FOOD SECURITY FOR SOUTHERN AFRICA

Edited by

Mandivamba Rukuni and Carl K. Eicher

University of Zimbabwe UZ/MSU Food Security Project

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NDIVAMBA RUKUNI AND CARL K. EICHER

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UZ/MSU Food Security Project
Department of Agricultural Economics
and Extension
University of Zimbabwe
P.O. Box MP 167
Harare, Zimbabwe
Telex: 4152 ZW
Telephone 303211 - Ext. 1574

CHAPTER ELEVEN

OPTIMAL GRAIN PRICING AND STORAGE POLICY IN CONTROLLED AGRICULTURAL ECONOMIES: APPLICATION TO ZIMBABWE

Steve Buccola and Chrispen Sukume

INTRODUCTION

Increased emphasis on food security in developing countries has heightened attention to domestic pricing and grain stock policies. Analysts frequently have concluded that consumer and producer prices in controlled agricultural markets tend to be too low, although Jabara has argued this is not the case for producer prices in Kenya (Adoyade; Pollard and Graham). Governments of middle-income countries also have been blamed for holding excessively high food and cash crop stocks (Bale, pp. 32-4).

To argue that agricultural policies consistently are in error, one must hold either that policy makers optimize poorly, use biased supply and demand forecasts, or pursue objectives different from those the analyst thinks important. Of these three, it usually is most fruitful to consider the diverse objectives that governments and other economic groups pursue when setting or influencing policy. Producers' interest in high farm prices and consumers' interest in low retail prices are well known. Much less understood are the high risks and conflicting demands faced by those governments which have concentrated pricing, storage, and trade decisions in the public sector. Analysis of these risks and conflicts not only helps explain current policies but provides a better idea of desirable policy adjustments.

In this chapter we consider a government marketing board that dominates farm grain purchases, sales to commercial millers, and external grain trade. Government regulates or heavily influences most agricultural input and product prices at all levels of marketing chain. It also maintains most of the nation's grain reserve stocks. This institutional setting is found commonly in Africa and, to a slightly lesser extent, in Asia and Latin America (Ahmed and Rustagi, Aboyade). Since unexpected changes in net domestic supplies must be balanced by changes in the board's stocks or external trade, the arrangement imposes on government much of the food industry's financial risk.

Our objective is to outline a framework for identifying combinations of prices and storage policies that best promote government's -- and to some extent society's -- welfare. Unlike most past studies, we avoid equating welfare with just expected returns or risks of 'shortfalls' (Martin and McDonald, Reutlinger). Rather, welfare is taken in the broader sense of expected utility, which considers the entire probability distribution of returns associated with a given policy. Principal findings, applied to the Zimbabwe maize sector, are that optimal stock and price policies are interrelated. Present board stocks suggest an excessive willingness to gamble on future income. At approximately equilibrating exchange rates, full-cost pricing would reduce government utility and increase producer utility. This would create pressure for market decontrol.

DECISION MODEL

The approach taken is to specify a marketing board income equation and functions relating policy variable to domestic maize demands and supplies. Monte carlo methods then are used to estimate income probabilities and utilities of alternative policies.

(a) Marketing Board Income

The marketing board's annual maize income is determined by export revenue (or import cost), revenue from sales to domestic commercial millers, cost of farm maize purchases, storage costs, and handling and fixed expenses. Specifically, board income is

$$Y = \begin{bmatrix} (S + Q_{st} - Q_{dt})(P_{wt} - T_e)X_t/(1 + i) \\ \text{if } (S_{t-1} + Q_{st} - Q_{dt}) > 0 \\ (S_{t-1} + Q_{st} - Q_{dt})(P_{wt} + T_i)X_t/(1 + i) \\ \text{if } (S_{t-1} + Q_{st} - Q_{dt}) < 0 \end{bmatrix} \tag{1}$$

export revenues (import costs) net of transport cost to (from) port, at time t

$$+ Q_{dt}P_d/[1 + (i/2)]$$

domestic revenues in t

$$- Q_{st}(P_s + H)/[1 + (i/4)]$$

farm maize purchase and handling costs in t

$$-(S_{t-1})(I) - F$$

storage insurance and fixed costs in t

$$- S_{t-1}(P_{w,t-1} - T_e)X_{t-1}$$

export value of stocks at t-1

where S_{t-1} = Quantity of maize carried from end of t-1 th to end of t^{th} fiscal year (tons);

Q_{st} = Quantity of maize supplied to the board by farmers in year t (tons);

Q_{dt} = Quantity of maize demanded of the board by commercial millers in year t (tons);

P_{wt}, $P_{w,t-1}$ = World maize price at port (US$/ton);

T_e (T_i) = Transfer cost to (from) port (US$/ton);

X_t, X_{t-1} = Zimbabwe - U.S. dollar exchange rate (Zimbabwe dollars per U.S. dollar: Z$/US$);

P_d = sale price charged commercial millers (Z$ per ton);

P_s = purchase price paid farmers (Z$/ton);

H, I = handling and storage insurance cost, respectively, (Z$/ton);

F = fixed cost allocated to maize account (Z$);

i = annual interest rate.

At end of the t-1 th fiscal year, when government selects price P_{st} to pay farmers, P_{dt} to charge millers, and strategic reserve stock S_{t-1} to carry into t, income Y is random.1/ Domestic supply response Q_{st}, domestic demand Q_{dt}, and hence net domestic supply $Q_{st} - Q_{dt}$, are yet unknown. And although current world price $P_{w,t-1}$ and exchange rate X_{t-1} are observable, those at future point t still are random.2/ Stocks carried forward from t-1 are assumed 'purchased' from the t-1 th fiscal year at current net world price and either are exported (or deducted from imports) at time t or 'sold' to the t+1 th fiscal year at net export price ($P_{wt} - T_e$). Thus, the board will export or import at t according as carryover plus net domestic supply, $S_{t-1} + Q_{st} - Q_{dt}$, is positive or negative. The distinction is important because to-port transfer cost T_e may not equal from-port cost T_i: imports may involve different per-ton freight rates than exports and deny policy makers the prestige of having achieved 'self sufficiency.'

Board income in (1) is expressed as a present value at decision point t-1. Interest rates are adjusted approximately to reflect the fact that domestic sales are nonseasonal while farm purchases peak early in the second quarter. External trades are assumed to occur near the end of the fiscal year and are discounted at the full annual rate. Variable storage cost consists principally of the time value of export revenues (or import costs) received at t rather than at t-1.

