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Government intervention in food grain markets is a common feature of most LDCs. Inasmuch as liberalizing markets is difficult for some of these governments, researchers have offered suggestions to reduce detrimental affects of intervention. The general advice for pricing policy has been for governments to set prices at c.i.f. or f.o.b. border prices. In countries where c.i.f. and f.o.b. prices are very different and the countries are marginally self-sufficient, this advice is inadequate. Analysis on which this general advice is based fail to take this and government motivations explicitly into account.

This thesis develops a more flexible model that rationalizes controlled price and stock policy making and takes into account the case of marginally self-sufficient economies. In the framework used, government is assumed to set policy levels as a result of optimizing the expected weighted sum of social incomes to consumers, producers, and taxpayers. Resulting from this optimizing are revealed preferences. Assuming Zimbabwe was optimizing such an objective

function from 1954 to 1986, these revealed preference functions were estimated using policy levels and exogenous factors affecting policy for this period.

Estimation of the model on Zimbabwe showed that the government set price and stock policies with the expectation of future exports. Results also show that Zimbabwe has, on average, fully adjusted its producer prices to world prices during the 1954 to 1986 period. Wholesale prices have only partially adjusted to world prices. The government in addition was influenced by supply and demand conditions. Estimates also show that government held stocks in order to speculate on world prices and that stocks were influenced by previous years' net domestic supply.

The model estimated also allowed for recovery of implicit weights the government has accorded the different economic groups in policy making. Results show that the Zimbabwe government has weighted consumer, producer, and public sector interests roughly in proportions 0.30, 0.35, and 0.35. Since these differ little, results seem to indicate on the average the government has been setting prices to maximize long-run efficiency. Tests showed the model was not very sensitive to small changes in demand and supply slopes.

A number of simulations were conducted to determine effects of exogenous factors and alternative weighting schemes on income distribution and social income stability. Weighting all groups equally resulted in Z$3.13 million more social income than had the optimal solution. However, it reduced stability of incomes in the face of varying exogenous shocks such as in world prices, prices of substitutes, and wage-income. It also reduced total production and exports. Reduction in production was not enough to convert the country from a net exporter to net importer. Thus, intervention has helped growth in the corn industry and stabilized incomes.

Also tested were the scenarios in which economic groups are weighted on the basis of populations and the scenario in which government exercises full monopoly power. The former resulted in less total income and more instability in social income and export earnings. The later resulted in maximal revenue to the government agency but reduced production far enough that corn self-sufficiency gave way to net imports.

Social Welfare-Optimal Policy Rules:
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SOCIAL WELFARE-OPTIMAL POLICY RULES: APPLICATION TO THE ZIMBABWE CORN INDUSTRY

CHAPTER I

INTRODUCTION

During the past quarter century or more, agricultural price policies have received a great deal of attention. A major influence has been the need for governments to be more sure of availability of food supplies at stable and affordable prices, particularly for the urban population, than they would be if food supply and demand were left to unregulated economic forces. Another strong influence is the agricultural production success of developed countries which have intervened in marketing of farm products. The lengthy existence in most countries of the practice and institutions of intervention is by now a strong self-perpetuating factor in the design and implementation of agricultural policy (F.A.O., 1987, p. 1).

The attention to price policy has attracted many studies on the effects of intervention on society welfare. Most of these studies followed the methodology outlined in Tolley, Thomas, and Wong (1982), where government policy is taken to be an exogenous imposition on an otherwise competitive market generated by estimated supply and demand functions. Welfare loss or gain is deduced from Marshallian surpluses with government intervention less surpluses without intervention. Although the above studies recognized the large role of government in the economies of less-developed countries (L.D.C.), little work has been done on the motivations behind government policy decisions themselves.

Governments set prices to achieve certain objectives which are sometimes explicitly stated or can be implied from experience. Typical government objectives (see F.A.O., 1987, p. 59) are to have:

a) Affordable and stable consumer food prices;

b) uninterrupted food supply;

c) stable producer prices, which give farmers incentives to produce;

d) more exports and less imports; and

e) favorable provision for government revenue.

The above objectives themselves do not specify the overall goal of government policy. Objectives (a) and (b) reflect government concern for consumers' welfare, while objective (c) reflects concern for producers' well-being. Objectives (d) and (e) are concerned with cutting treasury losses and enhancing revenue, thereby reducing the burden on taxpayers. It should be apparent from inspection that these objectives can be conflicting. Low consumer prices and high producer prices would imply the government does not pass the increases in producer prices on to consumers. This would require the government--and hence the taxpayers--to absorb the extra costs which would put the government into an unfavorable revenue position.

Thus, in making policy, the government has to trade off these conflicts.

The present study formulates a model to explain government intervention in the same way we explain consumers' and producers' behavior--as a result of maximizing economic gains subject to constraints, as Gardner (1987, p. 346) puts it. If government behavior is endogenously included in a commodity trade model, we can deduce the weights given to different economic groups. Such a model would reflect interaction between policy and the market. We would also be able to map out the effect of "truly" exogenous variables on policy and this would be useful to economic groups' anticipation of future policy.

The objective of this thesis is to gain insights into government price policy intervention in Zimbabwe and to measure econometrically its impact on the welfare of consumers, producers, taxpayers, and on external trade.

The institutional set up in Zimbabwe is typical of most Subsaharan Africa agricultural industries, where government legislates price levels and controls both imports (exports) and stocks. Thus, a model developed for the Zimbabwe case can readily be applied in any of these countries with few modifications. Also, historically Zimbabwe has been a net exporter in corn (see Appendix C). This has not been true for most other Subsaharan nations. Thus, a closer look into policy formation in a relatively successful agricultural sector such as Zimbabwe might shed light on ways to improve these other countries' sectors.

More specifically, the present study sought to pursue the following research questions:

(1) To what factors has the government been responding in price and stock policy formulation?

(2) What implicit weights did the government give each interest group in setting policy levels?

(3) What are the implications of such policy intervention with respect to: (a) income distribution, (b) trade, and (c) stability of exports and interest group incomes.

Literature Review

It is only recently that economists have begun to incorporate government interventions in commodity trade models. This is particularly true in Africa, were government control of food grain marketing is the rule. Most of the studies tended to be prescriptive rather than descriptive. Buccola and Sukume (1987) formulated a model which optimizes government policy variables according to a utility function in which consumer, producer, and taxpayer realizations are arguments. They concluded that Zimbabwe is holding more stocks than would be optimal under alternative objective functions and assumed parameters.

A more recent prescriptive study is by Pinckney (1987) on pricing and stockholding policies in Kenya. Unlike the Buccola-Sukume study, Pickney's model is cast in a dynamic programming framework to optimize set prices and stock levels using a government quadratic loss function. His objective function emphasizes concern for taxpayers, to the exclusion of concern for producers and consumers. This is unrealistic.

Some prescriptive studies emphasize an institutional change in policy setting. An example is the study by Muir, Blackie, and Child (1985), which attacked resource allocation inefficiency built into Zimbabwe's price setting procedure. In particular, the authors criticize panterritorial pricing and suggest a way to make spatial distribution of prices reflective of differences in transport cost between producing and nonproducing areas.

Inherent in these prescriptive studies is the assumption that government is failing in its interventions. The studies do not formally question the motivations behind government actions. Other research has, however, tackled the question of such motivations. This literature arose from realization that, in most agricultural markets, some countries wield power by virtue of the proportion of market they control. Major countries' domestic policies affect the distribution of income generated from external trade. This provides an impetus for such countries to set domestic policies not only to promote supply insurance, price stability, or favorable income distribution, but to extract as many benefits from external trade as possible. The following paragraphs sample some of these studies.

Sarris and Freebairn (1983) developed a theoretically interesting model in which government sets policy to maximize the weighted sum of returns to consumers, producers, and taxpayers assuming the world market is oligopolistic. Their study deduces parameters of government behavioral relationships on the supposition government was historically optimizing in such a framework. Applying the model to major rice exporters and importers, they found governments tend to give more weight to consumers than to producers. The Sarris-Freebairn model, however, does not consider stockholding decisions, which are important in pricing.

Along the lines of the study by Sarris and Freebairn was the study by Paarlberg and Abbott (1986). In their domestic policy formation objective function, Paarlberg and Abbott include private and public stockholding concerns in addition to consumer, producer, and taxpayer concerns. Unlike the Sarris-Freebairn model, their international market interaction uses a game theoretic approach.

Other studies of international market power did not explicitly take into account domestic policy formation (see Abbott 1979; Zwart and Meikle, 1979). These used excess demand and excess supply functions to investigate international market interactions.

Of the studies which concentrated only on domestic policy formation, those by Lopez (1989) and by Gerrard and Roe (1983) are interesting. According to Lopez, the U.S. government considers the concerns of consumers, producers, treasury, and foreign interests in formulating sugar policies. Unlike the studies considered above, this study uses an objective function where incomes to the different economic groups are the independent variables. The effects of different policies and exogenous variables are then simulated using parameters estimated for the objective function. This has the advantage of limiting the number of variables in the model but has the disadvantage of being restrictive.

The study by Gerrard and Roe is the first of its kind on controlled pricing. It is also interesting for this particular study because the country considered, Tanzania, has a marketing system similar to that in Zimbabwe and indeed most former British colonies in East and Central Africa. Gerrard and Roe developed a model in which government price setting and stockholding behavior were endogenous to the model but exogenous to consumers and producers. Policy levels were derived from optimizing a quadratic loss function where the policy maker minimizes the weighted sum of deviations of set policy from the market clearing level in a closed economy (i.e. self-sufficiency) and in an open economy (i.e. World price). Results of their study shows that Tanzania has been following a policy of relative self-sufficiency with the domestic market in food insulated from the international market. However, the objective function concentrated on only secondary objectives: self-sufficiency and welfare loss due to insulating the domestic from the world market.

Policy Context

Agriculture has historically been the backbone of the Zimbabwe economy annd is likely to remain the dominant sector for the foreseeable future. Almost 75 percent of the population depends on production and processing of agricultural products for their livelihood. Agricultural production alone comprises about 13 percent by value of the gross domestic product of Zimbabwe. In addition, 41 percent of all merchandise exports are accounted for by agriculture (Blackie).

