American Economic Association

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Source: *The American Economic Review*, Vol. 78, No. 1 (Mar., 1988), pp. 46-58
Published by: American Economic Association
Stable URL: http://www.jstor.org/stable/1814697
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The Effects of Commodity Price Stabilization Programs

By MARIO J. MIRANDA AND PETER G. HELMBERGER*

In this paper we analyze commodity programs in which the government attempts to support and stabilize price through open market purchases and sales. Specifically, we assess the effects of such programs on the U.S. soybean market using a rational expectations model that allows for private storage, expected price-responsive production, and arbitrary support and release prices. Stochastic simulations of the model demonstrate that price stabilization programs can reduce long-run market price and destabilize producer revenue.

This paper provides an empirical evaluation of commodity price stabilization programs in which the government offers to purchase and store a commodity at a fixed support price and offers to sell any quantities in its possession at a fixed release price. Price band buffer stock programs, so-called because they are designed to contain price within the band determined by the support and release prices, have played an important role in U.S. farm policy since 1933. Such programs have been used, often in conjunction with other programs, to stabilize the domestic prices of soybeans, wheat, rice, and corn and have been promoted as a means of stabilizing international markets for a wide range of primary commodities.

Specifically, this paper assesses the effects of price band buffer stock programs on the U.S. soybean market using a rational expectations model in which acreage planted is responsive to expected future prices, yield is uncertain, and storage is carried out by competitive, expected profit-maximizing arbitrageurs. A salient feature of the model, missing from conventional models of price stabilization programs, is that private production and storage behavior adjusts to changes in government policy.[1] Rational expectations equilibria, which cannot be derived analytically, are computed numerically.

Stochastic simulations of the U.S. soybean market under alternative support and release prices produce a number of significant results regarding the effects of price band programs. We find, for instance, that only those programs entailing a low support price and a wide price band stabilize price without destabilizing producer revenue. Although this and other findings may not apply directly to other commodity or financial markets, many of our results contradict conventional wisdom and therefore have relevance beyond the narrow focus of this specific commodity. It has become commonplace in the literature, for example, to suppose that a price band program raises market price and that narrowing the price band stabilizes market price. We find that both of these suppositions are false. Some price band programs can actually reduce long-run market price below the competitive level and narrowing

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[1]The theoretical models of price stabilization following in the tradition of Frederick Waugh, 1944, Walter Oi, 1961, and Benton Massell, 1969, ignore private storage completely. The econometric studies by Jere Behrman, 1978, Olarn Chaipravat, 1978, Meghnad Desai, 1966, Shlomo Reutlinger, 1976, and Willard Cochrane and Yigal Danin, 1976, assume private stockholding and planting decisions are not affected by changes in government stabilization policy; as such, these studies are subject to Robert Lucas's 1976 critique. Regarding previous econometric research on stabilization schemes, Stephen Salant (1983, p. 2) writes, "Although many of the recent agreements and proposals have been evaluated favorably, the methodology underlying these evaluations renders their favorable conclusions worthless."

the band by lowering the release level can actually destabilize price.

Section I sets forth the market model and discusses the methods used to compute rational expectations equilibria. Section II discusses the market effects of price band programs. Section III examines the welfare effects and government costs of price band programs. Section IV summarizes our findings.

I. The Market Model

Our annual model of the U.S. soybean market includes consumers, producers, arbitrageur storers, and the government.

Initial Conditions. A typical year t begins with a given supply s_t' held by private market participants and a given amount y_t' held by the government. Initial private supply s_t' is composed of private carryover from the preceding year x_{t-1} and new production, which equals the acreage planted the preceding year a_{t-1} times a random per acre yield $\tilde{\omega}_t$:

$$s_t' = x_{t-1} + a_{t-1} \cdot \tilde{\omega}_t. \tag{1}$$

Initial government stocks y_t' are composed of government carryover from the preceding year y_{t-1}:

$$y_t' = y_{t-1}. \tag{2}$$

Price Band Programs. The government offers to buy unlimited quantities of the commodity at a set support price $\bar{p}_s$ and to sell any quantities in its possession at a set release price $\bar{p}_R$. Government open market operations alter the distribution of total supply between private and government hands; denoting *net* government purchases in year t by g_t, final private supply is given by

$$s_t = s_t' - g_t, \tag{3}$$

and final government stocks by

$$y_t = y_t' + g_t. \tag{4}$$

The government does not purchase stocks if the market price exceeds the support level and does not sell any if the market price falls below the release level

$$p_t > \bar{p}_s \Rightarrow g_t \leq 0, \tag{5}$$

$$p_t < \bar{p}_R \Rightarrow g_t \geq 0. \tag{6}$$

Since the government is willing to acquire any amount of the commodity at the support price, market price never falls below the support level

$$p_t \geq \bar{p}_s. \tag{7}$$

The government, however, is able to release only as much as it holds in its stockpile initially,

$$g_t \geq -y_t'. \tag{8}$$

Thus, market price can rise above the release level, though only if the government stockpile is depleted:

$$p_t > \bar{p}_R \Rightarrow g_t = -y_t'. \tag{9}$$

Private Market Activity. Of final private supply, an amount x_t is stored by arbitrageurs and the remainder, $s_t - x_t$, is purchased by consumers at the market clearing price

$$p_t = \pi(s_t - x_t). \tag{10}$$

Competition among the expected profit-maximizing arbitrageurs eliminates profit opportunities; this yields the well-known intertemporal arbitrage conditions[2]

$$\begin{aligned} &x_t \geq 0, \\ &p_t \geq \delta p_{t+1}^e - \kappa, \\ &p_t > \delta p_{t+1}^e - \kappa \Rightarrow x_t = 0. \end{aligned} \tag{11}$$

[2]Given the widespread use of forward and futures contracts and the growing evidence that risk premiums may be small, we judge the present assumption of risk neutrality provides a useful first approximation. See Jeffrey Frankel (1984) for further discussion of this point.