If government were risk averse and knew it would be an exporter at t, it never would hold other than working stocks at t-1 unless world price were expected to rise substantially in the ensuing year. Stocks sold immediately at t-1 avoid interest charge and risk of future price and exchange rate changes. Because few developing countries invest in the information needed for successful world price speculation, they only would hold strategic reserves in order to reduce the *ex ante* utility cost of future imports. *Ex post* import costs vary with per-ton transportation rates and the prestige loss of importing. *Ex ante* costs vary also with government's risk aversion and with the probability of requiring imports, which in turn depend not only on carryover stocks but on domestic prices influencing next year's domestic demand and supply.

It makes a difference in this regard whether exchange rates used are official ones or those reflecting true scarcity of foreign exchange. Many developing countries peg their unit of account to a market basket of foreign currency values, which vary randomly. Even so, the pegging formula typically is such as to chronically undervalue hard currencies in the sense that domestic demand permanently exceeds supply. In the latter situation, use of an official or pegged rate in (1) would understate the local currency value of exports and local currency cost of imports. It therefore would understate foreign earnings risks to which government is subject and fail adequately to explain developing governments' distaste for imports. For planning purposes, it is better to employ an estimate of the equilibrating rather than official exchange rate probability distribution, even though results will diverge from accounting returns based on official rates.

(b) Maize Demand and Supply

Nations with large peasant farming populations are in the unique position that the farm and retail price of a product each can affect both farm supply and retail demand. Peasant farmers often may choose between consuming their own grain or selling it and buying retail grain meal. Allocation between home-produced and purchased staple would depend upon relative producer and retail prices. In contrast, urban consumers respond only to retail and commercial farmers only to producer price. Data availability generally requires aggregating urban and peasant farm demand but commercial and peasant farm supplies may be specified separately. Letting P_r be retail price, Z_d (Z_s) a vector of other policies affecting demand (supply), W random weather conditions, and e_{dt}, e_{s1t}, e_{s2t} excluded random factors, demand and supply facing the board are

$$Q_{dt} = Q_d(P_r, P_s, P_d, Z_d, e_{dt}) \qquad (2)$$

$$Q_{st}^{pea} = Q_s^{pea}(P_r, P_s, Z_s, W, e_{s1t}) \qquad (3)$$

$$Q_{st}^{com} = Q_s^{com}(P_s, Z_s, W, e_{s2t}) \qquad (4)$$

where pea and com refer to peasant and commercial supply, respectively, and $Q_{st}^{pea} + Q_{st}^{com} = Q_{st}$.

Demand policy factors Z_d include urban wages which, together with price ratio P_r/P_s, affect meal orders placed by retailers with commercial millers. Z_d also includes (government controlled) wholesale wheat prices, which millers would compare with the board's maize selling price P_d in order to determine volume Q_{dt} of maize to purchase from the board. Random factor e_{dt} consists partly of unpredictable yield changes on peasant farms, since these affect demand for the retail substitute of home-produced maize meal. Supply policy vector Z_s includes fertilizer and cotton prices, while e_{s1t} and e_{s2t} represent random factors other than weather conditions. Grain producer prices in Zimbabwe are announced prior to planting. In absence of pre-planting announcements, price expectations would have to be modelled with appropriate lags.

Functional forms needed to fit (2) - (4) greatly affect policy implications derivable from the research (Turnovsky; Just, Hueth, and Schmitz, pp. 244-46; Reutlinger). This is because form determines the manner in which policy variables affect both the expectation and variance of demand and supply. Choice of form was guided partly by theoretical considerations, partly by goodness of fit. Doublelog version of (2),

$$Q_{dt} = AK_1{}^a e_{dt} \qquad E(e_{dt}) = 1 \qquad (2')$$

where K_1 is policy vector (P_r, P_s, P_d, Z_d) and $K_1{}^a$ represents $P_r{}^{a1}P_s{}^{a2}P_d{}^{a3}...$, is the most widely recognized form of endogenous-quantity demand (Newbery and Stiglitz, pp. 120-1). Expectation and variance of demand in (2') are $AK_1{}^a$ and $A^2K_1{}^{2a}Var(e_{dt})$, respectively, so coefficient of variation is the constant $[Var(e_{dt})]^{1/2}$. Form (2') gave lower adjusted mean square error than did the linear and was employed in this study.3/

Supplies were specified with additive errors so that variance could partially be independent of mean. Letting K_2 be policy vector (P_r, P_s, Z_s), K_3 be (P_s, Z_s), and using the same notation as in (2'),

$$Q_{st}^{pea} = BK_2^{b}W^{g} + CK_2^{c}u \qquad (3')$$

$$Q_{st}^{com} = DK_3^{d}W^{g} + FK_3^{f}v \qquad (4')$$

where B, C, D, F are constants; $CK_2^{c}u = e_{s1t}$ and $FK_3^{f}v = e_{s2t}$; and $E(u) = E(v) = 0$, $Var(u) = Var(v) = 1$. Peasant farm supply (for example) has mean $BK_2^{b}E(W^{g})$ and variance $B^2K_2^{2b}Var(W^{g}) + C^2K_2^{2c}$, so its coefficient of variation is a nonconstant function of policy level. Forms (3'), (4') provided better fit than did doublelog versions, which, like (2'), have multiplicative errors.

