PRICING AND STORAGE DECISIONS

IN GOVERNMENT GRAIN MARKETING BOARDS

Steven T. Buccola

and

Chrispen Sukume

Presented as a Selected Paper at the American Agricultural Economics Association Annual Meetings, Michigan State University, August 2-5, 1987.

The authors are associate professor and graduate student, respectively, Department of Agricultural and Resource Economics, Oregon State University.

Research supporting this paper was financed by the Department of Agricultural Economics, Michigan State University, under the Food Security in Africa Cooperative Agreement DAN-1190-A-00-4092-00, jointly funded by the Bureau of Science and Technology (Office of Rural and Institutional Development), Bureau for Africa (Office of Technical Resources), U.S. Agency for International Development, and USAID's Southern Africa Regional Program in Harare, Zimbabwe.

PRICING AND STORAGE DECISIONS
IN GOVERNMENT GRAIN MARKETING BOARDS

Abstract

A model is developed of the pricing and storage decisions of a government grain marketing board. Price and storage levels are found to have interdependent effects on a board's utility. The model indicates that Zimbabwe's Grain Marketing Board pays higher prices and holds larger stocks than would be optimal for an expected utility maximizing monopsonist.

PRICING AND STORAGE DECISIONS
IN GOVERNMENT GRAIN MARKETING BOARDS

Increased emphasis on food security in developing countries has heightened attention to pricing and grain stock policies of government-owned marketing boards. Analysts frequently have concluded, for example, that consumer and producer prices in controlled agricultural markets tend to be too low (Aboyade; 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).

In the present paper 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 and maintains most of the nation's grain reserve stocks. This institutional setting is found commonly in the Third World (Ahmed and Rustagi; Aboyade). It imposes on government much of the food industry's financial risk since unexpected changes in net domestic supplies must be balanced by changes in the board's stocks or by its external trades. 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. The framework is applied to the Zimbabwe corn sector. We find that Zimbabwe's strategic corn stocks are too large, suggesting policy makers overestimate the probability of drought or are excessively willing to gamble on future income.

Decision Model

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

Marketing Board Income

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

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

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

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

domestic revenues in t

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

farm corn 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 corn carried from end of t-1$^{\underline{th}}$ to end of t$^{\underline{th}}$ fiscal year (tons);

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

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

P_{wt}, $P_{w,t-1}$ = world corn 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 corn account (Z$);

i = annual interest rate.

At end of the t-1$^{\underline{th}}$ fiscal year, when government selects price P_s to pay farmers, P_d to charge millers, and strategic reserve stock S_{t-1} to carry into t, income Y is random. 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. Stocks carried forward from t-1 are assumed "purchased" from the t-1$^{\underline{th}}$ fiscal year at current net export price ($P_{w,t-1} - T_e$) and either are exported (or deducted from imports) at time t or "sold" to the t+1$^{\underline{th}}$ 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. Stocks S_{t-1} are strategic reserves in the sense that they exceed the working stocks required by the seasonal nature of the board's domestic corn purchases.

Econometric Model

Variables in (1) are divisible into four categories: (a) those over which government has little short-run control but which are fairly predictable in the short run (H, I, i); (b) those which government cannot control and which are highly stochastic (P_{wt}, X_t, T_e, T_i); (c) those directly under government control (S_{t-1}, P_d, P_s); and (d) those government partly controls but which remain stochastic (Q_{st}, Q_{dt}). Transfer costs T_e, T_i are random due to the threat of South African right-of-way sanctions. Because quantities Q_{st} supplied and Q_{dt} demanded are affected by price policies P_d, P_s, the latter prices have both a direct and indirect effect on government income. Modelling supply and demand relations therefore is a crucial first step in forecasting policy effects on government and social welfare.

Demand and supply responses for Zimbabwe corn that were estimated for this purpose took the general form

(2) $$Q_{dt} = Q_d(P_d, Z_d, e_{dt})$$

(3) $$Q_{st}^p = Q_s^p(P_s, W, Z_s, e_{s1t})$$

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

where, besides previously defined terms, Q_{st}^p and Q_{st}^c are quantities supplied from the peasant and commercial farming sectors, respectively ($Q_{st}^p + Q_{st}^c = Q_{st}$); W is weather; Z_d (Z_s) is a vector of other policies affecting demand (supply); and e_{dt}, e_{s1t}, e_{s2t} are random factors excluded from the regression. Functional forms needed to fit (2) - (4) affect policy implications derivable from the research (Turnovsky; Just, Hueth, and Schmitz, pp. 244-46; Reutlinger).