The agricultural sector in Zimbabwe, like in most other Subsaharan Africa countries, is dual in nature, comprising a highly mechanized large-scale commercial subsector and a part-subsistent small-scale farming subsector. The commercial sector comprises about 4,100 farmers, mainly descendents of white settlers. The small-scale sector, on the other hand, is made up of over 800,000 farmers.

Although small in number, large-scale farmers have historically had the largest role in shaping Zimbabwe agricultural policy. Their farmers' associations, namely the Zimbabwe Tobacco Association and the Commercial Farmers Union, which have been in existence for more than 50 years, have effectively lobbied for their interests. Also before 1980 most elected officials in government came from this sector. In the early 1930s, they successfully lobbied for the formation of the Grain Marketing Board (G.M.B.) to bail them out of losses due to low corn prices on the world market. In the early sixties, they again successfully lobbied for the inclusion of other grains under control of the G.M.B., and pushed for the formation of the cotton marketing board (Blackie).

By 1965 the whole institutional environment under which the governing of agricultural policy is enforced today was already set up. The general theme of policy was self-sufficiency and generation of export revenue. This theme was further emphasized with the illegal declaration of independence by settler whites from colonial Great Britain in 1965 and the subsequent imposition of economic sanctions in the early seventies. This made self-sufficiency in all agricultural products a necessity and further tightened government controls over the agricultural economy.

The majority ruled government which came into power in 1980 maintained the tight control of the agricultural sector. It also maintained the close relationship with large-scale commercial farmers' associations, who up until 1980 supplied over 90 percent of food to the urban consumers. In addition, the present government wanted to improve the welfare of previously ignored small-scale farmers. To do this it embarked on programs to improve access to credit and inputs, and to markets. The result was a dramatic increase in marketed surplus from this sector such that by 1984, 45 percent of corn purchases by the government came from this sector. Another reason which has encouraged the continuation of strong government control has been the fear of South Africa denying access to its ports in the event of deficits, expecially for staple grain like corn. It is against this background that this thesis tries to gain insights into government policy formulation behavior between the years 1954 to 1986.

Corn Marketing Intervention in Zimbabwe

Zimbabwean food grain policy has had a major impact on corn production and consumption. The historical developments and mechanics of this policy have been covered in detail elsewhere (Muir, 1984) and only a brief overview will be given here. The government in Zimbabwe has intervened in corn marketing for more than 50 years.

Intervention policies began with the Maize Control Act of 1931, largely as a result of large scale farmer lobbying efforts. The Act led to the establishment of the Grain Marketing Board (G.M.B.), which is legally the sole buyer of corn from large scale farmers and the only seller to milling companies and retailers. Small-scale farmers are also required to sell to the G.M.B., although they can sell corn to private buyers within their resident districts.

The government in Zimbabwe sets producer and consumer prices for corn annually. This occurs in the second half of the calendar year, prior to planting for the November-to-April rainy season. Government's panterritorial policy requires that these official prices be applied uniformly throughout the country. The G.M.B. is responsible for guaranteeing prices at producer and wholesale levels, while the Ministry of Trade and Commerce enforces prices at the consumer level. The G.M.B. also holds government corn stocks to smooth out seasonal fluctuations in supplies and year-to-year contingencies in case of deficits in production. To the extent that the G.M.B. incurs losses within government-determined price margins, it is covered by government subsidy.

In setting producer prices the Agricultural Marketing Authority (A.M.A.), a body responsible for coordinating parastatal marketing boards, and producer representatives first analyze trading accounts and production costs and prepare background papers. The A.M.A. then forwards recommendations to the Ministry of Agriculture. These recommendations are then deliberated on by producer representatives, the A.M.A., and Senior Ministry officials. Results of such meetings aid the Minister of Agriculture in making recommendations on prices to the government-appointed Ministerial Economic Coordinating Committee (M.E.C.C.), consisting of representatives from all economic ministries. The M.E.C.C., in turn, makes recommendations to the cabinet. M.E.C.C. jointly views producer price and consumer price recommendations, the later coming from the Ministry of Trade and Commerce. Cabinet makes the final decisions on producer and consumer prices. Thus, the resulting decision is not based on some specific formula, but from a balance of economic and political considerations.

CHAPTER II

FRAMEWORK

The present study assumes that policymakers' behavior can be modelled as the solution of an expected welfare maximization. In this framework, producer and consumer welfare, government treasury gains, and preferences for price stability are explicitly traded off. The policymaker's criterion function is of the form:

$$W = \lambda_s PS + \lambda_d CS + \lambda_g G \tag{1}$$

where λ_i are weights attached to producers', consumers', and taxpayers' welfare by the policymaker; and PS, CS, and G are social incomes accruing to each of these economic groups respectively.

The following subsections derive policy formulation based on the above premise.

Government Social Income

Modelling of government income used in this study is similar to that of Buccola and Sukume (1988). The government through its statutory marketing board has monopoly in grain procurement and is the sole supplier to processors. In addition, the marketing board is also the sole exporter and importer and keeps most of the nation's strategic grain reserves. Costs and benefits contributing to government income can be broadly grouped into (i) procurement costs and domestic sales revenue, (ii) trade costs and benefits, and (iii) storage costs.

Procurement Costs and Domestic Sales Revenue

At the end of marketing year t, the policymaker sets producer price, P_t^s, and wholesale (to-processor) price, P_t^d, prior to planting for the t+1 harvest. Thus P_t^s and P_t^d are set strategically to affect quantities Q_{t+1}^s supplied and Q_{t+1}^d demanded in year t+1. These quantities are functions of price assumed known up to random error terms e_1 and e_2. To allow an analytical policy soluton, the functions are assumed linear. Thus,

$$\begin{aligned} Q_{t+1}^d &= \delta_0 - \delta_1 P_t^d + \delta_2 Z_d + e_1 \\ Q_{t+1}^s &= \gamma_0 + \gamma_1 P_t^s + \gamma_2 Z_s + e_2 \end{aligned} \tag{2}$$

with δ_1, $\gamma_1 > 0$. Z_d and Z_s are other factors affecting demand and supply, respectively.

Since government buys all the grain offered by the farmers and sells any quantity demanded by processors, procurement costs and domestic sales revenue are respectively given by:

$$\begin{aligned} Q_{t+1}^s(P_t^s + \beta) &= (\gamma_0 + \gamma_1 P_t^s + \gamma_2 Z_s + e_2)(P_t^s + \beta) \\ Q_{t+1}^d(P_t^d - \alpha) &= (\delta_0 - \delta_1 P_t^d + \delta_2 Z_d + e_1)(P_t^d - \alpha) \end{aligned} \tag{3}$$

where β is per unit assembly cost from farmers to depot and α is per unit distribution cost from terminal depot to processors.

Trade Costs and Benefits

At the end of period t, government determines current exports X_t by deducting its desired carry-in stocks, S_t, from any current surplus $SS_t = S_{t-1} + Q_t^s - Q_t^d$. In the event of a current deficit, SS_t

is negative. If current surplus is not enough to cover desired carry-in stocks, X_t is negative, implying an import. A decision on how much stocks to carry in thus implies a decision on exports (imports), and this decision is assumed made at the same time as the pricing decision. In the same way as X_t, the board's exports at the end of t+1 are $X_{t+1} = S_t + Q^s_{t+1} - Q^d_{t+1}$.

At decision period t, however, the board does not know whether it will be an exporter or an importer at t+1 and hence does not know whether it would face f.o.b. or c.i.f. border price. The likelihood of either happening would depend on S_t and supply and demand in t+1, which in turn depends on government-set prices P^s_t and P^d_t. The board's trade revenue (cost) can be represented thus:

$$R_{t+1} = [S_t + Q^s_{t+1} - Q^d_{t+1}][(W_{t+1} - T)I + (W_{t+1} + I)(1-I)] \qquad (4)$$

where W_{t+1} is world price in t+1 at an internatonal pricing point; T is unit cost of transfer to and from the pricing point, and I is an indicator variable defined as follows:

$$I = \begin{cases} 1 \text{ if } X_{t+1} = S_t + Q^s_{t+1} - Q^d_{t+1} \geq 0 \\ 0 \text{ otherwise} \end{cases}$$

<u>Storage Costs</u>

In the present model the board is assumed at time t to purchase at current f.o.b. price any carry-in stocks S_t from its preceding fiscal year t-1. This is the income foregone by not exporting the surplus. In addition the board incurs variable storage costs such as for fumigation and storage bags, which depend on the amount being stored. Assuming such variable costs are quadratic in stock levels, total storage and "purchase" cost incurred by government is:

$$ST_t = S_t(W_t - T) + cS_t^2 \tag{5}$$

where c is a cost parameter.

Consumer and Producer Income

Social income accruing to consumers and producers at time t+1 are represented by Marshallian consumer and producer surpluses, respectively. At time t+1 these are:

$$CS_{t+1} = \int_{P_t^d}^{\infty} (\delta_0 - \delta_1 P_t^d + \delta_2 Z_d + e_1) dP_t^d$$

and (6)

$$PS_{t+1} = \int_0^{P_t^s} (\gamma_0 + \gamma_1 P_t^s + \gamma_2 Z_s + e_2) dP_t^s$$

Policymaker's Criterion Function

Income realizations which occur after decision time t have to be discounted back to t by a social discount rate i. Of all the income figures making up criterion function (1) (discussed in Government Social Income and Consumer and Producer Income above), only the opportunity cost of carry-in stocks is incurred at decision time t. Even though some of these incomes are realized continuously over the period t to t+1, they are assumed realized at the end of period t+1.

Since the policy maker does not have perfect knowledge of outcomes at t+1 when making a decision at time t, he has to formulate expectations of them. That is, the policy maker sets policy to maximize expectation at t of the weighted sum of social incomes at t+1,

$$\begin{aligned} E_t(Y_{t+1}) = {} & \lambda_g \zeta E_t[R_{t+1} + Q^d_{t+1}(P^d_t - \alpha) - Q^s_{t+1}(P^s_t + \beta) \\ & \quad - cS^2_t - (1/\zeta)S_t(W - T)] \\ & + \lambda_d \zeta E_t[\int_{P^d}^{\infty} Q^d_{t+1}\, dP^d_t] \\ & + \lambda_s \zeta E_t[\int_0^{P^s} Q^s_{t+1}\, dP^s_t] \end{aligned} \tag{7}$$

where $E_t(\bullet)$ is expectation at t of $(\bullet)$, ζ is $(1/1+i)$, and λ_i's $(\Sigma\lambda_i=1)$ are welfare weights assigned to board income, consumer and producer surpluses.