Demand (2') was estimated with OLS and deflated 1968-85 time series; (3') and (4') were estimated with deflated 1953-85 data using the iterative nonlinear approach suggested by Buccola and McCarl. Elasticities of expected demand and supply with respect to stochastic and policy variables are shown in table 1. At first blush, a 0.81 wage income elasticity sounds high for a staple food. Actually, demand for commercially milled meal should be very wage-income-responsive since consumers tend to switch from home-produced to retail-purchased meal when moving from farms to wage employment. Producer price supply elasticity on commercial farms is very close to the (0.57) long-run wheat supply elasticity in developing countries estimated by Adams and Behrman (p.43). High response to fertilizer price underscores importance of fertilizer marketing policy in LDC's. Although we expected strong producer price response in the peasant sector, the large value estimated partly may result from the coincidence of rural security improvements, effective efforts at collective marketing, and

Table 1. Maize expected demand and supply elasticities facing marketing board, Zimbabwe

	Elasticity	t-Value
Wholesale Demand		
Wholesale Maize Price	-1.50	-3.13
Wholesale Wheat Price	0.90	1.06
Retail Maize Meal Price	-0.65 a/	a/
Producer Maize Price	0.65 a/	a/
Wage Income	0.81	2.43
Peasant Farm Supply		
Producer Maize Price	1.87 b/	7.97 b/
Producer Cotton Price	-1.87 b/	-7.97 b/
Retail Maize Meal Price	-1.75	-4.68
Tassling Season Rainfall c/	0.88	4.88
Commercial Farm Supply		
Producer Maize Price	0.55 b/	3.04 b/
Producer Tobacco Price c/	-0.55 b/	3.04 b/
Nitrogenous Fertilizer Price	-1.10	-3.07
Tassling Season Rainfall c/	0.62	4.21

a/ The ratio of producer to retail price was used in a doublelog model to forecast on-farm maize retentions, which is turn were used to forecast demand. Thus no direct t-values are available. On-farm retentions had elasticity -0.63 with standard error 0.20.

b/ These coefficients were constrained equal to overcome price collinearity.

c/ Indicates stochastic variable. All other variables were regarded as determined by government policy.

real price increases after the 1970's civil war (Bratton).[4] On the other hand, elasticities changed little when the time period of fit was varied from 1953-85 to 1968-85. Lower supply sensitivity to rainfall in commercial than in peasant areas is a consequence of supplemental irrigation on commercial farms.

(c) Simulation Procedure

Equations (2') - (4') make clear that government price policies affect the entire probability distribution of demand and supply. Through (1), policies also affect the probabilities of marketing board income. Because the board avowedly is operated on behalf of citizens and losses are charged to the public treasury, we argue that its income should be considered to accrue to all individuals in society. Thus board incomes should be evaluated in terms of a typical citizen's utility function.[5] Given widespread evidence of risk aversion in household decisions, it is appropriate further to cast effects of alternative policies in terms of expected utilities rather than expected profits. In this sense, we depart from the profit maximization approach taken by Pollard and Graham, who in other respects provide valuable insights into marketing board strategy and performance.

Analytical derivation of income probability moments and expected utilities would be unwieldy. Export income (import cost) alone involves the three-way product of random world price and random exchange rate with both random demand and random supply. Monte carlo simulation therefore is used instead. Two thousand random values of P_{wt}, X_t, e_{dt}, e_{s1t}, and e_{s2t} were drawn for each price and storage policy considered, and for each drawing a value of board income Y calculated. The latter then were used to compute income probability densities and expected utilities assuming citizens have exponential utility.6/ Absolute risk aversion employed for this purpose was derived from the modal or 'intermediate' partial risk aversion identified in Binswanger's study of Indian peasant farmers. Mean incomes in that study approximate average incomes in Zimbabwe. Details of utility derivations and other simulation parameter settings are available from the authors.7/

OPTIMAL PRICES AND RESERVE STOCKS

Domestic grain and meal prices that maximize the marketing board's expected utility depend upon reserve stock levels since stocks affect impacts of price changes on the board's expected income and risk. For the same reason, optimal stocks depend upon domestic prices in force. To demonstrate this, the board's expected utility is calculated for each of several producer prices at a given stockholding and the expected-utility-maximum price P_S* recorded for alternative stock levels S. We indicate such a relationship by [S, P_S*]. In similar fashion, the optimal reserve stock S* is calculated at a number of alternative producer prices -- [P_S, S^*].

Results are shown in figure 1, where prices other than for producer maize are held at 1986-87 positions. If the board holds no stocks, its privately optimal producer price is Z$130/ton; the optimum falls to Z$78/ton with a million-ton stock. At most producer prices, optimal reserves are zero; that is, the board is best off exporting any year-end excess over (or importing just to satisfy) working stocks. At prices below Z$90/ton, however, the probability distribution of net domestic supply (Q_{st} - Q_{dt}) is such that there is a substantial