Here, $\delta p^e_{t+1} - \kappa$, the discounted price expected next year less the constant unit storage cost, is the expected marginal revenue from storing the commodity.

The acreage planted by producers depends on the price expected next year at harvest time,[3]

$$a_t = \alpha(p^e_{t+1}). \tag{12}$$

Arbitrageurs and producers form their expectations of next year's price rationally,

$$p^e_{t+1} = \mathscr{E}_t p_{t+1}. \tag{13}$$

Model Parameterization. Farm-level demand and acreage supply equations for U.S. soybeans were estimated using ordinary least squares and 1951–80 data.[4] Exogenous shifters were assigned their 1977 values to obtain simplified exponential forms expressing quantity demanded in billions of bushels, and acreage supplied, in millions of acres, as functions of market price and expected market price, respectively, in real (1977) dollars per bushel. The simplified demand equation had a constant term of 5.18 and an elasticity of -0.61; the simplified acreage supply equation had a constant term of 13.0 and an elasticity of 0.89.

The random yields $\tilde{\omega}_t$ were assumed to be independently and identically distributed following a log-normal distribution with an estimated mean of 29.84 bushels per acre and a coefficient of variation of 17.43 percent. The annual discount factor of 0.916 was derived from a real rate of interest estimated by taking the interest rate on loans for feeder cattle adjusted for the change in the producer price index. Historical data suggested an approximate storage cost of $0.36 per bushel per year.

Rational Expectations Equilibria. To solve the market model (1)–(13), one must determine how expected price varies with changes in other endogenous variables. Stephen Salant (1983) and Miranda (1987) have shown that if price expectations are rational and the model is time stationary, then there exists an unique function f such that

$$\mathscr{E}_t p_{t+1} = f(x_t, y_t, a_t). \tag{14}$$

That is, the rationally expected price is uniquely determined by the current levels of private carryout, government carryout, and acreage planted. Given the conditional expected price function f, substituting (14) for (13) closes the model, allowing it to be solved for the equilibrium levels of price, private carryout, government carryout, and other endogenous variables.

The function f cannot generally be derived analytically.[5] However, an approximation to the function f can be numerically computed through successive approximation: Begin with an arbitrary guess f_0 for f. Having the nth iterate f_n, substitute

$$p^e_{t+1} = f_n(x_t, y_t, a_t) \tag{15}$$

for (13) and solve equations (3)–(13) for the equilibrium price for each level of initial private supply and government stocks on some specified grid. Interpolate the grid values bilinearly to construct a function ϕ_n that expresses the approximate equilibrium price

[3] The market model can easily be generalized to include stochastic terms in the demand and acreage supply equations; see Mario Miranda (1985). Preliminary simulation experiments indicated that the effects of these random shocks are negligible in comparison to the effects of yield variability. They were dropped to reduce the cost of computation.

[4] The demand equation was estimated using semiannual data with the demand elasticity restricted to be the same for both halves of the year. The semiannual demands were summed to obtain annual demand. In estimating the acreage supply function, the November futures price for soybeans as of planting time, deflated by an index of prices paid for farm inputs, was used as a proxy for expected price. The t-ratio for the demand elasticity was 2.19; the t-ratio for the supply elasticity was 3.65.

[5] In many recent econometric rational expectations macroeconomic studies (for example, Ray Fair and John Taylor, 1983), the conditional expected price relationship is embedded in the econometric model and is estimated directly. In our study, the conditional expected price function does not appear in the structural econometric model. The econometric model is estimated independently first and only then is the conditional expected price function implied by the model computed numerically.

$\phi_n(s', y')$ for all possible levels of initial private supply s' and government stocks y'. Construct the $n+1$th iterate by setting

$$(16)\quad f_{n+1}(x_t, y_t, a_t) = \mathscr{E}\tilde{\omega}\phi_n(x_t + y_t + \tilde{\omega}\cdot a_t, y_t)$$

for all x_t, y_t, and a_t. If the difference between f_n and f_{n+1} is sufficiently small, stop; otherwise repeat the steps above.

The algorithm above typically converged in six iterations or less to an approximation for the rational expected price function exhibiting a relative error not exceeding one-tenth of one percent. For details see Miranda (1987).[6]

II. Market Effects of Price Band Programs

Analysis of the effects of price band programs on the U.S. soybean market is based on the comparison of the steady-state means and coefficients of variation of selected market variables under different price band regimes. For each regime, the steady-state moments were estimated from samples of two million observations generated through Monte Carlo simulations of the market process. The simulations were performed by repeatedly drawing random yields from the assumed log-normal distribution.

Table 1 provides estimates of the steady-state mean government stocks, mean price, coefficient of variation of price, and coefficient of variation of producer revenue for various combinations of support and release price. Explosive policies, those whose steady-state mean government stocks are infinite, are marked with asterisks. Although not evident from this table, policies whose support price exceeds \$5.65 are explosive, regardless of the width of the band. Lowering the support price widens the range of price bands consistent with finite steady-state mean government stocks. Roughly speaking, the range for nonexplosive bands grows by forty cents for every twenty-cent drop in the support price.

Our first major result is that nonexplosive price band policies lower steady-state mean market price below its competitive level of \$5.72 (see Table 1). For this class of policies, steady-state mean price falls monotonically if either the support level or the bandwidth is increased. Only explosive price band policies raise the steady-state mean price above the competitive level. For explosive policies, steady-state mean price rises monotonically if either the support price or the bandwidth is increased.