The doublelog version of (2),

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

where K_1 is policy vector (P_d, Z_d) and $K_1{}^a$ represents $P_d{}^{a1} Z_{d1}{}^{a2} Z_{d2}{}^{a3}$...., was estimated by OLS with 1968-85 time series (Newbery and Stiglitz, pp. 120-21). Supplies were specified with additive errors so that variance could partially be independent of mean. Letting K_2 be policy vector (P_s, Z_s) and using the same notation as in (2′),

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

$$(4') \qquad Q_{st}{}^c = DK_2{}^d W^g + FK_2{}^f v$$

where B, C, D, F are constants; $CK_2{}^c u = e_{s1t}$, $FK_2{}^f v = e_{s2t}$; 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 $B^2 K_2{}^{2b} Var(W^g) + C^2 K_2{}^{2c}$, so its coefficient of variation is a nonconstant function of policy level. Equations (3′) and (4′) were estimated with deflated 1953-85 data using the iterative nonlinear approach outlined by Buccola and McCarl.

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 Zimbabwe's grain board is operated on behalf of citizens and losses are charged to the public treasury, we argue board incomes should be evaluated in terms of taxpayers' utility functions. It is appropriate further, given widespread evidence of risk aversion in household decisions, to cast effects of alternative policies in terms of expected utilities rather than expected profits.

Analytical derivation of expected utilities would be unwieldy. Export income (or 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 was used instead. Two thousand independent values of random variables 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 taxpayers have exponential utility. 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--including a certainty equivalent characterization of costs T_e, T_i--are available from the authors.

Optimal Prices and Reserve Stocks

Domestic grain 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. Optimal stocks, in turn, depend upon domestic prices because the latter influence distributions of quantities supplied to and demanded from the board. To demonstrate this, the board's expected utility is calculated for each of several producer prices at a given reserve stock 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--$[P_s, S^*]$. Overall optimal stock-price combination (S^{**}, P_s^{**}) is given at the intersection of these two functions.

Results are shown in figure 1, where prices other than for producer-level corn are held at 1986-87 positions. If the board holds no stocks, its privately optimal producer price P_s^* is Z$119/ton; the optimum falls to Z$58/ton with a million-ton stock. (Mean exchange rate was Z$2.25 per one U.S. dollar.) At producer prices above Z$160/ton, optimal reserves S^* 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$160/ton, however, the probability distribution of net domestic supply $(Q_{st} - Q_{dt})$ is such that there is a nonnegligible chance of requiring imports $(S_{t-1} + Q_{st} - Q_{dt} < 0)$ if there were no reserves. For instance, probability of imports rises from 8.7% to 15.1% as producer price falls from Z$100/ton to Z$80/ton when stocks are zero. This increases the desirability of holding stocks, which save round-trip transfer costs $(T_e + T_i)$ to port and help insulate the board from import price risk. Functions $[S, P_s^*]$ and $[P_s, S^*]$ intersect at point (S^{**}, P_s^{**}) in figure 1, indicating that a 105,000-ton reserve and a Z$102/ton producer price are optimal overall.

Simulations also were developed for alternative levels of substitute and input prices. In one application, wholesale wheat price (contained in vector K_1 in equation $2'$) was adjusted to two standard deviations above its 1968-1985 mean, increasing wholesale corn demand. This