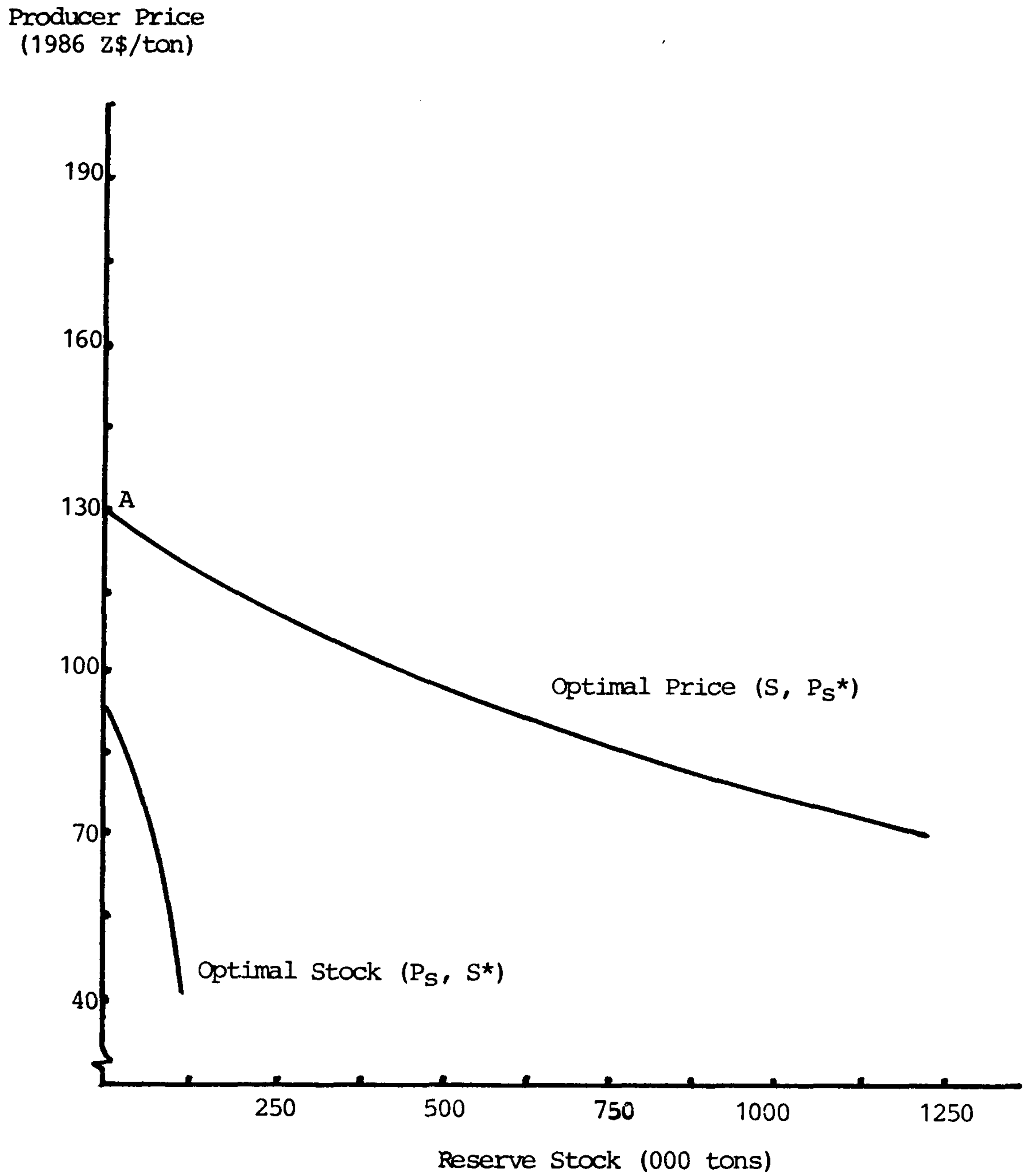

Figure 1. Board's optimal producer prices and reserve stocks given 1986-87 levels of other prices, Zimbabwe.

chance of requiring imports ($S_{t-1} + Q_{st} - Q_{dt} < 0$) if there were no reserves. For example, probability of imports rises from 8.7% to 15.1% as producer price falls from Z$100 to Z$80/ton when stocks are zero. This increases the desirability of holding stocks since stocks save round-trip transfer costs ($T_e + T_i$) to port and help insulate the board from import price risk.8/ Reaction functions [S, P_s*] and [P_s, S*] intersect at point A in figure 1, indicating that zero reserves and a Z$130 producer price are optimal overall.

Because the value of holding reserves increases with export and import transfer costs T_e, T_i, optimal reserve [P_s, S*] should rise as T_e or T_i increase in real terms. Viewed *ex ante* at decision point t-1, real transfer cost is its certainty equivalent, which increases with the mean or variance of the cost probability distribution.9/ Unpredictable cost variance (cost risk) is especially important for a land-locked country like Zimbabwe, whose principal import supply routes through South Africa are threatened by sanctions. To reflect more fully the presently high risk component of import transfer costs, they were quadrupled over present values. Export transfer costs were only doubled since most exports would not be shipped through South Africa but would be affected by increased petrol and parts costs. Functions [S, P_s*] and [P_s, S*] then were re-estimated.

Results are shown in figure 2. Relation [S, P_s*] has shifted down an average Z$19/ton from its figure 1 level, reflecting the impact of lower net export prices on prices the rd willingly would offer producers. More significant is the ift upward in the [P_s, S*] reaction function. The board now ptimally would retain strategic maize reserves even with

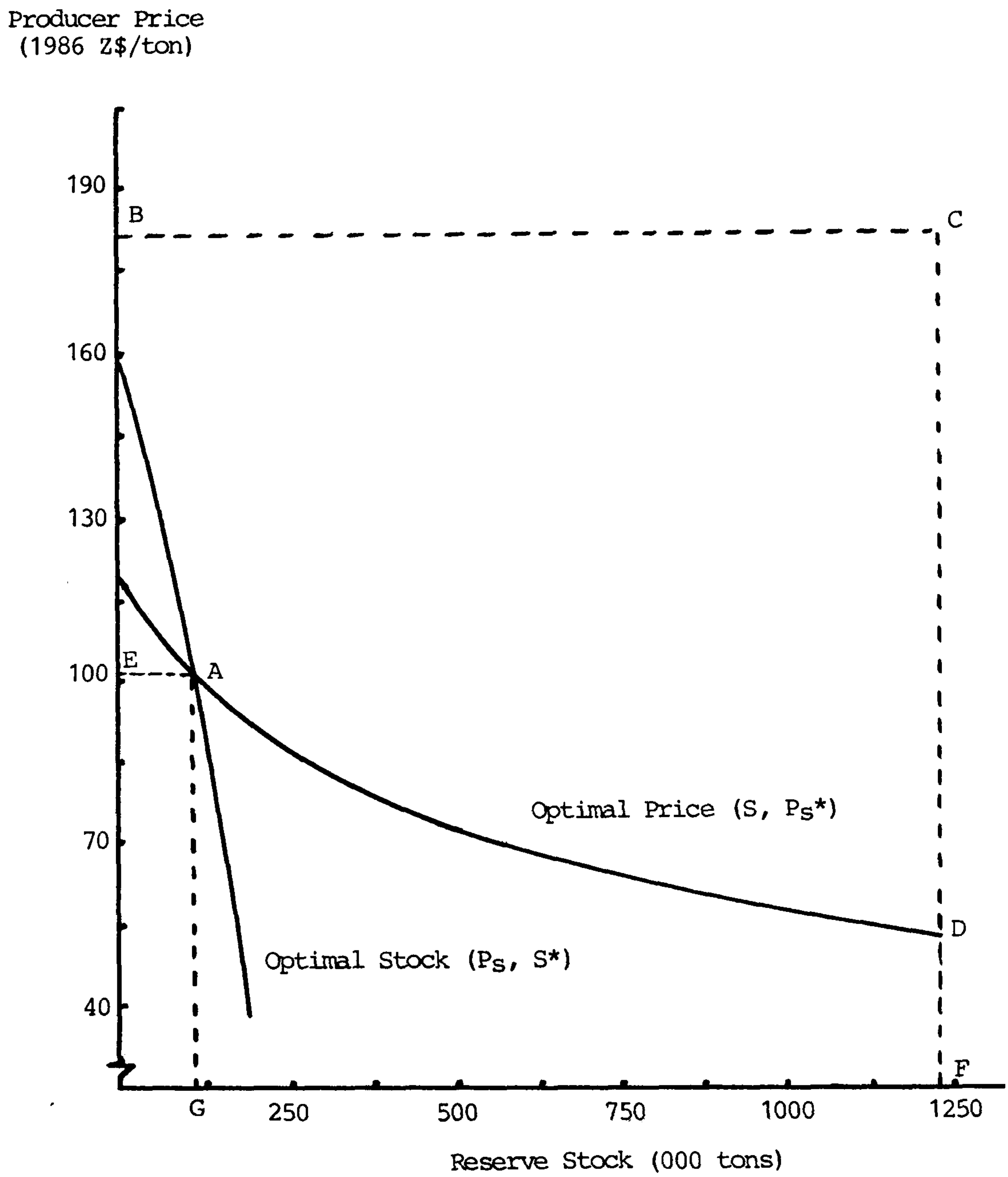

Figure 2. Board's optimal producer prices and reserve stocks given 1986-87 levels of other prices and import risk premium, Zimbabwe.