A second major result evident from Table 1 is that price can be stabilized substantially without causing government stocks to explode. For example, setting the support and release prices at \$5.50 and \$5.70, respectively, lowers the steady-state coefficient of variation of price from 20.24 percent, the competitive level, to 5.15 percent. The associated steady-state mean government stock equals 1.88 billion bushels, roughly one year's production. In general, raising the support price while holding bandwidth constant stabilizes market price. Perfect price stabilization can be achieved in the long run only by selecting an explosive policy with a zero bandwidth.

Price band programs affect price behavior by altering market demand and supply. Figure 1A gives the total demand for consumption and private storage, DD_C, under competitive conditions. Introduction of a price band program immediately causes total demand to become perfectly elastic at the support level $\bar{p}_s$, the result of the government's willingness to acquire unlimited stocks at that price. Total demand becomes DD_B. In the first year of the program, total supply, which is predetermined and thus perfectly inelastic, is composed of private carryover from the preceding year and new production. For a low market supply s_0, price p_0 exceeds the support level, obviating the need for government open market purchases. For a high market supply s_1, on the other hand,

[6] Brian Wright and Jeffrey Williams, 1982, and Mark Lowry et al., 1985, use computable rational expectations models to study competitive storage. Bruce Gardner, 1979, and Gerald Plato and Douglas Gordon, 1983, use similar methods to study government buffer stock schemes. These studies draw on the work of Robert Gustafson, 1958, who was the first to use computational methods to study commodity storage.

TABLE 1—STEADY-STATE MEAN PRICE, COEFFICIENT OF VARIATION OF PRICE, COEFFICIENT OF VARIATION OF PRODUCER REVENUE, AND MEAN GOVERNMENT STOCKS[a,b]

Support Price		Bandwidth (Release Price Minus Support Price) 0.00	0.20	0.40	0.60	0.80	1.00	1.20
4.50	Mean Price	5.71	5.71	5.71	5.71	5.71	5.71	5.71
	CV Price	20.01	19.98	19.89	19.74	19.58	19.45	19.38
	CV Revenue	8.70	8.69	8.63	8.47	8.28	8.08	7.92
	Govt. Stocks	0.03	0.03	0.03	0.04	0.04	0.04	0.04
4.70	Mean Price	5.71	5.71	5.71	5.70	5.70	5.70	5.70
	CV Price	19.44	19.28	18.95	18.54	18.09	17.58	17.01
	CV Revenue	9.51	9.43	9.16	8.82	8.45	8.05	7.62
	Govt. Stocks	0.06	0.06	0.07	0.08	0.10	0.13	0.17
4.90	Mean Price	5.70	5.70	5.69	5.69	5.69	5.68	5.68
	CV Price	18.19	17.69	17.05	16.29	15.42	14.37	13.23
	CV Revenue	10.68	10.34	9.89	9.40	8.87	8.30	7.67
	Govt. Stocks	0.09	0.11	0.13	0.16	0.21	0.30	0.53
5.10	Mean Price	5.69	5.68	5.68	5.67	5.67	5.66	5.70
	CV Price	16.04	15.14	14.05	12.75	11.16	9.21	9.39
	CV Revenue	11.85	11.33	10.75	10.14	9.48	8.77	7.95
	Govt. Stocks	0.14	0.17	0.22	0.32	0.58	2.43	***
5.30	Mean Price	5.67	5.67	5.66	5.66	5.70	5.75	5.80
	CV Price	13.03	11.49	9.53	6.83	6.52	7.89	9.12
	CV Revenue	13.07	12.42	11.74	11.01	10.06	9.20	8.53
	Govt. Stocks	0.24	0.33	0.58	2.26	***	***	***
5.50	Mean Price	5.66	5.65	5.70	5.77	5.82	5.86	5.90
	CV Price	8.62	5.15	3.39	4.90	6.27	7.49	8.57
	CV Revenue	14.32	13.57	12.52	11.44	10.58	9.91	9.41
	Govt. Stocks	0.55	1.88	***	***	***	***	***
5.70	Mean Price	5.70	5.79	5.86	5.91	5.95	5.98	6.01
	CV Price	0.00	1.68	3.21	4.58	5.79	6.86	7.79
	CV Revenue	15.24	13.93	12.85	11.99	11.32	10.82	10.45
	Govt. Stocks	***	***	***	***	***	***	***
5.90	Mean Price	5.90	5.97	6.02	6.06	6.09	6.11	6.13
	CV Price	0.00	1.55	2.91	4.11	5.15	6.05	6.83
	CV Revenue	15.24	14.15	13.30	12.64	12.15	11.79	11.53
	Govt. Stocks	***	***	***	***	***	***	***

[a] Prices are expressed in real (1977) dollars per bushel, coefficients of variation are expressed as percentages, and government stocks are expressed in billions of bushels. Asterisks denote infinite steady-state government stocks.

[b] For a competitive regime in steady state, mean price equals $5.72 per bushel, coefficient of variation of price equals 20.24 percent, and coefficient of variation of producer revenue equals 8.30 percent.

