Maize	$\hat{CP}_t/\hat{PP}_t$	2.5987	-.0002	2.4092
Wheat	$\hat{CP}_t/\hat{PP}_t$	2.914	-.035	2.937
Rice	$\hat{CP}_t/\hat{PP}_t$	3.498	-.020	3.580

b. Producer prices

Commodity	Ratio	Mean	Linear trend	t-statistic for trend
Export crops	τ_t 2/	.683	-.024	(-5.14)
Maize	$\hat{PP}_t/SSP_t$	.946	.018	(2.91)
	$\hat{PP}_t/WP_t$	.760	.023	(8.07)
	$\hat{PP}_t/(\tau_t \cdot WP_t)$	1.180	.089	(6.54)
Wheat	$\hat{PP}_t/SSP_t$	.8363	.0001	(0.05)
	$\hat{PP}_t/WP_t$	1.152	.015	(1.15)
	$\hat{PP}_t/(\tau_t \cdot WP_t)$	1.761	.100	(3.47)
Rice	$\hat{PP}_t/SSP_t$	.881	-.001	(-0.94)
	$\hat{PP}_t/WP_t$	.638	.010	(1.41)
	$PP_t/(\tau_t \cdot WP_t)$	.981	.060	(3.17)

Notes:

1/ Simple average of the mean ratios for Kenya, Tanzania, Zambia, and Malawi.

2/ The variable τ_t is the ratio of producer prices of export crops to their world prices, f.o.b. Dar-es-Salaam, weighted by quantities produced, as follows:

$$\tau_t = \left(\sum_{i=1}^{2} PP_{it} \cdot QP_{it}\right) / \left(\sum_{i=1}^{2} WP_{it} \cdot QP_{it}\right)$$, where i = 1, 2, refer to coffee and cotton.

would drop to zero in 1981. In general, food grains have been taxed less than export crops, and significantly less over time. This pattern is consistent with stated government policies, and therefore it is not surprising to find that food production has been increasing more rapidly than export crop production over the period. 12/

While at first glance it may seem inconsistent to tax the production of two food grains and subsidize the third, this is not so inconsistent when viewed in terms of a self-sufficiency objective. Our empirical results provide strong evidence that a degree of self-sufficiency in food grain production is indeed a major government objective. While the rate of taxation on the three crops varies considerably, the degree of self-sufficiency maintained varies much less, from 84 percent in the case of wheat to 95 percent in the case of maize. Rice production has been taxed the most because Tanzania is a low-cost producer in relation to the world price, and wheat production has been subsidized because Tanzania is a high-cost producer. As a general statement of government policy in Tanzania, we conclude that producer prices have been maintained at a roughly constant degree of self-sufficiency over the entire period, given the degree of taxation on export crops and the margins maintained by the National Milling Corporation, and therefore the rate of taxation on production has been higher, the lower the cost of producing the crop domestically. This conclusion supports that of section V that government-announced producer prices have been influenced more by the autarky price than by the world price.

The impact of Tanzanian pricing policy on the external trade in food grains is considered next. Based on the estimated equations, four simulations were performed. The results are reported in Table VI-2. The impact of

Table VI-2. The impact of government pricing policies on external trade in food grains, Tanzania, 1964 to 1977

Commodity	Variable	Simulation number	Mean	Linear trend	t-statistic for trend
Maize	WP_t/SSP_t	1	1.133	-.025	(-3.02)
	M_t	1	-126.3	21.2	(2.64)
	M_t	2	-183.7	22.1	(2.61)
	M_t	3	92.9	-15.5	(-2.72)
	M_t	4	47.9	-16.3	(-2.76)
Wheat	WP_t/SSP_t	1	.668	-.006	(-1.29)
	M_t	1	89.0	2.2	(2.59)
	M_t	2	84.6	3.9	(5.71)
	M_t	3	30.0	1.6	(1.81)
	M_t	4	31.5	3.6	(4.09)
Rice	WP_t/SSP_t	1	1.412	-.015	(-0.92)
	M_t	1	-80.5	2.5	(0.69)
	M_t	2	-69.9	2.7	(0.80)
	M_t	3	20.1	0.7	(0.79)
	M_t	4	21.6	1.1	(1.21)