producer price as high as Z$150/ton. Reserves reduce the probability of requiring imports and thus have increased importance in the presence of a severe import penalty. At 1986-87 fertilizer, maize substitute, and retail maize meal prices, however, chances of imports still are not high and the overall optimum reserve is a modest 105,000 tons (point B in figure 2). Optimal producer price at this stock is Z$102/ton (point E), down Z$28 from the low-transport-cost (figure 1) scenario.

Many developing countries have designed price, input procurement, and extension policies to promote food staple self-sufficiency, that is to reduce probabilities of staple imports. It is useful to see how maize producer price and storage policies best would change if Zimbabwe departed from this practice by setting prices of demand substitutes so as to increase frequency of maize purchases from abroad. This is done in figure 3, where wheat price charged domestic millers is fixed two standard deviations above its 1968-85 mean, maize price charged millers is at 1968-85 mean, and all other prices are at 1986-87 levels. Export-import transfer costs also are returned to 1986-87 (figure 1) levels to represent end of South African sanctions.

With maize demand parameters so boosted, the effect of a producer price decrease in decreasing expected peasant sector demand in (2') is magnified. The [S, P_s*] function consequently is flatter than in figure 1, since the reduction n producer price called for by larger stock positions pondingly has fallen. At a given producer price, the lity that domestic demand Q_{dt} will exceed domestic y Q_{st} is greater than in figure 1, so there is greater centive to insure against imports by holding a larger reserve

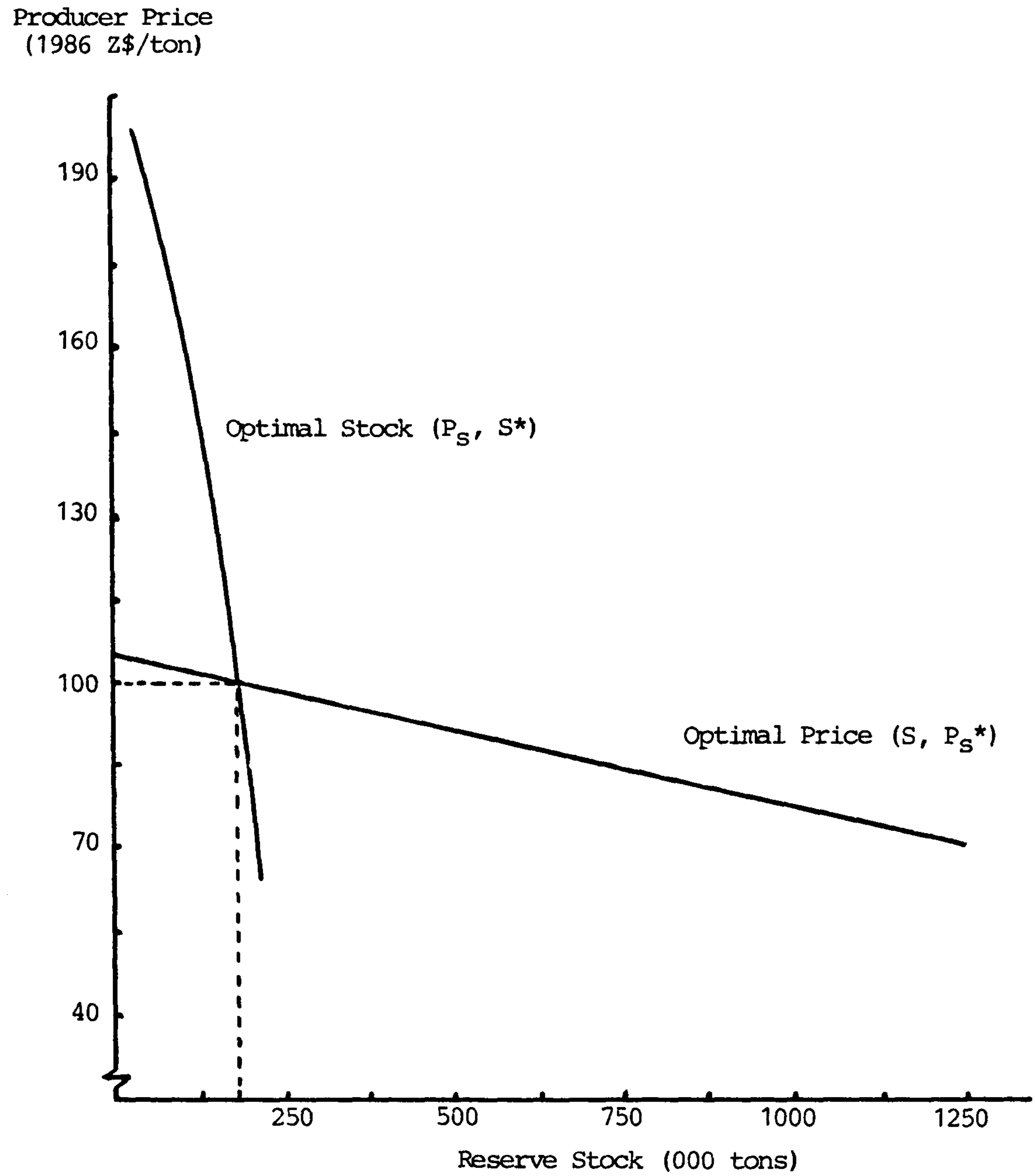

Figure 3. Board's optimal producer prices and reserve stocks given augmented wholesale wheat price, Zimbabwe.

stock. Locus [P_S, S^*] thus shifts upward and to the right. Optimal reserve stock is $S^* = 175{,}000$ tons, up from the zero reserve optimal when wheat price is at its 1986-87 level (figure 1). Optimal producer price is $P_S^* = Z\$100$/ton, down from Z$130/ton in the 1986-87 wheat price scenario.