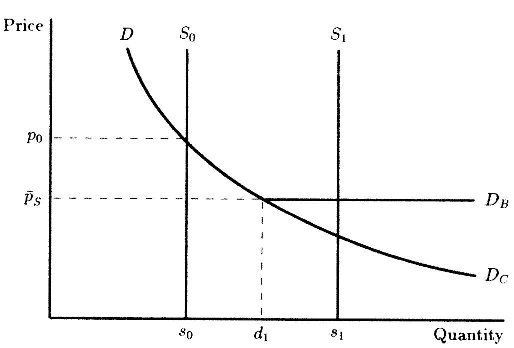

FIGURE 1A. DEMAND AND SUPPLY UNDER A PRICE BAND PROGRAM $t = 1$

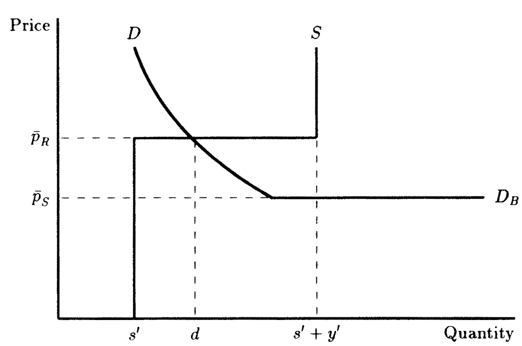

FIGURE 1B. DEMAND AND SUPPLY UNDER A PRICE BAND PROGRAM $t > 1$

the government must withdraw an amount $s_1 - d_1$ from the open market to prevent competitive forces from driving price below the support level.

After the first year, the government will typically have accumulated a stockpile through earlier open market purchases. As illustrated in Figure 1B, the government's offer to sell its stocks at the release price $\bar{p}_R$ alters open market supply. At prices below the release level, open market supply S equals s', the sum of private carryover from the preceding year and new production. At prices equal to or exceeding the release price, open market supply is displaced rightward by the amount offered by the government, say, y'. For a low initial private supply such as s', the government sells an amount $d' - s'$ on the open market to prevent competitive market forces from driving price above the release level.

The overall effect of a price band program on price level and price variability can thus be decomposed into two distinct effects. The demand effect, arising from the government's stock acquisition policy, is realized immediately upon the introduction of the program and acts to raise market price. The supply effect, arising from the government's stock release policy, varies over time with the level of government stocks and acts to reduce market price. As seen in Table 1, for certain price band programs, the supply effect eventually dominates the demand effect, causing steady-state mean market price to fall below the competitive level. The demand and supply effects work together to stabilize price. The former prevents sharp price downswings, the latter prevents or otherwise moderates sharp upswings.

Figure 2 illustrates the dynamic, short-term impact of introducing a price band program into the U.S. soybean market. Specifically, this figure depicts market performance during the fifteen years following the introduction of a \$5.10–\$5.50 price band program into a previously competitive market.[7] In the

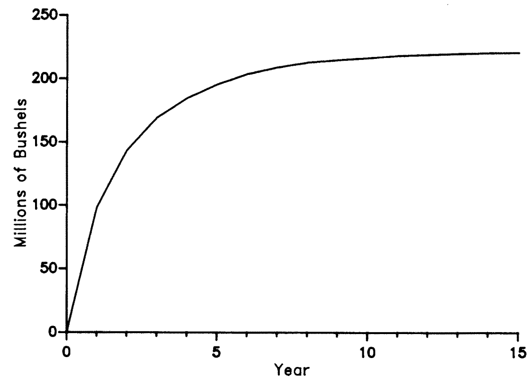

FIGURE 2A. MEAN GOVERNMENT STOCKS UNDER A \$5.10–\$5.50 PRICE BAND PROGRAM

first year of the program, the government on average acquires substantial stocks, raising mean market price and reducing price variability by preventing price downswings. In subsequent years, the mean level of government stocks approaches its steady-state value (Figure 2A). The growth of government stocks puts downward pressure on price, moderating the price hikes realized in the first year of the program (Figure 2B). By the fifth year, mean market price has dropped below the competitive steady-state price of \$5.72. The growth of government stocks enhances the government's ability to prevent sharp price upswings, further stabilizing price. As seen in Figure 2C, substantial price stability is realized soon after the introduction of a price band program.

A third major result from Table 1 is that for nonexplosive policies, widening the price band by raising the release price stabilizes market price, contradicting the claims of several writers (Walter Labys, 1978; Willard Cochrane and Yigal Danin, 1976; Olarn Chaipravat, 1978; and James Langley et al.,

[7]The means and coefficient of variation presented in Figure 2 were estimated from a sample of forty thousand simulated market histories. It is assumed that producers and arbitrageurs do not anticipate the introduction of the program. Miranda (1985) performs a similar analysis using the same model but under the alternative scenario that the government announces the program a year in advance. Comparing the results, we conclude that the effects of the announcement are negligible.