Because of the linearity and additive error assumptions in supply and demand relationships, the policy maker's criterion function reduces to:

$$\begin{aligned} E_t(Y_{t+1}) = {} & \lambda_g \zeta [E_t(R_{t+1}) + (P^d_t - \alpha)(\delta_0 + \delta_1 P^d_t + \delta_2 Z_d) \\ & - (P^s_t + \beta)(\gamma_0 + \gamma_1 P^s_t + \gamma_2 Z_s) - cS^2_t \\ & - (1/\zeta)S_t(W - T)] \\ & + \lambda_d \zeta \int_{P^d}^{\infty} (\delta_0 + \delta_1 P^d_t + \delta_2 Z_d)dP^d \\ & + \lambda_s \zeta \int_0^{P^s} (\gamma_0 + \gamma_1 P^s_t + \gamma_2 Z_s)dP^s \end{aligned} \tag{7'}$$

Looking closely at the government trade revenue equation (4), it can be noted trade revenue is subject to three sources of risk: (a) world price W_{t+1} is random; (b) exportable surplus (importable deficit) X_{t+1} is random; and (c) because X_{t+1} may be positive or negative, I is also random. If X_{t+1} is positive, the board's unit trade revenue is a random value equal to $(W_{t+1} - T)$; if on the other hand X_{t+1} is negative (i.e., in case of a deficit), unit cost is the random value $(W_{t+1} + T)$. Taking the expectation of (4) over random variables Q^d, Q^s, and W, and assuming e_1 and e_2 independent of W, gives the expected trade revenue:

$$E_t(R_{t+1}) = [S_tE_t(I) + E_t(Q^s_{t+1}I) - E_t(Q^d_{t+1}I)](W^* - T) \quad (8)$$
$$+ \{S_tE_t(1-I) + E_t[Q^s_{t+1}(1-I)] - E_t[Q^d_{t+1}(1-I)]\}(W^* + T)$$

where W* denotes expected world price in t+1; $E_t(I)$ is the probability that there would be an exportable surplus, and $E_t(1-I)$ the probability of imports in t+1. If government expects exportable surplus, I would be identically one and (8) reduces to $E_t(R_{t+1}) = E_t(X_{t+1})\bullet(W^* - T)$. By the same reasoning if policy makers are virtually certain of a deficit in supply, expectation of trade revenue reduces to $E_t(X_{t+1})\bullet(W^* + T)$ where $E_t(X_{t+1})$ is negative. However, in situations discussed by Jabara (for Kenya) and Gerrard and Roe (for Tanzania), for example, direction of trade can be uncertain and simplifications just mentioned would be difficult to defend.

Optimization of Criterion Function

Approximations to optimal price and stock policy can be obtained by differentiating (7′) with respect to the policy variables P^s, P^d, and S_t, solving for first order conditions, and checking that second order conditions hold. It is apparent from (7′) that differentiating all terms except $E_t(R_{t+1})$ would yield expressions linear in the policy variables. If $E_t(R_{t+1})$ also were quadratic in the policy variables, first order conditions would be linear functions.

Alternatively we can write the expression of expected trade revenue in terms of net domestic supply, X_{t+1}, as:

$$E_t(R_{t+1}) = E_t(X_{t+1}I)(W^* - T) + E_t[X_{t+1}(1-I)](W^* + T). \tag{9}$$

Because X_{t+1} is linear in the policy variables and the latter affect trade revenue through net supply, if we specify the effect of X_{t+1} on R_{t+1}, the effect of individual policy variables easily follow. Thus, if we denote $\partial E_t(R_{t+1})/\partial E_t(X_{t+1})$ by D_x, the partial effects of individual policies on trade revenue would be:

$$\begin{aligned} \frac{\partial E_t(R_{t+1})}{\partial P_t^s} &= D_x \gamma_1 \\ \frac{\partial E_t(R_{t+1})}{\partial P_t^d} &= D_x(-\delta_1) \\ \frac{\partial E_t(R_{t+1})}{\partial S_t} &= D_x(1) \end{aligned} \tag{10}$$

Now for D_x we have from (9):

$$D_x = \frac{\partial E_t(X_{t+1}I)}{\partial E_t(X_{t+1})}(W^* - T) + \frac{\partial E_t[X_{t+1}\,(1-I)]}{\partial E_t(X_{t+1})}(W^* + T)$$

<u>or</u>

$$D_X = W^*\{\frac{\partial E_t(X_{t+1}I)}{\partial E_t(X_{t+1})} + \frac{\partial E_t[X_{t+1}\ (1-I)]}{\partial E_t(X_{t+1})}\}$$

$$- T\{\frac{\partial E_t(X_{t+1}I)}{\partial E_t(X_{t+1})} + \frac{\partial E_t[X_{t+1}\ (1-I)]}{\partial E_t(X_{t+1})}\} \tag{11}$$

Now let X_{t+1} be (y+u) where y is expected net supply ($S_t + E_t(Q^s_{t+1}) + E_t(Q^d_{t+1})$) and u is error term of net supply (= $e_2 - e_1$). Then D_X can be reduced to:

$$D_X = W^* - T\{\partial[2yE_t(I) + 2E_t(uI) - y]/\partial y \tag{12}$$

Relationship (12) shows that as expected net domestic supply y increases indefinitely, probability $E_t(I)$ of exports increases and approaches unit in the limit. $E_t(uI)$ would approach $E_t(u)$ or zero and the bracketed term after T reduces to $\partial y/\partial y$ or unit. On the other hand as $E_t(X_{t+1})$ decreases indefinitely, the probability of imports increases and $E_t(I)$ and $E_t(uI)$ both approach zero and the bracketed term after T reduces to $\partial(-y)/\partial y$ or -1. Thus the effect of net domestic supply on the board's trade revenue ranges continuously from (W* + T) to (W* - T) as net domestic supply increases. This can be graphically illustrated by Figure 1 for normally distributed supply and demand errors.

The relationship depicted by Figure 1 could be described by the logistic function:

$$D_X = W^* + T - 2T/\{1 - \exp[-hE_t(X_{t+1})]\}$$

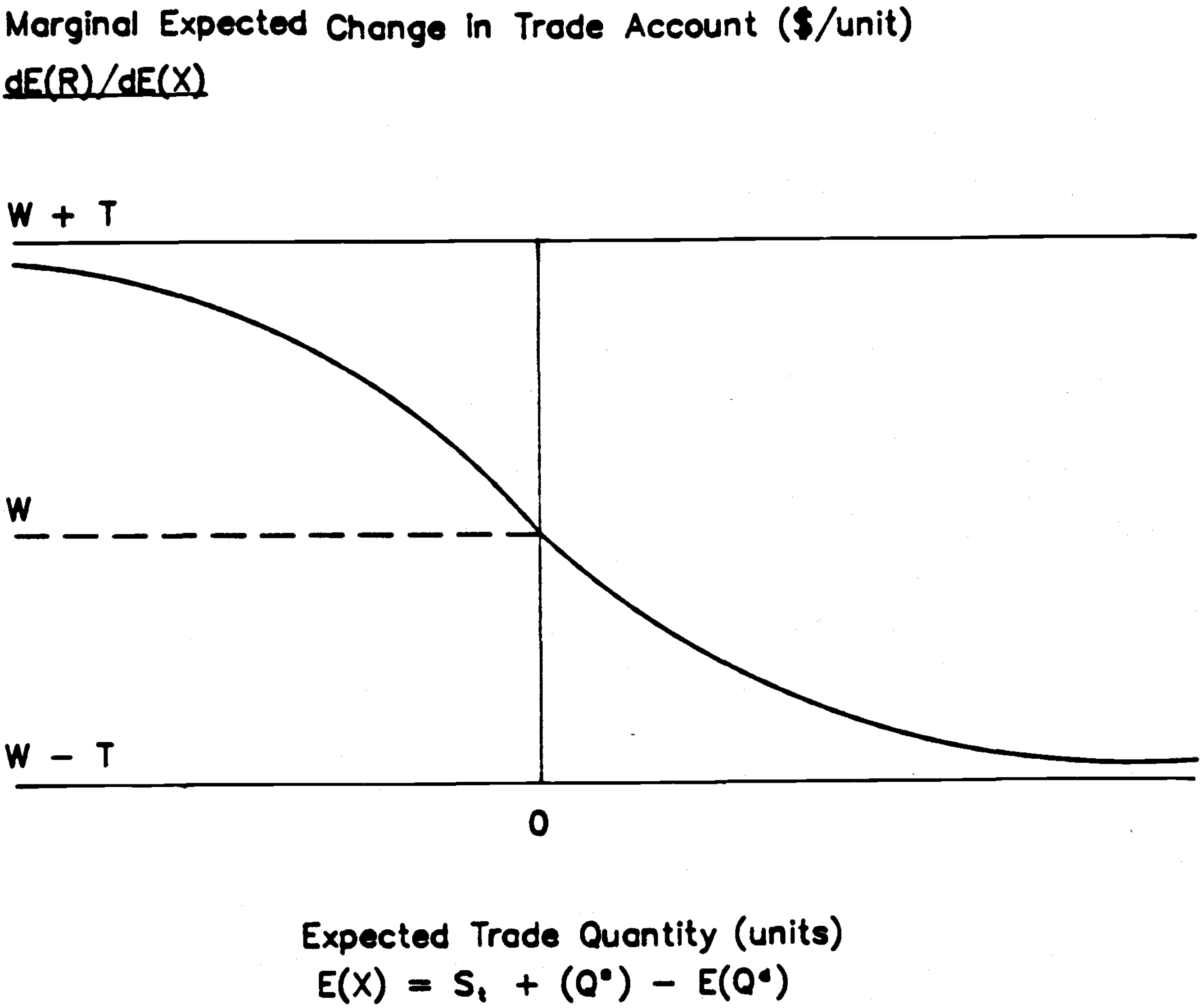

Figure 1. Impact of expected trade quantity on marginal expected change in trade revenue or cost.

where h is determined by ex ante variance of net domestic supply (see Appendix A). As variance of net domestic supply, $Var(X_{t+1}) \equiv Var(e_2 - e_1)$ increases, value of h drops and the graph in Figure 1 flattens, signifying reduced sensitivity of marginal expected trade revenue (or cost if negative) to expected net domestic supply. To facilitate an analytical policy solution, the relationship in Figure 1 can be broken down into three linear segments:

$$D_X = \begin{cases} \text{(a)} \quad W^* + T & \text{if } \infty^- < E_t(X_{t+1}) \leq -1/k \\ \text{(b)} \quad W^* - TkE_t(X_{t+1}) & -1/k < E_t(X_{t+1}) < 1/k \\ \text{(c)} \quad W^* - T & 1/k \leq E_t(X_{t+1}) < \infty^+ \end{cases} \qquad (k > 0) \tag{13}$$

where k is the slope of the middle segment. One might look at 1/k as the expected net domestic supply above which the policy maker is virtually certain there would be exports. If the policy maker is virtually certain there will be exports or certain there will be imports, then the D_X he uses is (13c) or (13a), respectively, otherwise he would use (13b).