PRIVATE VERSUS SOCIALLY OPTIMAL POLICY

Zimbabwe Grain Marketing Board's actual maize reserves on March 31, 1986, adjusted for working stocks needed to compensate for farm supply seasonality, were 1,226,000 tons.[10] Producer price on that date was Z$180/ton. This stock-price combination is plotted at point C in figure 2, where it clearly differs from the point (A) considered most desirable on basis of the figure 2 analysis. Examination of the difference reveals the multiplicity of factors government takes into account when setting agricultural policy.

Deviation between actual producer price and the one determined in figure 2 as privately optimal to the board is vertical distance BE. The implied policy discrepancy is much greater than this, however, since if stocks are at 1,226,000 tons, optimal price is DF; true discrepancy between current and privately optimal price is distance CD. The board pays farmers a great deal more per ton than it would if it were acting as an expected utility maximizing monopsonist.

The most likely reason is that price policy has responded to a broader goal than maximization of the marketing board's welfare. Expected producer surplus always rises with producer price increases, and although variance of surplus rises as well (see analysis below equation 4'), producers' expected utility should improve with price increases given typical risk aversion levels. In their capacity as consumers, peasant farmers also gain from a higher producer price because it encourages them to sell maize and purchase retail maize meal, stimulating retail demand and increasing consumer surplus associated with a given retail price. Producers and peasant farm consumers thus form a natural lobbying front in favor of higher producer prices. Governments that have maintained low farm prices effectively have resisted this pressure in deference to the interests of their marketing board accounts. That is, they have imputed to the farming industry a low weight in the social welfare function (Pollard and Graham).[11]

The second form of discrepancy revealed by figure 2 is that if price is maintained at Z$180/ton, a reserve stock of 1,226,000 tons (length BC) is far higher than optimal given the intermediate risk aversion assumed. Optimum reserve in fact is zero, indicated by point B on figure 2's [P_S, S*] line. Difference BC is not likely explained by producer or consumer political pressure or by a welfare function that includes producer or consumer interests. Grain reserves immediately affect the mean and stability only of marketing board returns because domestic prices usually are fixed on an annual basis. Assuming policy makers are effective optimizers, a more plausible reason for the discrepancy is that risk aversion, mean exchange rate, or random variable probabilities we have employed differ from those policy makers actually have used.

These possibilities are examined in table 2 and figure 4a, which give estimated probability moments and cumulative frequency distributions of board income at 1986-87 domestic prices for a zero and 1,226,000-ton reserve stock. Income

Table 2. Prospects facing board with 1986-87 maize and other prices intact a/

	Actual Reserve Stock, 3/31/86	Optimal Reserve Stock, 3/31/86 b/
Reserve Stock (000 tons)	1,226	0
Expected Net Domestic Supply (000 tons) c/	622.91	622.91
Chance of Imports (%)	4.4	8.1
Expected Income (000 Z$)	32,820	44,389
Standard Deviation of Income (000 Z$)	291,382	113,392
Income Skew d/	0.08	0.25

a/ Producer, wholesale (domestic selling), and retail meal prices are Z$180.00, 222.00, and 381.22/ton, respectively.

b/ Assumes government is intermediately risk averse on Binswanger's scale.

c/ Expected domestic supply less expected domestic demand.

d/ Skewness statistic is third central moment of income divided by the cube of the standard deviation.