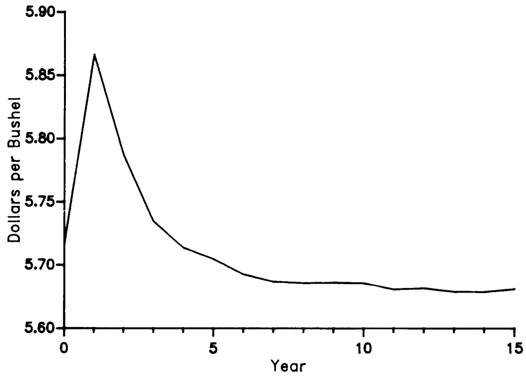

FIGURE 2B. MEAN MARKET PRICE UNDER A $5.10–$5.50 PRICE BAND PROGRAM

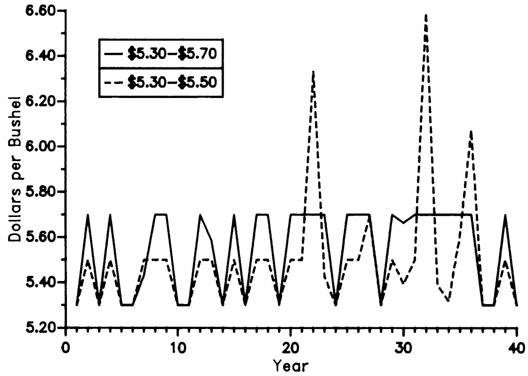

FIGURE 3. SIMULATED HISTORIES OF MARKET PRICE UNDER $5.30–$5.50 AND $5.30–$5.70 PRICE BAND PROGRAMS

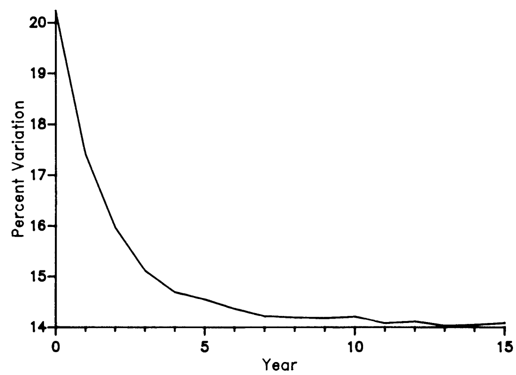

FIGURE 2C. COEFFICIENT OF VARIATION OF MARKET PRICE UNDER A $5.10–$5.50 PRICE BAND PROGRAM

1985). Raising the release price leads to a larger long-run level of government stocks, reducing the likelihood of high prices resulting from government stock-outs during strings of poor harvest. In other words, it is easier to contain price within a wide price band than to contain it within a narrow one. For explosive policies, on the other hand, government stock-outs cease to occur in the long run, causing the release price to become an effective price ceiling; widening the band destabilizes price.

Figure 3 illustrates how bandwidth affects price variability in the case of nonexplosive policies. This figure shows representative price histories for price band programs with a $5.30 support price and bandwidths of $0.20 and $0.40, respectively; both histories were generated by the same sequence of exogenous supply shocks. Over the first twenty years, price is contained within the price bands and exhibits greater variability under the wider band. The remainder of the forty-year period, by contrast, is characterized by a sequence of poor harvests. For the narrow band, the government buffer stock is quickly depleted, resulting in a series of high prices. For the wide band, on the other hand, the government has a larger stockpile when the series of poor harvests begins, enabling it to contain price within the band throughout the period of poor harvests. We estimate that in the long-run government stock-outs occur with probability 0.24 for the narrow band regime and probability 0.14 for the wide band regime.

A fourth result is of interest in light of the frequent assumption that support and release prices can be maintained equidistantly from a trend price. For example, Jere Behrman (1978, p. 307) assumes that "the buffer stock managers operate with sufficient financial and commodity reserves so that they can buy or sell to keep the average annual deflated commodity prices within specified bands (± 15 percent) of the known secular trends...." Such strategies may be infeasible. For many nonexplosive policies, as shown in Table 1, the entire price band lies below the long-run price. Bracketing a given target price with arbitrary equidistant support and release prices does not guarantee that prices will subsequently fluctuate symmetrically about the target.

A fifth result evident from Table 1 is that a simple relationship between price and revenue variability does not exist. For nonexplosive price band policies, raising the support price stabilizes price but destabilizes revenue. For the same class of policies, however, raising the release price stabilizes both price and revenue. Importantly, only price band policies involving low price supports and wide bands reduce the coefficient of variation of total revenue below its competitive level of 8.3 percent. Even in these cases, the reductions are small. Most price band policies destabilize total revenue.[8]

Price band programs affect revenue variability by altering the relation between price and production. Under competitive conditions, if production falls, price rises, and vice versa; price response offsets variations in production, tending to stabilize producer revenue. Price band programs destabilize producer revenue by suppressing price response to production variation. For example, increasing the support price from \$4.50 to \$5.50, holding bandwidth equal to zero, causes the steady-state correlation between price and production to rise from -0.83 to -0.36. Price becomes less responsive to supply conditions and producer revenue is destabilized even though price is stabilized. Holding the support price at \$5.10 but increasing the bandwidth from \$0.00 to \$1.00 causes the correlation between price and production to fall from -0.63 to -0.84. Widening the band enhances price responsiveness, helping to stabilize revenue.

The variation in total revenue is important because of its implications for the variation of producer quasi rent. We do not report coefficients of variation for producer quasi rent because their measurement involves using the entire area under the supply curve to estimate cost; this requires placing reliance on a portion of the estimated supply curve well outside the range of observed data. Nonetheless, it is probably significant that the variability of producer quasi rent follows the same pattern as that of revenue. For example, introducing a price band program with a \$5.30 support price and a \$0.20 band into a competitive market causes the coefficient of variation of total revenue to rise from 8.3 percent to 12.4 percent. For this same change in regime, the coefficient of variation of quasi rent rises from 13.2 percent to 22.5 percent. Summing up, price band programs cannot be relied upon to stabilize either producer revenue or quasi rent. On the contrary, such programs often have the opposite effect.

To test the sensitivity of our findings to demand and supply elasticity, we performed simulations for which the elasticities were varied 20 percent above and below their base values (namely, 0.89 for supply and -0.61 for demand). Table 2 gives selected results of these simulations for three different regimes: a competitive market, a price band program for which the support and release prices both equal \$5.30, and a price band program for which the support and release prices equal \$5.30 and \$5.50, respectively.

From Table 2 we see that the patterns found in Table 1 are preserved as elasticities vary. For all elasticities, the selected price band programs lower steady-state mean price, reduce long-run price variability, and increase long-run revenue variability. Moreover, comparing the results for the \$5.30–\$5.30 price band to those of the \$5.30–\$5.50 price band, we see that raising the release price reduces and stabilizes market price and destabilizes revenue, regardless of the elasticity.

Table 2 also shows how the impact of a price band program varies with the elasticities of demand and supply. First, the decline in steady-state mean price resulting from the introduction of a nonexplosive price band program, though small, is more pronounced as either demand or supply becomes more inelastic. Second, price and revenue variability appear to be insensitive to supply elasticity, but highly sensitive to demand elasticity.