Differentiating the other quadratic relationships and incorporating relationship (13) into (10) gives first order conditions from which government intervention rules or policy formation equations are derived.

Policy Formulation Equations

Case 1: Direction of Trade Uncertain (13b). First consider the case of a marginally self-sufficient country. This is the case represented by (13b), where $D_X = W^* + TkE_t(X_{t+1})$. The resultant first order conditions yield the optimal policy instruments:

$$P_t^d = a_0 + a_1W^* + a_1Tk(S_t + \gamma_1P_t^s + \gamma_2Z_s) + (1-a_1)(\delta_2/\delta_1)Z_d \quad (14)$$

$$P_t^s = b_0 + b_1W^* + b_1Tk(S_t - \delta_1P_t^d + \delta_2Z_d) - (1-b_1)(\gamma_1/\gamma_1)Z_s$$

$$S_t = c_0 + c_1[W^* - 1/\varsigma)W_t] + c_1Tk(\delta_1P_t^d + \gamma_1P_t^s - \delta_2Z_d + \gamma_2Z_s)$$

where, as shown in Appendix B, coefficients are:

$$a_0 = \frac{Tk(\gamma_0 - \delta_0) + \alpha + (\delta_0/\delta_1)(1 - \lambda_d/\lambda_g)}{-Tk\delta_1 + 2 - \lambda d/\lambda g}$$

$$a_1 = 1/(-Tk\delta_1 + 2 - \lambda_d/\lambda_g)$$

$$b_0 = \frac{Tk(\gamma_0 - \delta_0) - \beta - (\gamma_0 /\gamma_1)(1 - \lambda s/\lambda g)}{-Tk\gamma_1 + 2 - \lambda s/\lambda g}$$

$$b_1 = 1/(-Tk\gamma_1 + 2 - \lambda s/\lambda g)$$

$$c_0 = Tk(\gamma_0 - \delta_0)/(-Tk + 2c)$$

$$c_1 = 1/(-Tk + 2c)$$

It is apparent from equation (14) that when direction of trade is uncertain, levels of policy instruments are simultaneously determined. Each of the policy instruments depends on the other two, on world prices, and on demand and supply shifters, Z_d, Z_s. Interaction among policy instruments comes about because each policy affects net domestic supply, the effect on expected trade revenue of which determines the combination of c.i.f. and f.o.b. prices to which the other two respond. The equations also highlight the importance of government assumptions on parameters of demand and supply shifters. These affect sensitivity of policy levels to demand and supply shifters Z_d, Z_s. Thus, if the effect of the shifters on supply and demand is large, this translates into a strong effect of shifters on policy levels.

If demand and supply parameters are known, estimates of equation (14) may be used to recover values which government assigns to trade revenue parameters Tk, cost parameters α, β, c, and economic group welfare weights λg, λd, λs. For example, we can deduce Tk from a_1, the coefficient of W*, and from the coefficient (a_1Tk) of S_t in (14a). Using the estimated Tk, we can deduce c from equation (14c), $\lambda d/\lambda g$ from a_1 in equation (14a), and $\lambda s/\lambda g$ from equation (14b). Utilizing the identity $\Sigma\lambda_i = 1$, we can recover λs, λd, and λg. Within- and cross-equation restrictions in (14) ensure that unique values of parameters a_1, b_1, c_1, Tk are implied at the optimum (see Appendix B).

<u>Case 2: Direction of Trade Certain</u>. If the government is virtually certain there will be an exportable surplus (or imports), it would base its price and stock policy on f.o.b. price (c.i.f. price). This is the case represented by segment (13c) [(13a)]. In this case first order conditions for an export good would yield:

$$P_t^d = a_0' + a_1'W^* + (1 - a_1')(\delta_2/\delta_1)Zd \qquad (15)$$

$$P_t^s = b_0' + b_1'W^* - (1 - b_1')(\gamma_2/\gamma_1)Zs$$

$$S_t = c_0' + c_1'[W^* - (1/\zeta)W_t]$$

where (Appendix B),

$$a_0' = [(\alpha - T) + (\delta_0/\delta_1)(1 - \lambda d/\lambda g)]/(2 - \lambda d/\lambda g)$$

$$a_1' = 1/(2 - \lambda d/\lambda g)$$

$$b_0' = [(-\beta - T) - (\gamma_0/\gamma_1)(1 - \lambda s/\lambda g)]/(2 - \lambda s/\lambda g)$$

$$b_1' = 1/(2 - \lambda s/\lambda g)$$

$$c_0' = 0$$

$$c_1' = 1/2c.$$

The relationships would be identical for the import good except -T in a_0' and b_0' is replaced by +T.

Equations (15) say that if direction of trade is certain, price and stock policy would be determined independently of each other. Producer price depends only on expected world price and on other factors affecting supply, while consumer price depends only on world price and demand shifters. However, even though consumer and producer prices are independently determined, they would be correlated since they move in the same direction with world prices. Stocks depend only on expected change $[W^* - (1/\zeta)W_t]$ in discounted world prices.

Second order conditions for maximum welfare in Case 2 are that a_1', b_1', and c_1' be positive. This implies in turn that $\lambda g > .5\ \lambda d$, $\lambda g > .5\ \lambda s$, and $c > 0$. This insures that government treasury has some weight and removes the trivial phenomenon in which consumer and producer welfare can be increased indefinitely by continuously lowering consumer prices and raising producer prices with government absorbing costless losses. The upper bound on government weight is 1.0, at which consumers and producers have zero weight. This is a situation where government would be acting as a profit maximizing monopolist.

<u>Case 3: Direction of Trade Certain and Welfare Weights Equal</u>. If in Case 2 we weight consumers, producers, and government equally ($\lambda g = \lambda d = \lambda s$), we derive an important special case. This case is equivalent to maximizing the discounted sum of consumer and producer surplus and government income, which is the criterion used in most studies on optimal price and stock policy in LDCs. Intervention rules in this case would, for an exported good, be:

$$P_t^d = \alpha - T + W^* = (W^* - T) + \alpha$$

$$P_t^s = -\beta - T + W^* = (W^* - T) - \beta.$$

This is equivalent to setting prices at expected world prices. The board's domestic selling price is f.o.b. price plus transfer cost to processors, while farm purchasing price is f.o.b. price less to-depot transfer cost. For imported grain, corresponding intervention rules would be c.i.f. border prices adjusted for transfer costs.

Case 3 is equivalent to maintaining a nominal protection coefficient $(P^d - \alpha)/(W^* \pm T)$, $(P^s + \beta)/(W^* \pm T)$ equal to one. This is equivalent to setting prices at their long-run competitive equilibria, which yields the greatest economic surplus.

Case 3 is used as the standard advice on price policy in LDCs. Under conditions of known trade direction and a goal of maximizing long-run efficiency, it is good advice. However, Cases 1 and 2 show that it is not valid advice under all circumstances. For instance, equation (14) shows that if trade direction is uncertain, the long-run efficiency goal still yields partial adjustment intervention rules because of the $(-Tk\delta_1)$ and $(-Tk\gamma_1)$ terms in the denominators of the W* coefficients. The present study seeks to clarify these points and provide a basis for econometric estimation of controlled price and stock relationships. Using (14) and (15), one can estimate welfare weights and cost parameters government has employed in setting domestic price and stock levels. This framework was used to analyze government intervention in the Zimbabwe corn market.

CHAPTER III

SPECIFICATION

Supply and Demand

The aggregate supply function considered in this study is for corn quantities marketed through official channels. Buccola and Sukume (1988) estimated separate functions for large scale commercial and small scale farmers using nonlinear forms. In this study, an aggregate linear supply function was instead specified. In addition to own price, supply was hypothesized to be affected by product price of flue-cured tobacco, the main corn substitute in production, and by varietal and management improvements represented by a time trend.

Demand was estimated at the wholesale level where information is readily available. Also, since retailer price is determined officially by adding miller and retailer cost, surplus derived from such a function would approximate that from a primary demand function. The function considered does not incorporate demand for home grown and custom milled corn meal. It only considers demand by large scale commercial millers who buy their corn from the government marketing board (G.M.B.). It is hypothesized that the main demand shifters are income and the price of wheat, wheat being the principal substitute in consumption.

Policy Formation Equation

Equations (14) are underidentified for econometric estimation purposes. However, governments which control prices claim one of their objectives is to stabilize prices and stocks (F.A.O., p. 59). They do that by only partially adjusting to new information on exogenous variables. This may be tested by including lagged endogenous variables P^d_{t-1} in (14a), P^s_{t-1} in (14b), and SS_{t-1}, the potential carry-in stocks at t, in (14c). Variable SS_{t-1} is equal to $(S_{t-1} + Q^s_t + Q^d_t)$, which contains S_{t-1} and thus tests for the stabilization objective. Potential carry-in stocks should affect actual carry-in because a land locked country such as Zimbabwe would not import corn that it expects to export the following year. Equation (15) is expanded to include the same lagged endogenous variables.

CHAPTER IV

DATA SOURCES AND TREATMENT

Prices

Corn Producer Prices

Annual corn producer prices were obtained from the Agricultural Marketing Authority of Zimbabwe. Prices indicated for each year are prices which were set that year to affect planting in the coming rainy season. This needs clarification because prior to 1975 the Zimbabwe government announced prices at the start of the harvest season. From 1976 onward, government set pre-planting floor prices to affect future harvest. It is assumed in this study that before preplanting price announcements began, producers used prices which government had paid for the preceding harvest as expectations of prices they would get for the coming harvest. Also, government sets post-planting prices to influence farmers' future planting decisions (see Jayne and Thompson, 1987). Producer prices in Z$/MT were deflated using the consumer price index for low income families (1980 = 100). Data on consumer price indices are published regularly in the Monthly Statistical Digest--a publication of the Central Statistical Office of Zimbabwe.