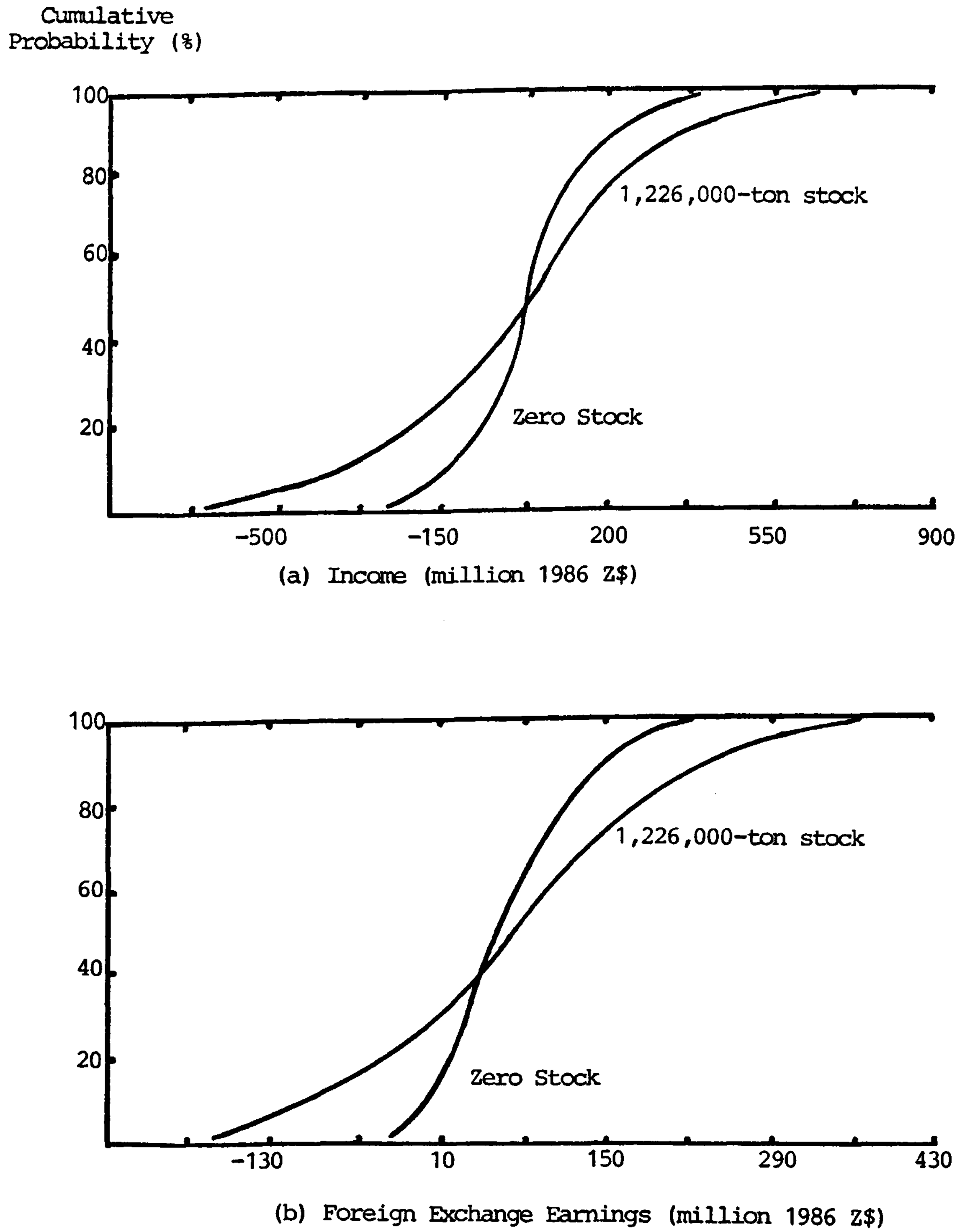

Figure 4. Cumulative probability distributions of marketing board income and foreign exchange earnings, zero-stock and large-stock policies, Zimbabwe. a/

a/ Figure assumes all prices are at 1986-87 levels.

associated with a zero stock has higher mean, lower variance, and more positive skew than does income with a 1,226,000-ton reserve. For risk averters with nonincreasingly risk averse utility functions, each of these differences favors the zero-stock policy (Tsaing, pp. 356-9).12/ More importantly, the zero-stock distribution's left tail in figure 4a lies well to the right of that of the 1,226,000-ton-stock distribution, indicating the zero stock is associated with lower probabilities of large losses. Because at any income level the area under the zero-stock cumulative probability distribution is smaller than that under the large-stock distribution, zero stock dominates the 1,226,000-ton stock in the second degree and is preferred to the latter by all risk averters (Anderson, Dillon, and Hardaker, pp. 284-88). If, then, our probability and exchange rate assumptions are correct, the board's large stockholdings imply policy makers are risk seekers, quite at odds with the risk aversion shared by most citizens.

The possibility that the foregoing conclusion results from undervaluing foreign exchange is dispelled by figure 4b, which gives cumulative distributions of foreign exchange earnings under the no-stock and large-stock scenarios. Figure 4b, rather than 4a, would interest policy makers if they infinitely valued hard over local currency, that is ignored local currency costs and revenues. Implications of figure 4b, however, are little different from those of 4a. Large maize reserves still are associated with the greater chance of a large loss. Maintaining the large stock reduces the probability of imports only from 8.1% to 4.4%, so the principal effect of the stock is to increase exposure to export price risk. Besides this, the stocks incur interest charges: mean present value of hard currency income is US$53,505,000 under the large-stock and US$56,693,000 under the zero-stock policy. Holding reserves would, of course, have reduced earnings risk if chances of imports had been higher.

Finally, policy makers may operate under probability assumptions different from those we have been using. Large carryover stocks at end of the 1982-83 fiscal year were, in hindsight, beneficial because they enabled Zimbabwe to weather two succeeding years of drought with minimal imports. But fixating on recent events obscures probabilities based on a wider range of experience. Chances of an early repetition of the 1983-85 yield depression in fact are quite small and serve as an inadequate basis for present policy.

IMPACT OF REMOVING SUBSIDIES

A number of countries have begun reducing subsidies on consumer staples and, where applicable, taxes on producer prices in order to improve domestic resource allocation. Eliminating such interventions changes the probability distribution of net domestic supply, so marketing boards also must reassess reserve stock policy. Complete subsidy and tax removal was modelled in this study by setting domestic maize selling price equal to expected border price at t (world price less transfer cost to port) times expected exchange rate at t.[13/] Producer price was domestic maize selling price less board handling and storage cost, and consumer price was domestic selling price plus milling and distribution cost. Table 3 shows results assuming alternately that (a) the board maintains its present large reserve stock and (b) stocks are adjusted to maximize expected utility given intermediate risk

Table 3. Prospects facing board if maize price subsidies are removed a/

	Actual Reserve Stock, 3/31/86	Optimal Reserve Stock, 3/31/86 b/
Reserve Stock (000 tons)	1,226	0
Expected Net Domestic Supply (000 tons) c/	919.14	919.14
Chance of Imports (%)	4.3	5.3
Expected Income (000 Z$)	9,002	22,273
Standard Deviation of Income (000 Z$)	336,264	153,049
Income Skew d/	0.01	0.01

a/ Assuming an exchange rate of Z$2.25/US$, nonsubsidized producer, wholesale, and retail price are Z$227.22, 271.84, and 410.90/ton, respectively. At the official exchange rate of Z$1.66/US$, the prices are Z$156.66, 201.28, and 340.34/ton, respectively. A Z$2.25/US$ rate was used in this table.

b/ c/ d/ See footnotes under table 2.

aversion. The optimal adjustment again is to eliminate reserve stocks altogether.

At an approximately equilibrating exchange rate of Z$2.25/US$, full-cost pricing would increase producer, wholesale, and retail prices. Thus, producers presently are taxed and consumers subsidized relative to border prices. The net effect of these price changes is to reduce the expectation, raise the variance, and reduce the skew of board income (compare tables 2 and 3). If the board had well-behaved (decreasingly risk averse) utility, it clearly would be worse off on all counts. Extent of the expected loss is about the same whether the large-stock or optimal (zero-stock) policy is maintained. One way, therefore, to cushion the impact on the Zimbabwe government of price policy reforms is to reduce reserve stocks.

The conclusion that the board would suffer from full-cost pricing seems counter to the usual notion that such pricing would help rid boards of chronic financial losses. Actually, there is no conflict between these two ideas. Accounting losses typically are based on official exchange rates that understate the social value of foreign exchange and therefore of exports. In export surplus years, the board's official net returns thus understate social returns. For the same reason, 'full-cost' producer prices based on official exchange rates typically would be too low relative to export value. Because they often also are lower than producer prices currently in force, switching to an official 'full-cost' price tends to improve a board's accounting returns.