[8]Several writers (for example, Jere Behrman, 1978, and David Newbery and Joseph Stiglitz, 1981) have examined the relationship between price and revenue variability, though without regard to the underlying stabilization mechanism.

TABLE 2—STEADY-STATE MEAN PRICE, COEFFICIENT OF VARIATION OF PRICE, AND COEFFICIENT OF VARIATION OF PRODUCER REVENUE UNDER COMPETITION AND TWO ALTERNATIVE PRICE BAND PROGRAMS FOR VARIOUS COMBINATIONS OF DEMAND AND SUPPLY ELASTICITIES[a]

		Competitive Market			\$5.30–\$5.30 Price Band			\$5.30–\$5.50 Price Band		
	Demand Elasticity	Supply Elasticity 0.71	0.89	1.06	0.71	0.89	1.06	0.71	0.89	1.06
Mean Price	−0.49	5.73	5.72	5.71	5.68	5.67	5.67	5.67	5.67	5.66
	−0.61	5.73	5.72	5.71	5.68	5.67	5.67	5.67	5.67	5.66
	−0.74	5.72	5.71	5.70	5.68	5.67	5.67	5.67	5.67	5.67
CV Price	−0.49	23.9	23.6	23.3	15.0	14.7	14.5	13.1	12.9	12.6
	−0.61	20.4	20.2	20.1	13.2	13.0	12.8	11.7	11.5	11.3
	−0.74	17.9	17.7	17.6	11.9	11.8	11.6	10.6	10.5	10.3
CV Revenue	−0.49	11.6	11.6	11.6	14.2	14.2	14.3	13.3	13.3	13.4
	−0.61	8.2	8.3	8.4	12.9	13.0	13.2	12.3	12.4	12.5
	−0.74	5.8	6.0	6.1	12.1	12.2	12.3	11.7	11.8	11.9

[a] In the base case, demand and supply elasticities equaled −0.61 and 0.89, respectively.

Third, the destabilizing effects of price band programs on revenue are more pronounced as demand becomes more elastic. Fourth, both price and revenue variability are more sensitive to demand elasticity under competition than under price band programs, reflecting the decline in the relative importance of private consumption demand under a price band program.

A number of other results, which we now summarize, are not apparent from either Table 1 or 2. Nonexplosive policies, which reduce long-run price, also reduce long-run production and consumption. Although such policies scarcely affect production variability, they can stabilize consumption substantially. For example, a \$5.10–\$5.50 price band policy lowers the steady-state coefficient of variation of consumption from its competitive value of 11.1 percent to 7.2 percent while leaving the coefficient of variation of production unchanged at 15.6 percent. We also find that even price band policies that have only a modest effect on price variability can have a profound impact on private stockholding. For example, if the support price is set equal to \$4.90 and the bandwidth is set equal to 80 cents, steady-state mean private stocks plummet from a competitive level of 65 million bushels to about two million bushels.[9]

III. Some Benefit-Cost Considerations

The dynamic welfare effects of introducing a price band program to a historically competitive market are illustrated in Figure 4. This figure gives the expected changes in consumer and producer surplus and the expected government outlays in each of the first fifteen years of a \$5.10–\$5.50 price band program.[10] As seen in Figure 4, producer gains and consumer losses are substantial in the first year of the program but subsequently moderate. This is consistent with Figure 2A, which shows that introducing a \$5.10–\$5.50 price band program causes mean price to rise sharply at first and then to fall gradually toward its steady-state value. As seen in Figure 4, government outlays in the first year of the program are high due to the

[9] Jimmye Hillman, D. Gale Johnson, and Roger Gray (1975, p. 14) urge that the "range between acquisition and selling prices must be large enough to permit private firms to obtain profits from holding stocks." They provide no reason for believing that widening the price band would encourage private stockholding, however. Our analysis suggests that for a given price support, widening the band has practically no effect on private stockholding. The scope of private stockholding depends almost exclusively on the support level.

[10] Producer surplus in year t is defined as $CS_t = p_t \cdot h_t - \delta \cdot c(a_{t-1})$, where h_t is quantity harvested in year t and the cost of planting in year $t-1$ is given by

$$c(a_{t-1}) = \mathscr{E}_{t-1}\tilde{\omega}_t \cdot \left[\mathscr{E}_{t-1} p_t \cdot a_{t-1} - \int_0^{\mathscr{E}_{t-1} p_t} \alpha(p^e)\, dp^e \right].$$

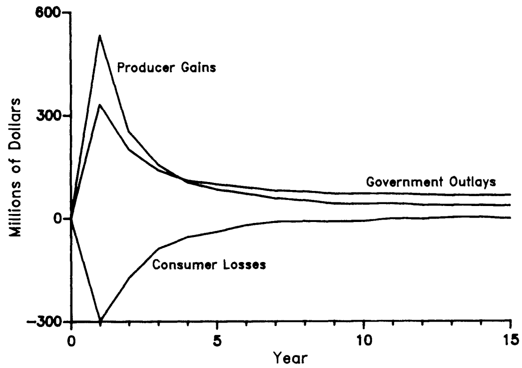

FIGURE 4. DYNAMIC WELFARE EFFECTS OF A $5.10–$5.50 PRICE BAND PROGRAM

large government stock acquisitions and the absence of government sales. Government outlays subsequently fall but remain positive, even though mean government net open market purchases approach zero, due to the costs of storing the buffer stocks.

Most comparative static studies focus on the steady-state welfare effects of price stabilization and on the sensitivity of these effects to demand and supply curvature. Introducing a price band program into a competitive market invariably leads to immediate and substantial producer gains and consumers' losses that greatly exceed the smaller and more heavily discounted long-run effects. Because comparative static studies fail to recognize the importance of the short-run welfare effects, their results are potentially misleading.[11] Moreover, since the elevation of expected price is inevitable in the short run, quite without regard to the curvature of demand or supply, the importance these studies attach to curvature may be exaggerated.