Tobacco Producer Price

Tobacco prices are annual averages of auction prices of flue-cured tobacco in Z$/t. Data on these prices were obtained from annual reports of the Zimbabwe Tobacco Association. Tobacco prices were deflated using the low income consumer price index (1980 = 100).

Wholesale Corn Price (Z$/MT)

Wholesale corn prices, P_d, i.e. prices charged to millers by the G.M.B., were obtained from the A.M.A. These prices were then deflated using the low income consumer price index.

Wholesale Wheat Prices

Annual wholesale wheat prices, P_{wh}--prices paid by millers--were obtained for the years 1959 to 1986 from the A.M.A. Of these, only prices from 1969 to 1986 were government-set prices. Before 1969, wholesale wheat prices were not controlled by government and millers could import wheat on their own. Thus, prices from 1959 to 1969 are landed import prices. To get landed prices for 1953 to 1959, a linear extrapolation was performed on the series from 1959 to 1969 using the relationship between Chicago Wheat Prices and the 1959-1969 series. The relationship used was:

$$P_{wh} = \underset{(1.83)}{68.6} - \underset{(-2.55)}{.328}\,CWP$$

$$R^2 = .31$$

where CWP is the Chicago Wheat Price and the numbers in parentheses are t-statistics. Estimates of P_{wh} for 1953 to 1959 were obtained by substituting corresponding values of CWP. Data on CWP were obtained from the International Financial Statistics Yearbook, a publication of the I.M.F. Resulting wholesale wheat price series was deflated using the low income consumer price index.

World Prices

Two world price variables were used in the study, both derived from annual average Gulf Port corn price, GP. The first of these was the expected world price in period t, which was calculated from the Gulf Port price (US$/MT) as follows:

$$E_{t-1}(WP_t) = (GP_{t-1} + GP_{t-2} + GP_{t-3})ER_{t-1}/3$$

where $E_{t-1}(WP_t)$ is the expectation in t-1 of the world price and ER_{t-1} is the Zimbabwe-dollar-to-US-dollar exchange rate. The other variable was the expected change in world price derived from the relationship:

$$ECWP_{t-1} = E_{t-1}(WP_t) - WP_{t-1}$$

where $ECWP_{t-1}$ is the expectation in period t-1 of change in world price. Both $E_{t-1}(WP_t)$ and $ECWP_{t-1}$ were deflated using the low income consumer price index. Gulf Port corn prices were obtained from the I.M.F.'s International Financial Statistics Yearbook.

Income

The income variable, INC_t, is total income in million Z$ paid to Black employees each year. Annual figures were available on a calendar year basis from the Central Statistical Office (C.S.O.) of Zimbabwe for the years preceding 1979. As of 1979, however, the

C.S.O. stopped publishing disaggregated income figures. Annual income data for 1979 to 1984 were obtained by multiplying total income by an estimate of the proportion of Black to total national income. The resultant series was deflated using low income consumer price index.

Quantities

Supply quantities, Q_s, used in the study were taken to be total sales by farmers to the G.M.B. in thousands of metric tons. Annual total sales were obtained from the A.M.A. Demand quantities, Q_d, i.e. amounts of corn sold to millers by the G.M.B., were also obtained from A.M.A.

Stocks available, S_{t-1}, represent quantities of corn carried over into the new decision period. Data for this variable were obtained from the G.M.B. Another related variable is SS_t, representing supply of stocks, which is deduced from the following relationship:

$$SS_t = S_{t-2} + Q_{s,t-1} - Q_{d,t-1}$$

as indicated in Chapter II.

CHAPTER V

ESTIMATION

Demand and Supply

Since in the specification of demand and supply, prices are set by government, farmers and consumers take these prices as exogenous. Demand and supply shifters are also exogenous, so that estimation using ordinary least squares (OLS) should yield consistent estimates. However, applying OLS to these models gave Durbin-Watson (DW) values significantly different from 2, hinting at the presence of first-order serial correlation. To correct for this, the Cochrane-Orcutt iterative specification was employed for the results shown in Table 1.

In the demand function estimates all variables have the right signs and the R^2 of 0.83 suggests the main factors affecting demand have been included. None of the factors except wages have coefficient estimates significant at the five percent level. This can partially be attributed, perhaps, to the linearity restriction imposed on the function.

All supply function estimates are, in addition to showing the expected signs, significant at the five percent level. A 0.90 value for the R^2 indicates the variables accounted for most of the variation in marketed corn.

Table 1. Wholesale Demand and Producer Supply of Corn Facing Zimbabwe Grain Marketing Board, 1954-1986.[a]

Factor	Slope	Standard Error	Elasticity at Centroid
Demand			
Corn Whole Price P^d (Z$/ton)	-2.62	1.97	-0.60
Wheat Wholesale Price P^{wheat} (Z$/ton)	2.03	1.61	0.64
Industry wages Wg (million Z$)	0.54	0.11	0.86
Constant	46.37	301.02	
	Mean Q^d = 416.99	R^2 = 0.83	
	s.d. Q^d = 271.1	rho = 0.46 (2.13)	
Supply			
Corn Producer Price P^s (Z$/ton)	9.69	3.32	0.97
Tobacco Producer Price P^{tob} (Z$/ton)	-0.54	0.24	-0.91
Time	37.88	8.12	
Constant	63.51	381.6	
	Mean Q^s = 774.29	R^2 = 0.90	
	s.d. Q^s = 496.36	rho = 0.07 (2.42)	

[a] Demand and supply quantities are in thousands of tons. Price and wage data are deflated by the CPI for lower-income families. Z$ refers to Zimbabwe dollars.

Policy Formation Equations

Case 1

Equations of the expanded form of (14) are simultaneous and linear in the variables. However, cross-equation restrictions for the system are nonlinear. Also, by the nature of their derivation, the equations' error terms are related. A simultaneous equation system with contemporaneous error correlations can be consistently and efficiently estimated using three-stage least squares (3SLS). Because of nonlinearity in the restrictions, the system was estimated using nonlinear 3SLS employing a Gauss-Newton iterative subroutine.

Estimation of equation (14) gave h-statistics indicating error terms were significantly and positively serially correlated.

Serial Correlation Correction. Sargan (1958) proposed various maximum likelihood estimators for estimating simultaneous equations that are serially correlated and that have lagged endogenous variables. These estimators however saw limited use because of the large number of regressors they introduced. Fair (1970) developed 2SLS and 3SLS estimators which required fewer regressors than Sargan's approach.

In Fair's approach, each equation can be represented in the form:

$$y - ry_{-1} = -A(Y - rY_{-1}) - B(X - RX_{-1}) + [(r^* - r)u_{-1} + e_1] \qquad (17)$$

where y is the endogenous variable under consideration; Y is a vector of included endogenous variables; X is a vector of included exogenous variables and y_{-1}, Y_{-1}, and X_{-1} are their lags; r^* is the actual correlation coefficient; r is the trial correlation coefficient; A and B are vectors of parameters; u_{-1} is error term in the original specification; and e_{-1} is the nonserially correlated error term. Fair's procedure is as follows.

(i) First stage of the 3SLS estimation involves deriving expected Y, Y* from OLS using instruments which include at least Y_{-1}, y_{-1}, X, and X_{-1}.

(ii) The second and third stages involve replacing Y in (17) by Y* and r by an assumed correlation coefficient, and estimating the resulting equation as in ordinary 3SLS.

(iii) Procedure (ii) is repeated with different values of r for each equation. Since the system under consideration in this study has three equations, a grid search method was employed to derive a set of three r values which minimize the sum of squared errors for the equations.

Results of estimating equations (14) are given in Table 2. The estimated model shows all coefficients have the hypothesized signs.

<u>Case 2</u>

Equations (15) are nonsimultaneous and thus OLS should give consistent estimates. All the policy variables, however, likely are affected by common excluded variables and thus would be related through their error terms. In this case, efficiency is gained by employing Zellner's seemingly unrelated regression (SUR) technique.

The h-statistics from such estimation indicated serial correlation was present in error terms. A similar correction procedure as in Case 1 was employed to correct for this. Final results of SUR estimation are given in Table 3.

CHAPTER VI

EMPIRICAL RESULTS

Supply and Demand

Results for supply and demand elasticities evaluated at the centroid are given in Table 1. Own price demand elasticity of -0.60 compares well with the -0.89 estimated in a similar study in Tanzania (Gerrard and Roe, 1983). The cross-price elasticity of 0.64 is relatively large, though, compared to 0.03 estimated by Gerrard and Roe. Income elasticity is 0.86, approximately equal to that estimated by Gerrard and Roe and only five percent lower than that estimated by Buccola and Sukume (1988). At first glance, this income elasticity might seem too large for a staple grain. However, demand for commercially milled corn should be wage-income responsive since consumers tend to switch from home-produced to retail-purchased meal as they move from farm to wage employment.

Results for aggregate marketed supply are more conventional. The own price elasticity of 0.97 is between the 1.87 estimated for peasant farmers and 0.55 estimate for commercial farmers by Buccola and Sukume. For the substitute crop the -0.91 cross-price elasticity falls reasonably between the -1.87 and -0.55 Buccola and Sukume estimates. As noted by Buccola and Sukume, the rather large supply response, especially in the peasant farming sector, may have been due to the coincident rural security improvements, effective efforts at collective marketing, and real price increases after the 1970's Civil War which created large sudden increases in production and marketing.

Policy Relationships

Results of estimating the government policy relationships are given in Tables 2, 3, and 4. Table 2 shows the estimated coefficients under the hypothesis of uncertain expected trade direction, while Table 3 shows coefficients under the alternative hypothesis of expected exports. Table 4 shows elasticities evaluated at the centroid for policy relationships derived under the hypothesis of expected exports.

Results in Table 2 show that the coefficient Tk is very low (about 0.0036) with a t-value less than one. Thus, the hypothesis of uncertain expected trade direction is rejected, implying corn price and stock policies in Zimbabwe are not simultaneously discovered. It can be concluded that government has assumed, for policy purposes, that the possibility of importing corn is negligible. The rarity of imports in the more than 30 years looked at in this study makes this conclusion understandable. Rejection of the simultaneity hypothesis implies Case 2 model should be appropriate for analyzing Zimbabwe corn policy.