Simulation number	Producer prices		Consumer prices	
	World prices at official exchange rate	Estimated long run target prices	Overall mean margin for four countries	Estimated long run target margin
1	✓		✓	
2	✓			✓
3		✓	✓	
4		✓		✓

producer pricing policy can be seen by comparing simulations 1 and 2 with simulations 3 and 4. Simulations 1 and 2 set producer prices at world prices, evaluated at official exchange rates. Simulations 3 and 4 permit the estimated government pricing equations to determine producer prices. Simulation 1 is distinguished from simulation 2 by permitting consumer prices to be based on the mean margin between consumer and producer prices observed in four countries in East Africa (simulation 1) compared to the consumer prices given by the estimated government pricing equation for consumer prices (simulation 2). This margin represents an alternative estimate of the actual cost of marketing services. The same distinction applies to simulations 3 and 4. These distinctions serve to provide insights into the sensitivity of the results to consumer pricing policy.

Except for government producer and consumer prices for food grains and export crops, the simulations incorporate the impact of all other development policies in Tanzania, the rate of growth of agricultural production, population growth, the rate of growth in real private consumption per capita, the expenditure elasticity of the demand for food grains, and the rate of inflation in Tanzania (as represented by PPF_t and CPI_t) compared to the rate of inflation in the rest of the world (as represented by the world prices of food grains and export crops). If domestic prices had actually been at world prices, an argument could be made that real private consumption per capita would have grown more rapidly, but, lacking a general equilibrium model of economic development in Tanzania, it has not been possible to incorporate this effect. Neither were the effects of fertilizer subsidies or the overvalued exchange rate taken into account.

The simulation suggests that Tanzania has been a low-cost producer of maize and rice in relation to the world price--the ratio, WP_t/SSP_t has been greater than unity--and a high-cost producer of wheat. These results are hardly surprising considering that wheat is a temperate crop, while maize and rice are sub-tropical. The cost of producing all three crops has been increasing over time and in the case of maize, Tanzania became an average cost producer of maize (with WP_t/SSP_t = unity) roughly in 1976.

A comparison of simulations 1 and 2 with simulations 3 and 4 indicates that the major impact on food grain markets has been the governments producer pricing policy. If domestic prices had been at world market prices over the period, Tanzania would have been a net exporter of maize and rice and a net importer of wheat. In all three cases, net exports would have declined (or net imports increased) over time. Instead, by taxing maize and rice production, Tanzania became a net importer of both, and by subsidizing wheat production, it became a less significant net importer of wheat. The picture does not change dramatically when the impact of government consumer prices is added. Not surprisingly, the government's policy of self-sufficiency in food grain production has reduced Tanzania's participation in international trade from net exports of 126.3 thousand metric tons to net imports of 47.9 thousand metric tons in the case of maize; from net imports of 89.0 to 31.5 thousand metric tons of wheat; and from net exports of 80.5 thousand metric tons to net imports of 2.16 thousand metric tons of rice. In the case of maize, policy has also reversed the trend from one of increasing net imports by 21.2 thousand metric tons a year to one of decreasing net imports by 16.3 thousand metric tons.

VII. CONCLUSIONS

It has been shown that government market intervention in Tanzania has effectively divorced the domestic market for food grains from the international market and that this has had a significant impact on external trade in food grains. We have put forward a method, easily duplicated by other researchers, and demonstrated its efficacy in separating short-term government policy from long-term policy, and long-term pricing policy from long-term development trends. While the method can be improved, especially with regard to the treatment of the exchange rate, it utilizes a conceptually simple partial equilibrium framework that estimates endogenously the degree to which domestic prices diverge from international prices without stretching the existing data in most developing countries beyond its limits. In Tanzania, within a general policy of import substitution industrialization that has taxed on net the agricultural sector, specific government policy with regard to food grains can be characterized as one that seeks to maintain a degree of self-sufficiency in food grain production, and that therefore limits the degree of taxation that the government can consistently impose on the food grain sector. External trade in food grains has been very unstable from year to year owing to the operation of short-term constraints and the government's response to them. Over the long run, Tanzania is becoming a higher cost producer of all three food grains in relation to the world price, and therefore in order to maintain its policy of self-sufficiency, taxes of food grains have become lower and lower over time in relation to taxes on export crops.