Table 3 gives for various price band programs the average annual producer gains and consumer losses expected over the fifty years following the introduction of the program into a previously competitive market.[12] As is evident in Table 3, producers gain and consumers lose from the introduction of price band programs. That this is true even for policies that reduce long-run market price is perhaps surprising. As indicated earlier, however, the effects of low prices realized in the distant future are heavily discounted and have a small impact on the present value of the sums of producer and consumer surplus. For the most part, welfare gains and losses are determined in the early years of the program when prices are high. Consumer losses during the first five years of a $5.10–$5.50 price band program, for example, account for 89 percent of the total losses incurred over the first fifty years; producer gains during the first five years account for 63 percent of the gains obtained over the first fifty years.

Table 3 also gives expected annual government outlays and expected annual deadweight loss (consumer losses plus government outlays less producer gains) over the first fifty years of program operation. These estimates indicate that substantial price stability can be obtained for relatively modest government outlays. A $5.10–$5.50 price band program, for example. reduces price variability by about one-third soon after it is introduced (see Figure 1B). The cost of such a program equals, on average, $115 million annually, a meager sum compared to the billions of dollars spent annually on conventional farm programs.

Figure 5 illustrates how one might achieve both price and revenue stability at minimal cost. In this figure, the steady-state coefficients of variation of price and revenue are plotted against the discounted sum of gov-

[11] In their analysis of competitive storage, Wright and Williams (1984) also recognize the dynamic welfare effects of the introduction of storage. The impact from the introduction of government storage, however, can be significantly greater than the impact from the introduction of competitive storage. Mean steady-state stocks under price band program with a $5.50 support level and a zero bandwidth, for example, is ten times what it is under competitive conditions.

[12] Producer gains and consumer losses were measured by the change in producer and consumer surplus and were discounted to produce an amortized average annual figure for each of the ten thousand market histories simulated. It was assumed that the introduction of the program was not anticipated by producers or arbitrageurs.

TABLE 3—AVERAGE ANNUAL PRODUCER GAINS, CONSUMER LOSSES, GOVERNMENT OUTLAYS, AND DEADWEIGHT LOSSES, IN MILLIONS OF DOLLARS, EXPECTED FROM INTRODUCTION OF A PRICE BAND PROGRAM TO A COMPETITIVE MARKET[a]

Support Price		Bandwidth (Release Price Minus Support Price) 0.00	0.20	0.40	0.60	0.80	1.00	1.20
4.50	Producer Gains	7	7	9	10	12	12	12
	Consumer Losses	4	5	6	6	9	9	10
	Govt. Outlays	5	6	6	7	9	10	10
	Deadweight Loss	3	3	3	4	6	7	8
4.70	Producer Gains	22	24	27	31	33	39	46
	Consumer Losses	9	11	13	16	18	23	32
	Govt. Outlays	17	18	21	26	33	44	59
	Deadweight Loss	4	5	7	11	18	29	45
4.90	Producer Gains	52	56	59	66	76	90	105
	Consumer Losses	21	24	26	32	43	59	77
	Govt. Outlays	40	44	53	67	88	118	163
	Deadweight Loss	10	13	20	33	55	87	135
5.10	Producer Gains	94	102	113	128	148	173	201
	Consumer Losses	39	46	57	74	97	127	162
	Govt. Outlays	80	93	115	152	207	281	367
	Deadweight Loss	25	37	59	97	156	235	328
5.30	Producer Gains	153	171	195	227	265	304	339
	Consumer Losses	70	88	116	155	201	250	294
	Govt. Outlays	151	190	254	348	462	581	692
	Deadweight Loss	68	107	175	275	398	527	647
5.50	Producer Gains	246	287	337	390	438	478	511
	Consumer Losses	133	181	243	307	367	417	457
	Govt. Outlays	305	419	569	728	877	1004	1109
	Deadweight Loss	193	314	474	646	805	942	1055
5.70	Producer Gains	417	488	553	607	650	683	710
	Consumer Losses	285	371	450	516	568	610	643
	Govt. Outlays	687	900	1097	1263	1399	1508	1595
	Deadweight Loss	555	783	994	1172	1318	1434	1527
5.90	Producer Gains	687	757	813	857	890	917	937
	Consumer Losses	546	631	698	751	792	823	848
	Govt. Outlays	1360	1577	1750	1887	1995	2079	2145
	Deadweight Loss	1220	1451	1635	1781	1896	1985	2055

[a]Amortized averages over the first fifty years of program operation. Producer gains and consumer losses are measured by the changes in producer and consumer surplus, respectively.

ernment outlays for policies involving bandwidths of \$0.00 and \$1.20. The figure shows that for any government outlay policies of either bandwidth provide essentially the same degree of price stability. The figure also shows that for any government outlay the wider band provides substantially more revenue stability. These results, which hold for other bandwidths as well, suggest that if price and revenue stability are both important goals, then an efficient policy will entail a low price support and a wide band.

Two caveats regarding the recommendation of a low price support and a wide price band are in order. First, the degree of revenue stability that can be secured through price band programs is at best limited, as we have already noted. If the primary objective of government intervention is revenue stabilization, then the effectiveness of price band programs is questionable. Second, certain levels of price stability may be unattainable without destabilizing revenue or causing government stocks to explode. As shown in Table 1, any nonexplosive price band policy that reduces the coefficient of variation of price below 10.1 percent, half its competitive value, also destabilizes total revenue.