The first equation in Table 3 shows that, on average, the Zimbabwe government has raised domestic wholesale corn prices only Z\$0.85/ton for every one Z\$/ton increase in expected world price. Thus, it has only partially adjusted to world prices. This also implies that coefficient $(1 - a_1')$ in (15) is not zero since a_1' is significantly different from one at any reasonable confidence level. That is government-set prices have been influenced by the demand shifters--wholesale wheat price and income--as well as by world price

Table 2. Corn Price and Stock Policy Relationships Under Case 1, Zimbabwe, 1954-1986.[a]

Factor	Wholesale Price[b] Z$/t	Producer Price[b] Z$/t	Stocks[b] (000 tons)
Constant	-25.31	-14.01	
	21.50		
	(21.59)	(25.38)	(90.34)
P^d	--	0.011	0.052
		(0.014)	(0.075)
P^d_{t-1}	0.36	--	--
	(0.19)		
P^s_t	0.008	--	0.19
	(0.037)		(0.27)
P^s_{t-1}	--	0.26	--
		(0.23)	
ΔW	--	--	5.53
			(3.08)
W*	0.80	1.12	--
	(0.063)	(0.14)	
pwheat	0.15	-0.0082	-0.04
	(0.0098)	(0.011)	(0.058)
ptob	-0.016	0.0067	-0.011
	(0.0021)	(0.00094)	(0.016)
Wg	0.043	-0.0022	-0.011
	(0.0026)	(0.0029)	(0.016)
Time	0.11	-0.47	0.75
	(0.15)	(0.066)	(1.084)
SS_t	--	--	0.54
			(0.06)
S_t	0.0029	0.004	--
	(0.0039)	(0.005)	
Mean	95.13	82.13	270.91
s.d.	17.25	22.59	346.91
RMSE	7.66	12.32	156.5
rho	0.80	0.75	0.65

a/ Standard errors are shown in parentheses.

b/ Standard errors for products of parameters calculated using approximation as in Yates (1953). For example, s.e. of a_1TK = $a_1Tk\sqrt{[s.e.(a_1)^2/a_1^2 + s.e.(Tk)^2/(Tk)^2]}$.

Table 3. Corn Price and Stock Policy Relationships Under Case 2, Zimbabwe, 1954-1986.

Wholesale Price (Z$/ton)

$$P_t^d = \underset{(18.65)}{-10.03} + \underset{(.05)}{0.85W^*} + \underset{(0.04)}{0.12P^{wheat}} + \underset{(0.01)}{0.03Wg} + \underset{(0.16)}{0.25P_{t-1}^d}$$

Mean P^d = 95.13 RMSE = 7.96

s.d. P^d = 17.25 rho = 0.80

Producer Price (Z$/ton)

$$P_t^s = \underset{(23.54)}{-9.08} + \underset{(0.13)}{1.19W^*} + \underset{(0.01)}{0.01P^{tob}} + \underset{(0.51)}{0.74Time} + \underset{(0.21)}{0.11P_{t-1}^s}$$

Mean P^s = 82.13 RMSE 12.61

s.d. P^s = 22.59 rho = 0.75

Year-End Stocks (000 tons)

$$S_t = \underset{(89.04)}{13.81} + \underset{(3.16)}{5.60}(W^* - \varsigma W_t) + \underset{(0.06)}{0.54SS_{t-1}}$$

Mean S_t = 270.91 RMSE = 156

s.d. S_t = 346.91 rho = 0.65

Table 4. Elasticities for Policy Relationships Calculated at the Mean, Zimbabwe, 1954-1986.[a]

Factor	Wholesale Price	Producer Price	Stocks
W*	.72	1.17	1.68
P_t^{wheat}	0.17		
Wg	0.21		
P_t^{tob}		0.16	
SS_{t-1}			1.08

a/ These are elasticities considering Case 2.

expectations. Elasticities for these influences at the centroid (see Table 4) are, respectively, 0.21 and 0.17. The autoregressive term in the first equation, P^d_{t-1}, had a low coefficient (0.25) and t-value well below one, indicating the sluggish pattern of time series plots of wholesale corn prices do not reflect an attempt by government to stabilize prices. Also important to note is that an a_1' value of 0.85 implies, from (15), that $\lambda d = 0.82\lambda g$. By weighting consumer interests less than marketing board interests, government has marginally exploited consumers.

Results for the producer price equation were quite interesting. The estimated coefficient for expected world price, b_1', was 1.19 with a standard error of 0.13. Since 1.19 is within two standard errors of one, $(1-b_1')$ is not significantly different from zero. Indeed, re-estimation of the model with b_1' restricted to one changed the results little. Hence, the results indicate, from (15), that λs is not significantly different from λg and that policy makers have weighted board and producer interests about equally in setting prices. Here, too, as in the wholesale price relationship, the autoregressive term, P^s_{t-1} was nonsignificant. That is, producer prices have entirely been explainable by a moving average expectation of world prices, confirming Timmer's (1986, p. 75) observation that "Zimbabwe's [producer] price policy for corn traditionally was based on export quotations."

Results for the stocks equation show that potential stocks (lagged net supply) indeed have had a strong effect on current carry-in stocks. Expected change in world price constant, a ten percent increase in last year's net supply has led to a 10.8 percent increase in carry-in stocks (see Table 4). This is understandable in that a financially risk averse country would never import to add to strategic stocks when the country expects to export the following year, especially given the large gap between c.i.f. and f.o.b. prices. A rather startling result is the strong effect on stocks of an expected change in world price. Holding all else constant, a ten percent increase in expected world price change raises carry-in stocks 17 percent, implying the government speculates on world prices. This is unexpected for Zimbabwe, a land-locked country whose transport routes have not been very secure during the period considered. The storage cost parameter c implied by c′ in (15) is $1/[(2)(5.6)] = 0.089$, giving a 270,000-ton per-unit storage cost of Z$22/ton in 1980 dollars. This approximates estimates made available to the author by the G.M.B.

Sensitivity of Model to Demand and Supply Slopes

Because of the rather large standard errors in supply and demand estimates, policy relations were re-estimated with different slope values γ_1, δ_1 to see how deduced welfare weights would be affected. Holding δ_1 at the estimated value of 2.62, the policy relationships were estimated using, in turn, γ_1 values of 15.0 and 5.0, which are about one standard error above and below the estimated supply slope of 9.69. Subsequently, γ_1 was held at 9.69 and policy rules estimated for δ_1 values of 3.5 and 1.5, which are about half a standard error above and below the estimated 2.62. For each setting of γ_1 and δ_1, new λ values were deduced. Results of this exercise are summarized in Table 5.

Table 5 results indicate that varying γ_1 by any amount would not appreciably change results of the policy relationships. This is because producer prices respond almost entirely to world prices. In other words, board and producer interests would be weighted about equally under any assumed supply slopes. Reducing the own-price demand slope, on the other hand, from -2.62 to -1.50 increased the $\lambda d/\lambda g$ ratio from 0.82 to 0.94. However, the demand slope needs to be set unrealistically near zero to conclude that consumers and taxpayers have been weighted equally. Thus under any reasonable slope values, the essential result that producer and taxpayer interests are equally weighted, and that each of these is weighted more heavily than consumer interests, is maintained. Rather high standard errors in supply and demand estimates do not call the policy model results seriously into question.

Table 5. Effects of Varying Supply and Demand Slopes on Deduced Welfare Weights.

Scenario		Deduced Weights		
γ_1	δ_1	λg	λd	λs
9.69	2.62	0.35	0.30	0.35
15.0	2.62	0.35	0.30	0.35
5.0	2.62	0.35	0.30	0.35
9.69	1.5	0.34	0.32	0.34
9.69	3.5	0.37	0.26	0.37

CHAPTER VII

POLICY IMPLICATIONS

Social Weights

Deduced Social Weights

Results of the study indicate that the Zimbabwe government has weighted marketing board (hence taxpayer), consumer, and producer interests roughly in proportions 0.35, 0.30, and 0.35 in its corn policy settings during the past 30 years. Insufficiency of data bar any reliable estimations of trends in these weights. However, it is unlikely that policy makers have changed social preferences substantially in recent times. Successive regimes during this period all have maintained a strong support toward farming interests (Blackie, 1986). In any event these weights do not differ much from each other, which tends to suggest that Zimbabwe has tried to emulate a competitive market environment. That is, they nearly have set prices to maximize long-run economic efficiency. Aggregate loss accruing from maximizing (1) with the estimated weights rather than with equal weights is only Z$3.13. million, equivalent to about Z$3.13 per family. This, however, excludes losses due to excessive marketing and storage costs in a monopoly parastatal (Christensen and Witucki, 1986).

Social weights deduced in this study differ from evidence on LDC's weights reported by other researchers. Pollard and Graham (1985), Bale (1987), and Bautista (1986) all concluded that LDC governments typically have strongly preferred consumer over producer interests. Bale (p. 102) echoes sentiments of most researchers when he states that "typically, the direction of [wealth] distribution is from rural producers to the more politically powerful urban consumers." The deviation in the case of Zimbabwe could be attributed to highly organized large-scale commercial farmers who wielded much political influence during the period under consideration. Developed countries have tended to favor producers over consumers (Sarris and Freebairn, 1983). In the case of wheat policy formation, though, Sarris and Freebairn (p. 222) report Sub-saharan countries have weighted taxpayer, consumer, and producer concerns in the proportions 0.34, 0.32, 0.34, which accords closely with the Zimbabwe estimates reported in this study.

Effects of Exogenous Variables on Social Incomes and Trade

This study sought to gain insight into how changes in variables exogenous to the system affected exports and social incomes of the various economic groups. To accomplish this, the model given in Table 3 was evaluated for the endogenous policy variables at the centroid of the exogenous variables. Using these endogenous variables together with mean levels of the exogenous variables, and using equations (3)-(6) and identity $E(X) = S + EQ^s - EQ^d$, expected exports and social incomes for each economic group were calculated. This process was repeated with each exogenous variable varied, in turn, by one unit holding the other exogenous variables constant. Resulting changes in the form of elasticities with respect to each exogenous variable are given in the estimated weight rows of Table 6.