To illustrate this, solutions in tables 2 and 3 were rerun using as a mean exchange rate the October 1986 average official rate of Z$1.66/US$. Expected board income with 1986-87 prices intact (corresponding to table 2) fell to -Z$6,029,000 given the 1,226,000-ton reserve and to Z$1,043,000 given a zero reserve. Standard deviations fell to Z$166,766,000 and Z$63,725,000, and skew coefficients to 0.02 and -0.12, respectively. 'Full cost' pricing at the official exchange reduced producer, wholesale, and retail prices below current levels (see footnote a of tables 2 and 3). Corresponding mean income, again using the official exchange rate, was only Z$6,793,000 given a 1,226,000-ton reserve (compared to the Z$9,002,000 in table 3) and only Z$10,270,000 given a zero reserve. Thus, whatever the stock level, mean accounting income at the official exchange rate rises when taxes and subsidies are removed. Reverting to an approximately equilibrating mean rate not only adjusts incomes to more accurate, higher levels but shows that producer prices actually rise and board incomes fall under full-cost pricing.[14] Net social welfare change depends upon the weight assigned producers' gains relative to government's losses.

CONCLUSIONS

A framework has been set out in this paper for evaluating the impact on a government marketing board of selected price and reserve stock policies. We have argued that impacts should be addressed *ex ante* in terms of the expected utilities of alternative policies. This involves assessing not just expected effects or likelihoods of arbitrarily defined disasters, but the entire probability distributions of random returns. Using this approach, optimal price and reserve stock levels were found to be interdependent. Producer price ideal from government's viewpoint depends upon the board's stockholdings and vice versa. At 1986-87 prices, Zimbabwe's optimal reserve (i.e. that net of working requirements) would be zero unless account were taken of the riskiness of import transfer cost. When the latter is considered, optimal reserve is only 105,000 tons. Larger reserves would be desirable if demand-stimulating wholesale prices were adopted.

Socially optimal prices are likely to be higher than those indicated in figures 1 through 3 because government must keep consumer and producer as well as marketing board interests in mind. However, with producer prices presently in force, the high reserve stocks maintained in Zimbabwe imply policy makers either are prone to take unusually large financial risks or dwell excessively on the recent drought experience. Given empirically validated risk aversion and import probability assumptions, the board's stocks are much too large to maximize expected utility. Allowing for differences in assumed objectives, this agrees with Pollard and Graham's conclusion (p. 1074) that Jamaican export marketing boards are 'inefficient both in terms of the maximization of their own profits and the maximization of foreign exchange earnings.'

The effect of removing subsidies or taxes from domestic prices depends crucially on the exchange rate used to convert world prices to a domestic equivalent. At official Zimbabwe dollar - U.S. dollar rates, producer prices are subsidized and wholesale and retail prices taxed relative to world prices.15/ Removing these interventions would increase the expectation of the marketing board's accounting income. But official exchange rates do not reflect the true scarcity value of hard currency.

When a rate closer to equilibrating level is used, producer prices are taxed and wholesale and consumer prices subsidized relative to world price. Removing the latter interventions would reduce government's mean income and expected utility while improving producer welfare.

In the bleaker world in which government would find itself with full-cost pricing, there would be incentives to share grain marketing functions with other firms. Market sharing would shift to other equity-holders some of the enormous risks presently saddling government marketing efforts (see figure 4). Inter-firm competition also would help provide information on equilibrium prices necessary for determining true minimum costs, which in turn are needed for identifying the incidence of taxes and subsidies. Market decontrol thus is a natural consequent of, as well as requirement for, true full-cost pricing. Analysis of the likely impacts of decontrol would require additional information on the grain marketing costs that would be incurred by new firms.

NOTES

1. Strategic reserves are distinguished from working stocks held due to the seasonal nature of the board's domestic maize purchases. Terms 'reserve stock' or 'stock' in this chapter refer to such strategic reserves.

2. Because they tend to be stable in deflated terms, costs H, I, and F are assumed known at t-1.

3. To render comparable the mean square errors of doublelog and linear fits, the latter must be multiplied by the squared inverse of the dependent variable's geometric mean (Box and Cox).

4. We are indebted to Kay Leresche for pointing out the rural security effect on food supplies.

5. As Pollard and Graham point out (p. 1068), actual benefits to citizens depend upon how board losses are financed or how profits are distributed. We assume losses or profits are distributed broadly in some manner but do not venture to measure the effect of alternative distribution schemes.

6. Exponential utility is $U = -\exp(-mY)$, where Y is income and m is constant absolute risk aversion. Use of a decreasing absolute risk aversion function made little difference to the study's results and is not reported here.

7. Random variables e_{s1t}, e_{s2t} were assumed normally distributed with mean zero and variance derived from (3'), (4'). Variable e_{dt} was lognormally distributed with mean one and variance taken from (2'). World price P_{wt} was normally distributed with mean and variance derived from

its 1972-84 trend line. Variance of exchange rate X_t was derived from its 1980-85 trend but mean set at Z$2.25/US$. The latter is above official levels (Z$1.66/US$ in October 1986) but near what is commonly thought to be an equilibrating rate (Financial Gazette, p. 4.).

8. The additional argument that stocks 'save the foreign exchange cost of importing' assumes implicitly that hard currency is worth more than its official rate.

9. Certainty equivalent cost is expected cost plus risk premium, where the latter is a positive function of cost variance and the decision maker's risk aversion (Pratt, pp. 124-5).

10. Total fiscal-year-end stocks were 1,426,000 tons. The board's monthly net maize intake is negative until early July, when cumulative maize purchases begin to exceed cumulative domestic sales. We have assumed liberally that a four-month working stock is needed at 50,000 tons per month, so the effective strategic reserve on March 31 was 1,226,000 tons.

11. Pollard and Graham (p. 1068) note that when boards act as expected profit maximizers, this 'may reduce the potential benefits to society, depending on the state of the social welfare function.'

12. Increasing risk aversion is regarded by many as unreasonable because it implies an individual would be increasingly unwilling to bear a risk of fixed size as his income increased.

13. Deducting transfer cost from, rather than adding it to, world price assumes the board expects to export rather than import at time t. This is justified by subsequent results and by Zimbabwe's typically export position. If policy makers have rational expectations, disposition of transfer cost is endogenous because it must be consistent with the mean solution obtained.

14. Full-cost prices of imported farm inputs also would rise if the exchange rate employed to determine them were increased from official to equilibrating levels.

15. Also using official exchange rates, Jabara (pp. 616-17) found maize prices in Kenya to be roughly in line with world prices, hence neither taxed nor subsidized.

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