1/ Food and Agriculture Organization, Provisional Food Balance Sheets, 1972-74 average (Rome, 1977).

2/ United Republic of Tanzania, Ministry of Agriculture, (January 1977) National Development Programs; Phase I, Vol. I, Annex I, pp. 1-2.

3/ The National Agricultural Development Program states that:

> "the broad objective of the Tanzania Government's Agricultural price policy is to maintain the momentum of expanding food crop production but at the same time give greater emphasis to the expansion of export crops by offering farmers renumerative (sic) fixed producer prices and by providing assured markets.. . . In incentives for increased farm output, it is essential that marketing margins be strictly controlled. There is a need for a price policy which aims at steadily improving the earning potential of the peasant producer; this is an essential pre-requisite to the expansion of agricultural production, which in turn has to be achieved to support national economic development."

United Republic of Tanzania (January, 1977) National Agricultural Program: Phase I, vol. I, Annex I, pp. 7-8.

4/ _____, Price Policy Recommendations for the 1979-80 Agricultural Price Review, Annex 1 - Food Crops, Sept., 1978, pp. 70-80.

5/ C. Peter Timmer and Walter P. Falcon (1975a), "The Impact of Price on Rice Trade in Asia," in George S. Tolley and Peter A. Zadrozny, eds., Trade, Agriculture, and Development (Cambridge, Mass: Ballinger). Also, C. Peter Timmer and Walter P. Falcon (1975b), "The Political Economy of Rice Production and Trade in Asia," in Lloyd G. Reynolds, ed., Agriculture in Development Theory (New Haven: Yale University Press).

6/ Philip C. Abbot (1979) "Modeling International Grain Trade with Government-controlled Markets," American Journal of Agricultural Economics 61, pp. 22-31.

7/ While it would have been preferable to use total food aid received from all donor governments, no continuous series was available except for United States government food aid under the PL480 program, which has been the largest source of food aid to Tanzania. All food aid received has been either US dollar credits or donations.

8/ A. Zellner (1962) "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," Journal of the American Statistical Association 57, pp. 348-368.

9/ T. S. Breusch (1979) "Conflict among Criteria for Testing Hypotheses: Extensions and Comments," Econometrica 47, pp. 203-207. The Lagrange multiplier test statistic is given by

$$LM = -2 \log \left(L(\tilde{a}|\tilde{\Omega})/L(\hat{a}|\tilde{\Omega})\right) \quad .$$

where $L(\hat{a}|\hat{\Omega})$ is the maximum likelihood corresponding to the vector of unconstrained parameter estimates, $\hat{a}$, and $L(\tilde{a}|\tilde{\Omega})$ is the maximum likelihood

corresponding to the vector of estimates, $\tilde{a}$. This is similar to the likelihood ratio statistic except that both the constrained and unconstrained parameter estimates, $\tilde{a}$ and $\hat{a}$, are now conditional on the variance-covariance matrix of the disturbances, $\tilde{\Omega}$, corresponding to the constrained estimation.

10/ One of the authors has estimated the equivalent consumer-producer price margins for four countries in East Africa -- Kenya, Zambia, and Malawi in addition to Tanzania -- as part of his Ph.D. research. The overall mean for the four countries comprises one country (Zambia) in which the margin is subsidized very heavily, another country (Malawi) in which it is taxed in order to generate development resources, and two countries (Kenya and Tanzania) where the situation is intermediate.

11/ At the end of 1980, the NMC had a bank overdraft of $US 350 million (at the official exchange rate), which represented 40 percent of all Bank of Tanzania loans. Africa Research Bulletin: Economic Financial, and Technical Series 17 (Exeter, England: African Research Ltd., 1980), p. 5739.

12/ Between 1964 and 1978, agricultural production (both food and export crops) grew by 1.9 percent per year in Tanzania, and food production alone at 3.0 percent. Calculated from USDA, ESCS, "Indices of Agricultural Production in Africa and the Near East," Statistical Bulletins 556 and 623.