Results indicate expected world price increases have a positive effect on expected exports. All other factors constant, a single percentage point increase in expected world price raises expected exports by 2.32 percent. This is quite small compared to the 11.45 percent evaluated for the Tanzania corn industry by Gerrard and Roe (1983). Relatively speaking, the corn industry in Tanzania is quite sensitive to world prices. It would not take a very large change in world prices to change Tanzania from a net importer into a net exporter or visa versa. Moreover, Tanzania has been marginally self-sufficient in corn. In contrast, it would take drastic world price changes to turn Zimbabwe from a net exporter to net importer because corn exports respond slowly to changes in world prices.

World price expectations affect consumer surplus negatively and producer and board incomes positively. The elasticities are, respectively, -0.72, 2.45, and 2.89. Effect on consumers and producers is understandable. For instance, producer prices depend entirely on world prices and the effect of producer price on producer surplus is positive. On the other hand, the direction of effect of world price on board income is not obvious a priori. An increase in world price would lead to an increase in producer price, which leads to higher production and hence larger exportable surplus. However, higher production entails a higher purchasing cost; and increases in world price lead to increases in wholesale demand price, which induce

Table 6. Elasticities of Exports and Group Incomes With Respect to Changes in Exogenous Variables, Given Alternative Social Weighting Schemes, Zimbabwe, 1954-1986.

	Weighting[a/] Scheme	Exogenous Variables			
		W*	ptob	pwheat	Income
Exports	Estimated	2.32	-1.13	-0.36	-0.48
	Equal	2.38	-1.13	-0.42	-0.56
	Population	2.04	-1.06	-0.42	-0.56
Consumer Surplus	Estimated	-0.72	0.0	0.91	1.21
	Equal	-0.88	0.0	1.11	1.47
	Population	-0.86	0.0	1.08	1.43
Producer Surplus	Estimated	2.45	-2.22	0.0	0.0
	Equal	1.52	1.37	0.0	0.0
	Population	0.70	-0.81	0.0	0.0
Board (Taxpayer) Income	Estimated	2.89	-0.55	-0.32	-0.42
	Equal	1.05	0.21	-0.15	-0.20
	Population	0.06	0.68	-0.18	-0.24

a/ See footnotes to Table 7.

consumer resistance even though per-unit gain from domestic sales is higher.

As expected, producer tobacco price, wholesale wheat price, and wage income all had negative impacts on exports. Such effects are easy to deduce since exports are linear in these variables. Since tobacco price has no effect on consumer demand, it could have no effect either on consumer surplus. Wholesale wheat price and income have positive direct but negative indirect effects on consumer surplus. The direct effect is that increases in these variables shift the corn demand function to the right. Indirectly--through (15a)--such increases raise the corn wholesale price, which dampens consumer surplus. As can be seen from Table 5, the net effects are positive. Elasticity of consumer surplus with respect to wheat price, for example, is 0.91.

Net effects of tobacco price, wholesale wheat price, and wage income on board income are, like the net effect of world price, not apparent _a priori_. At the centroid, the estimated net effects were -0.55, -0.32, and -0.42 respectively.

Effects of Social Weights on Income Distribution and Trade

We now consider the effects of changing the welfare weights from those which were estimated to (a) an equal weighting scheme and (b) weighting according to populations comprising each economic group. The equal weighting scheme weights each dollar equally and allows government to set policy maximizing long-run efficiency. As shown in Chapter II, it provides greatest total income. The weighting scheme in which groups are valued according to the populations they represent is equivalent to weighting every person (rather than every dollar) in the country equally.

To investigate the question posed in the above paragraph, policy settings were derived, using definitions of a_1' and b_1' in (15), from the weights implied by assumptions (a) and (b). Given these alternative policy settings, incomes, exports, and marketed quantities were simulated at the means of the exogenous variables. Results are compared with those derived from welfare weights which were historically estimated. Results of this exercise are given in Table 7.

Results in Table 7 show rather remarkably that weighting all groups equally would reduce producer prices by about Z$37.00/ton (compared to the use of the current or estimated weights) while consumer prices would drop by only Z$4.00. Weighting groups in proportion to population reduces producer prices even more, while consumer prices remain relatively constant.

Weighting all groups' interests equally would increase board (G) and consumer (CS) incomes and reduce producer (PS) incomes compared to the use of the current weights. However, it would increase total social income by [25,755 + 16,923 + 6,803 - (24,328 + 44,381 - 22,358)] = Z$3.13 million, which supports the widely accepted contention that weighting groups equally results in maximal total gains. Weighting groups by their populations benefits board or taxpayer interests and hurts producers, as shown by improvements in the board's account and the drop in producer surplus compared to the

Table 7. Policy Levels and Income Distribution Under Different Welfare Weighting Schemes.

	Estimated[a/]	Group Population[b/]	Equal Weights[c/]
Policy Levels (Z$/ton)			
p^s	96.7	38.29	60.10
p^d	118.2	118.3	114.31
S	287.7	287.9	287.9
Income Distribution (000Z$)[d/]			
CS	24,328	24,307	25,755
PS	44,381	6,739	16,923
G	-22,358	13,778	6,803
TR	55,084	18,765	31,654
Quantities (000 tons)			
Exports	858.2	292.3	493.14
EQD	357.0	356.9	367.40
EQS	927.0	361.4	572.65

a/ This column assumes weights are as estimated for 1954 to 1986, i.e., λc = .30; λg = .35; λs = .35.

b/ Assumes weights are assigned according to group populations.

c/ Assumes equal weights ($\lambda c = \lambda g = \lambda s$).

d/ CS, PS, G, and TR are consumer surplus, producer surplus, board income, and board trade revenue, respectively.

other weighting schemes. Weighting groups according to the population in each reduces total income and trade revenue below those in the other two weighting schemes. Population-based weighting schemes clearly would hinder economic growth.

Exports are reduced using either the equal-weighting or population-weighting schemes. An interesting observation, though, is that under either scheme, Zimbabwe would remain a net exporter. This implies that, provided government intervention in input markets related to corn production is insignificant, Zimbabwe has a comparative advantage in corn production. Thus, insofar as government intervention is defined as changing welfare weights from an equal-weighting scheme, self-sufficiency is not a plausible motivation for government intervention. Results do show that trade revenue is greatest under the historically estimated weights. Given the importance of foreign currency for foreign debt service and for financing development projects, increasing trade revenue is a probable force for policy intervention.

Effects of Weights on Impacts of Exogenous Variables

Results of Table 6 indicate that when we weight all economic groups equally, effect of world prices on exports increases only slightly compared to the historically estimated scheme. Impacts of wheat price and wage income on exports also rise slightly. Both equal weighting and population weighting increase sensitivity of consumer surplus to all the exogenous variables. In contrast, both equal weighting and population weighting reduce sensitivity of producer incomes to exogenous shocks. However, total producer incomes fall under both schemes (see Table 7), so there is a tradeoff between total income and sensitivity of producer income to exogenous stocks.

On the whole, it can be said that the present (estimated) social welfare weights have well served consumers, producers, and government's trade revenue provisions. Net government interest, however, would have been better served by either of the other weighting schemes, both in terms of net income (Table 7) and generally reduced sensitivity to exogenous shocks (Table 6).

Private Welfare-Optimal vs Social Welfare-Optimal Policy Rules

In this section, policy rules which assume the government board maximizes monopoly profit in the corn industry are derived and resulting welfare implications are compared to the case of the historically estimated weights. This case is equivalent to giving welfare weights equal to zero to consumers and producers in equation (1) and optimizing a welfare function consisting entirely of costs and benefits accruing to the GMB. For the export-expecting policy maker, resulting policy rules from first order conditions are:

$$P_t^s = \frac{\gamma_1(W^* - T - \beta) - \gamma_0 - \gamma_2 Z_s}{2\gamma_1}$$

$$P_t^d = \frac{(-\delta_1)\ (W^* - T - \alpha) + \delta_0 + \delta_2 Z_d}{2\delta_1}$$

$$S_t = \frac{1}{2c}\ [\ W^* - (1/\varsigma)W_t]. \qquad (16)$$

Evaluated at the means, this gives policy levels P_t^s = Z$58.55, P_t^d = Z$112.70, and S_t = 16,570 tons. Compared to the historical levels evaluated at the centroid (Table 7), the monopoly profit maximizing levels represent a drop in producer price of more than Z$38/ton and a drop in wholesale price of only Z$5.50/ton. A monopoly-profit environment would reduce stocks from 287,000 tons to a mere 16,700 tons. Translated into quantity terms, farmers in a government monopoly-profit maximizing setting would sell to GMB about 359,000 tons per annum less than they sell presently and consumers would demand about 652,000 tons more per annum than they do presently. These figures are high enough to turn Zimbabwe from a net exporter to a net importer. Some countries in Africa have changed from being net exporters to net importers of food grain in the past 30 years. It would be interesting to test the hypothesis that marketing boards in these countries have indeed abandoned their role as social guardians.

CHAPTER VIII

CONCLUSIONS

This study develops a flexible model that attempts to rationalize policy formation in LDCs. The study recognizes that governments often should determine stock and price levels simultaneously. That is, if one assumes that government wishes to maximize expected total economic surplus, if c.i.f. and f.o.b. border prices differ substantially, and the nation is marginally self-sufficient, prices and stocks should be set in conjunction with one another. Most advice on price policy have been based on the assumption of certainty in the direction of trade or on the assumption that c.i.f. and f.o.b. prices are equal. This study demonstrates that advice based on such analyses might be inappropriate for marginally self-sufficient countries. Flexibility introduced by the present approach is that one can analyze price formation for net exporters/importers and also for marginally self-sufficient countries.

Application of the model to the Zimbabwe corn industry showed that the Zimbabwe government does not view the nation as marginally self-sufficient and hence prices and stocks are determined independently. The study also showed that, on the average during the past 30 years, the Zimbabwe government has weighted producer and taxpayer interests more than consumer interests. This is in stark contrast to evidence from other LDCs. Wholesale corn prices have responded only partially to world prices, implying government has been influenced by domestic supply and demand conditions as well as by world prices. The study does confirm Timmer's hypothesis that producer prices in Zimbabwe have been determined largely by world prices.

Experiments with alternative welfare weights showed that intervention has somewhat reduced consumer surplus sensitivity, and increased government income sensitivity, to exogenous shocks. Weighting all individuals in society equally would hinder economic growth. The experiments also showed that setting prices to maximize the marketing board's own income reduces self-sufficiency. Inasmuch as intervention essentially is a matter of making welfare weights unequal among economic groups, intervention has benefited farmers and resulted in large exportable surpluses. However, taxpayers have paid the price of much of this distortion.