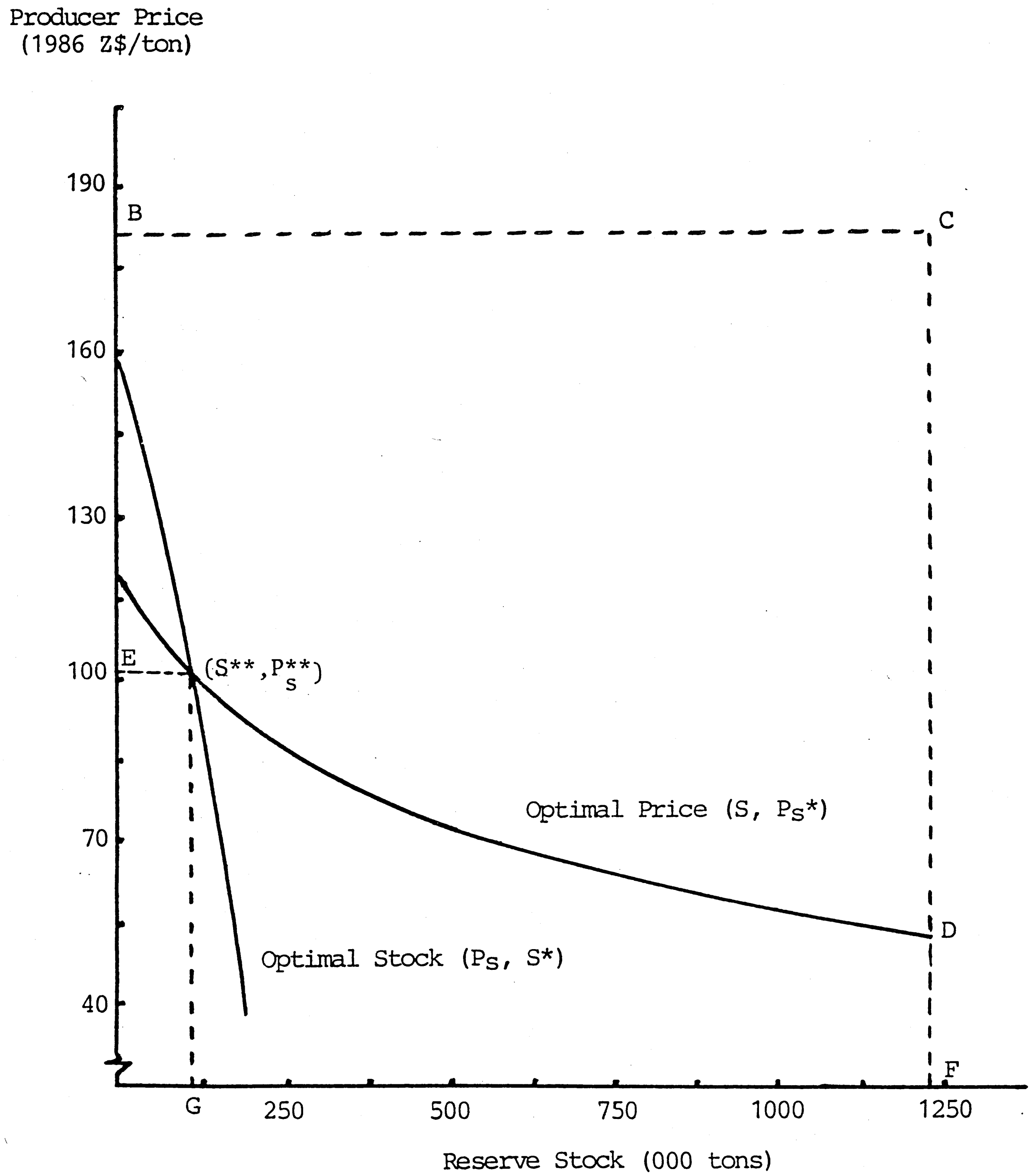

Figure 1. Board's optimal producer prices and reserve stocks given 1986-87 levels of other prices, Zimbabwe.

resulted in an upward shift both in the optimal stock [P_s, S^*] and optimal price [S, P_s^*] function. Intersection point (S^{**}, P_s^{**}) of these functions shifted rightward 65,000 tons, giving a new overall optimal storage level S^{**} of 175,000 tons. Overall optimal producer price P_s^{**} did not change appreciably.

Private Versus Socially Optimal Policy

Zimbabwe Grain Marketing Board's actual corn reserves on March 31, 1986, adjusted for working stocks needed to compensate for farm supply seasonality, were 1,226,000 tons. Producer price on that date was Z$180/ton. This stock-price combination is plotted at point C in figure 1, where it clearly differs from the point (S^{**}, P_s^{**}) considered most desirable on basis of the figure 1 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 1 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 more per ton than it would if it were acting as an expected utility maximizing monopsonist. It evidently has responded to farmer pressure for higher producer prices, thereby imputing to farmers a nonzero weight in the implicit social welfare function.

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

These possibilities are examined in figure 2, which gives cumulative frequency distributions of board income at 1986-87 domestic prices for a zero and 1,226,000-ton reserve stock. The zero-stock distribution's left tail in figure 2 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 assumptions are correct, the board's large stockholdings imply policy makers are risk seekers, quite at odds with the risk aversion presumably shared by most citizens. Alternatively, policy makers may be assuming probability distributions of P_t, X_t, e_{dt}, e_{s1t}, and e_{s2t} which are different from those implicit in figure 2. Specifically, they may be reacting to the recent (1983-85) drought by overestimating the likelihood of a near-term yield depression. But