This study's model, however, does not include all factors relevant to welfare weight estimation. Because parastatal board marketing costs are probably higher than those in free markets, the board's existence is additional evidence of preference for the public sector. As is the case in most LDCs, Zimbabwe has subsidized its marketing board, millers, and producer inputs in varying degrees. This study did not attempt to include such subsidies nor to reflect the divergence of official from market exchange rates.

Other possible limitations of the study are the linear supply and demand forms and the assumption of risk neutrality. These simplifications have enabled us to see most clearly the underlying economic relationships involved. The study has, finally, been a partial equilibrium one, though it easily may be expanded to include joint price and stock determination in related industries.

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APPENDICES

APPENDIX A

MATHEMATICAL APPENDIX

APPENDIX A

MATHEMATICAL APPENDIX

The rate at which D_X passes from W+T to W-T in (13) as $E_t(X)$ increases depends on σ_u = Var(X), the <u>ex ante</u> variance of net domestic supply. To see this, substitute $E(I) = 1 - \int_{-\infty}^{0} f(x)dX$ and and $E(uI) = Cov(u,I) = \sigma_u\sigma_I\rho_{uI}$ into the bracketed term of (12) to obtain:

$$d[1y(1 - \int_{-\infty}^{0} f(x)dX) + 2\sigma_u\sigma_I\rho_{uI} - y]/dy \tag{A1}$$

$$= 1 - [2yf(0) + 2\int_{-\infty}^{0} f(x)dX] + 2\sigma_u(d\sigma_I\rho_{uI}/dy)$$

In the limiting case where $\sigma_u = 0$, (A1) equals +1 if $y = x > 0$ and it equals -1 if $y = x < 0$.. This is consistent with the fact that if the board knows it will import (export) in t+1, its impending opportunity cost is the c.i.f. border price W*+T (f.o.b. border price W*-T). On the other hand as σ_u rises, the rate of change of (A1) with respect to y increases also; and since from (13) this rate of change equals $-[d^2E(R)/dE(X)^2]/T$, rate $d(D_X)/dE(X)$ must fall. That is, as long as net domestic supply is unpredictable, algebraic increases in its expectation (reducing expected imports or increasing expected exports) only gradually change marginal expected trade revenue (D_X) from W+T to W-T. The slowness of the change increases as net domestic supply variance increases.

APPENDIX B

MATHEMATICAL APPENDIX

APPENDIX B

MATHEMATICAL APPENDIX

Derivatives of (7′) with respect to P_t^d, P_t^s, and S_t are, on segment (13b):

$$\frac{dE(Y)}{\varsigma dP^d} = \lambda g W^* \delta_1 + \lambda g Tk(S + EQ^s - EQ^d) + \lambda g \delta_1 (P^d - \alpha) + EQ^d(\lambda g - \lambda d) \qquad \text{(B1a)}$$

$$\frac{dE(Y)}{\varsigma dP^d} = \lambda g W^* \gamma_1 + \lambda g TK \gamma_1 (S + EQ^s - EQ^d) - \lambda g \gamma_1 (P^s + \beta) - EQ^s(\lambda g - \lambda s) \qquad \text{(B1b)}$$

$$\frac{dEY}{\varsigma dS} = \lambda g W^* + \lambda g Tk(S + EQ^s - EQ^d) = w \lambda g c S - \lambda g (1/\varsigma)(W_t \pm T) \qquad \text{(B1c)}$$

On segment (13a), the second RHS terms of (B1a), (B1b), and (B1c) are replaced with $\lambda g T \delta_1$, $\lambda g T \gamma_1$, $\lambda g T$, respectively, and on segment (13c) they are replaced with $-\lambda g T \delta_1$, $-\lambda g T \gamma_1$, $-\lambda g T$. Setting (5b) version derivatives equal to zero, substituting $EQ^d = \delta_0 - \delta_1 P^d + \delta_2 Zd$ and $EQ^s = \gamma_0 + \gamma_1 P^s + \gamma_2 Zs$, and solving for P^d, P^s, and S yields:

$$P^d = \frac{1}{-Tk\delta_1 + 2 \_0 \lambda d/\lambda g} [Tk(\gamma_0 - \delta_0) - \beta - (\gamma_0/\gamma_1)(1 - \lambda s/\lambda g) + W^* + Tk(S + \delta_1 P^s + \delta_2 Zs) + (\delta_2/\delta_1)(-Tk\delta_1 + 1 - \lambda d/\lambda g)Zd] \qquad \text{(B2a)}$$

$$P^s = \frac{1}{-Tk\gamma_1 + 2 - \lambda s/\lambda g} [Tk(\gamma_0 - \delta_0) - \beta - (\gamma_0/\gamma_1)(1 - \lambda s/\lambda g)$$

(B2b)

$$+ W^* + Tk(S = \delta_1 P^d - \delta_2 Zd) - (\gamma_2/\gamma_1)(-Tk\gamma_1 + 1 - \lambda s/\lambda g)Zs]$$

$$S = \frac{1}{-Tk+2c} \{Tk(\gamma_0 - \delta_0) + [W^* - (1/\zeta)W_t] + Tk(\delta_1 P^d + \gamma_1 P^s \qquad \text{(B2c)}$$

$$- \delta_2 Zd + \gamma_2 Zs)\}$$

Defining $a_1 = 1/(-Tk\delta_1 + 2 - \lambda d/\lambda g)$, $b_1 = 1/(-T + 2 - \lambda s/\lambda g)$, and $c_1 = 1/(-Tk + 2c)$ gives the form shown in (15). Note that on segment 13a (13c), term T (-T) is added to the numerators of a_0 and b_0.

Form (15) takes advantage of within and cross-equation restrictions evident from (B2). For instance, the coefficient of $(\delta_2/\delta_1)Zd$ in (B2a) is $(1 - a_1)$ while with the same reasoning coefficient of $(\gamma_2/\gamma_1)Zs$ in (B2b) is $(1 - b_1)$. Second, coefficients a_1, b_1 of expected world price, and c_1 of expected change in world price also are coefficient common to respective blocks of variables preceeded by Tk. Third, since Tk is common to all three such blocks, we have the cross-equation restriction that, for example, $dP^d/a_1dS = dP^s/b_1dS = dS/c_1\delta_1dP^d$.

APPENDIX C

DATA USED IN ESTIMATIONS

APPENDIX C

DATA USED IN ESTIMATIONS: 1953-1986[a]

WHOLESALE CORN PRICE (Z$/T)	PRODUCER CORN PRICE (Z$/T)	TOBACCO PRICE (C/KG)	WHOLESALE WHEAT PRICE (Z$/T)	GULF-PORTS CORN PRICE (Z$/T)	CARRY-IN STOCKS ('000T)	GMB SALES ('000T)	GMB PURCHASES ('000T)	WAGE-INCOME (Z$M)	LOW-INCOME CONSUMER PRICE INDEX (1980=100)
117.66	130.53	216.37	140.12	190.96	119.40	251.60	233.00	262.57	34.20
115.30	131.10	174.79	140.64	177.91	95.80	185.90	367.00	288.83	34.90
127.44	122.81	200.56	137.82	143.32	190.00	217.40	343.00	304.85	35.90
121.68	120.77	178.19	134.26	140.13	86.70	209.80	303.00	304.25	37.60
112.31	103.07	163.63	128.45	134.57	137.00	214.00	241.00	311.69	38.50
108.64	87.24	158.29	114.29	122.16	127.00	238.00	252.00	321.61	39.80
107.29	64.69	153.85	108.04	120.65	108.00	161.00	495.00	334.00	40.30
105.72	72.30	156.47	119.11	128.48	94.00	163.00	335.00	346.70	40.90
104.19	76.92	183.13	122.25	122.02	5.00	172.00	237.00	371.08	41.50
99.86	82.67	110.85	115.66	118.89	20.00	253.00	252.00	379.45	43.30
96.95	76.32	136.77	133.95	117.89	29.00	346.80	337.00	375.78	44.60
94.92	63.07	94.30	125.56	97.17	59.00	193.00	525.00	387.72	45.60
93.19	62.78	109.91	95.61	90.04	97.00	192.30	876.20	417.46	46.40
91.22	68.63	107.59	98.70	84.87	99.00	314.60	424.50	447.05	47.40
91.03	65.20	96.84	90.93	78.91	25.00	226.50	961.00	483.58	47.50
88.43	67.42	94.07	162.48	91.51	85.00	410.20	628.50	521.47	48.90
86.14	59.86	101.59	155.85	90.24	59.00	310.50	1112.30	564.94	50.20
83.48	49.96	98.56	145.42	74.27	142.00	231.90	1400.20	610.62	51.80
80.67	71.59	102.61	140.54	125.65	412.00	446.50	550.40	691.79	53.60
75.07	69.64	135.42	138.04	140.69	158.00	371.40	1336.90	752.60	57.60
81.42	58.45	109.00	158.09	114.69	408.00	386.50	1006.90	761.14	63.30
71.29	63.62	103.73	138.41	102.48	263.00	392.70	950.50	733.06	72.30
65.32	60.84	103.93	143.68	82.28	530.00	503.90	941.10	726.49	78.90
58.35	64.00	113.14	137.91	84.37	538.00	545.30	877.00	737.94	87.50
64.02	76.22	83.74	136.18	90.05	310.30	635.10	511.90	917.58	98.40
86.83	117.07	77.55	130.72	110.39	67.80	716.10	814.80	1238.15	102.50
117.90	103.27	158.14	135.11	116.48	157.80	664.90	2013.80	1467.47	116.20
104.74	91.74	127.92	129.21	90.01	1200.70	1046.20	1390.30	1416.28	130.80
96.26	85.84	115.60	146.54	73.32	1035.10	1273.20	616.40	1213.73	163.10
95.68	97.30	111.65	154.05	108.11	122.70	859.70	941.60	1145.95	185.00
107.66	87.29	130.20	138.21	45.35	461.90	560.60	1815.30	1180.17	206.20
93.71	75.98	134.95	136.56	17.27	1426.00	650.00	1677.60	1138.37	236.90

[a] All prices and wage income deflated using low-income consumer price index (1980 = 100).