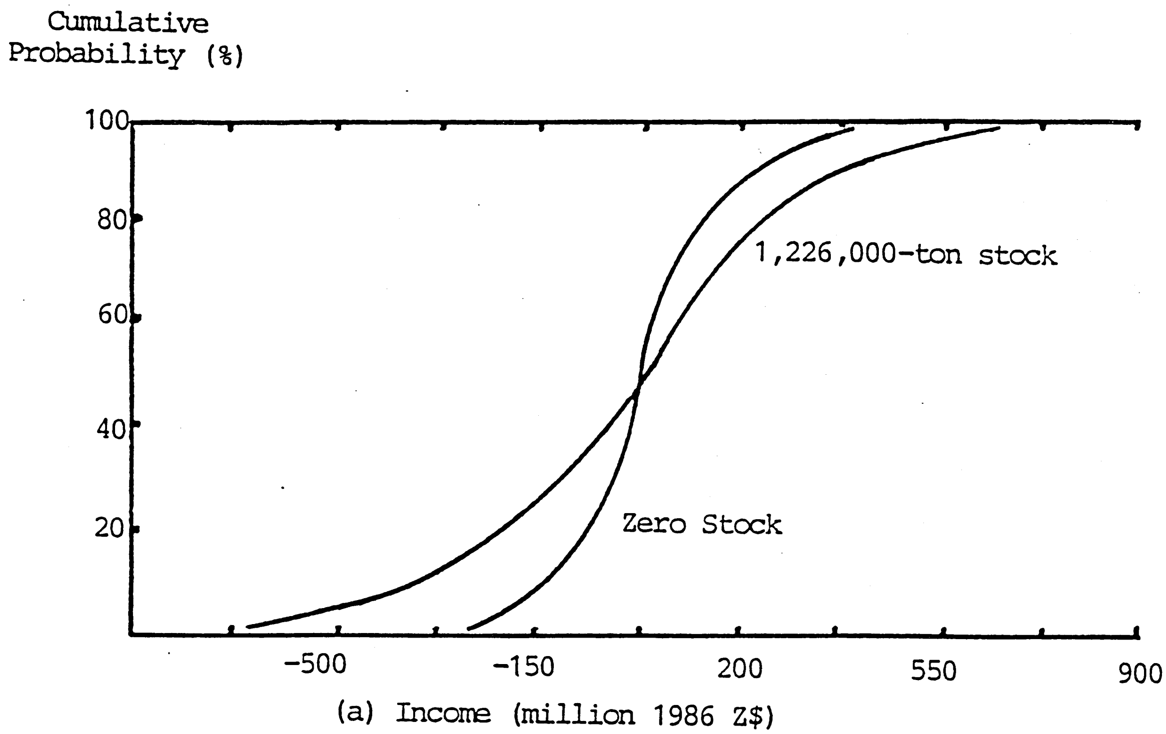

Figure 2. Cumulative probability distribution of marketing board income, zero-stock and large-stock policies, Zimbabwe.[a]

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

chances of an early repetition of drought of the 1983-85 magnitude are small and serve as an inadequate basis for present policy.

Conclusions

A framework has been set out in this paper for evaluating the impact on a government marketing board of 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. That is, producer price ideal from government's viewpoint depends upon the board's reserve stocks and _vice versa_. Overall optimal prices and stocks therefore must be determined simultaneously.

In contrast to Aboyade's and Pollard and Graham's findings that marketing boards' prices are too low, producer corn prices in Zimbabwe are substantially above levels that would maximize a monopsonist's expected utility. However, with producer prices presently in force, the high reserve stocks maintained imply policy makers either are prone to take unusually large financial risks or dwell excessively on the recent drought experience. Given reasonable risk aversion and import probability assumptions, the board's stocks are too large to maximize expected utility. Such a conclusion is consistent with Bale and others and suggests the board could make more efficient use of taxpayer capital.

References

Aboyade, O. Administering Food Producer Prices in Africa: Lessons from International Experiences. Int. Food Pol. Res. Inst., 1985.

Ahmed, R., and N. Rustagi. Agricultural Marketing and Price Incentives: A Comparative Study of African and Asian Countries. Int. Food Pol. Res. Inst., 1985.

Anderson, J.R., J.L. Dillon, and B. Hardaker. Agricultural Decision Analysis. Ames: Iowa State University Press, 1977.

Bale, M.D. Agricultural Trade and Food Policies: The Experience of Five Developing Countries. World Bank Staff Working Papers No. 724, 1985.

Binswanger, H.P. "Attitudes Toward Risk: Theoretical Implications of an Experiment in Rural India." Economic Journal 91 (December 1981): 867-90.

Buccola, S.T., and B.A. McCarl. "Small-Sample Evaluation of Mean-Variance Production Function Estimators." American Journal of Agricultural Economics 68 (August 1986): 732-38.

Just, R.E., D.L. Hueth, and A. Schmitz. Applied Welfare Economics and Public Policy. Englewood Cliffs: Prentice-Hall, Inc., 1982.

Newbery, D.M.G., and J.E. Stiglitz. The Theory of Commodity Price Stabilization. Oxford: Clarendon Press, 1981.

Pollard, S.K., and D.H. Graham. "Price Policy and Agricultural Export Performance in Jamaica." World Development 13 (September 1985): 1067-75.

Reutlinger, S. "A Simulation Model for Evaluating Worldwide Buffer Stocks of Wheat." American Journal of Agricultural Economics 58 (February 1976): 1-12.

Turnovsky, S.J. "The Distribution of Welfare Gains From Price Stabilization: A Survey of Some Theoretical Issues." in F. G. Adams and S. A. Klein, Stabilizing World Commodity Markets, Lexington: Lexington Books, 1978.