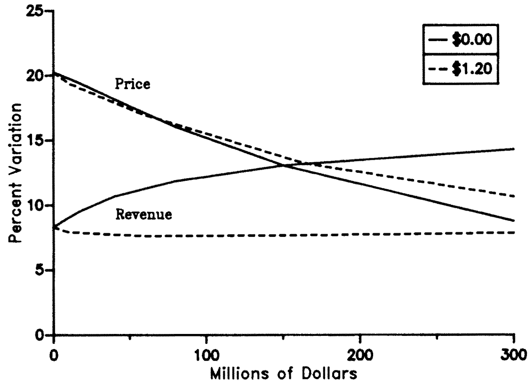

FIGURE 5. PRICE AND REVENUE VARIABILITY VS. EXPECTED ANNUAL GOVERNMENT OUTLAYS FOR PROGRAMS WITH BANDWIDTHS OF $0.00 AND $1.20

IV. Summary

In this paper we have examined a rational expectations model of the U.S. soybean market in which the government attempts to stabilize price within a specified band through open market purchases and sales. The model extends conventional static equilibrium models to a dynamic framework, allowing for private storage, expected price-responsive production, exhaustible government stocks, and distinct support and release prices.

Through stochastic simulations of the market model we obtained a number of novel results regarding the effects of price band buffer stock programs. First, although all price band programs raise market price in the short run, some can also reduce market price in the long run. Only price band policies that lead to explosive government stocks effect a sustainable increase in market price. Second, although price band programs can substantially stabilize price, they can also destabilize producer revenue. Only policies with low support prices and wide bands stabilize both price and producer revenue, and even then the degree of revenue stability attainable is relatively modest. Third, widening the price band by raising the release price lowers price variability in the case of nonexplosive policies. Narrow price bands are more difficult to defend because they are more susceptible to stock-outs. And finally, we have shown that the welfare effects of price band programs are determined largely in the first few years of the program with producers gaining and consumers and taxpayers losing.

Numerical solution and simulation of a rational expectations model has been shown in this paper to be a powerful technique for analyzing intertemporal equilibrium models too complex to handle analytically. Although computable rational expectations models are difficult and expensive to develop, the effort and cost involved in implementing them may well be worthwhile, particularly where essential market features might otherwise be ignored to ensure mathematical tractability.

REFERENCES

Behrman, Jere R., "International Commodity Agreements: An Evaluation of the UNCTAD Integrated Programme for Commodities," in F. Gerard Adams and Sonia A. Klein, eds., *Stabilizing World Commodity Markets*, Lexington: Lexington Books, 1978.

Chaipravat, Olarn, "International Rice Buffer Stock Operations: A Simulation Study," in F. Gerard Adams and Sonia A. Klein, eds., *Stabilizing World Commodity Markets*, Lexington: Lexington Books, 1978.

Cochrane, Willard W. and Danin, Yigal, *Reserve Stock Grain Models, the World and the United States, 1975–1985,* Minnesota Agricultural Experiment Station Technical Bulletin, No. 305, University of Minnesota, Saint Paul, 1976.

Desai, Meghnad, "An Econometric Model of the World Tin Economy, 1948–1961," *Econometrica*, January 1966, *34*, 5–134.

Fair, Ray C. and Taylor, John B., "Solution and Maximum Likelihood Estimation of Dynamic Nonlinear Rational Expectations Models," *Econometrica*, July 1983, *51*, 1169–85.

Frankel, Jeffrey A., "Commodity Prices and Money: Lessons from International Trade," *American Journal of Agricultural*

Economics, December 1984, *66*, 560–66.

Gardner, Bruce L., *Optimal Stockpiling of Grain*, Lexington: Lexington Books, 1979.

Gustafson, Robert L., *Carryover Levels for Grains: A Method for Determining Amounts That Are Optimal Under Specified Conditions*, Technical Bulletin No. 1178, United States Department of Agriculture, Washington: USGPO, October 1958.

Hillman, Jimmye, Johnson, D. Gale and Gray, Roger, *Food Reserve Policies for World Food Security: A Consultant Study on Alternative Approaches*, Food and Agricultural Organization of the United Nations, Rome, ESC:CSP/75/2, January 1975.

Labys, Walter C., "A Critique of Econometric Studies of Commodity Price Stabilization," *Proceedings of the Business and Statistics Section*, American Statistical Association, August 1978, 187–93.

Langley, James A., Reinsel, Robert D., Craven, John A., Zellner, James A. and Nelson, Frederick J., "Commodity Price and Income Support Policies in Perspective," in U.S. Department of Agriculture, Economic Research Service, *Agricultural-Food Policy Review: Commodity Program Perspectives*, Agricultural Economics Report No. 530, U.S. Department of Agriculture, Economic Research Service, July 1985.

Lowry, Mark N., Glauber, Joseph W., Miranda, Mario J. and Helmberger, Peter G., "Pricing and Storage of Field Crops: A Quarterly Model Applied to Soybeans," *American Journal of Agricultural Economics*, November 1987, *69*, 740–49.

Lucas, Robert E., Jr., "Econometric Policy Evaluation: A Critique," in K. Brunner and A. Meltzer, eds., Carnegie-Rochester Conference on Public Policy, *Journal of Monetary Economics*, Suppl. 1976, *1*, 19–46.

Massell, Benton F., "Price Stabilization and Welfare," *Quarterly Journal of Economics*, May 1969, *83*, 284–98.

Miranda, Mario J., "A Computable Rational Expectations Model for Agricultural Price Stabilization Programs," unpublished paper, University of Connecticut, Storrs, 1987.

______, "Analysis of Rational Expectations Models for Storable Commodities Under Government Regulation," unpublished doctoral dissertation, University of Wisconsin-Madison, 1985.

Newbery, David M. G. and Stiglitz, Joseph E., *The Theory of Commodity Price Stabilization*, Oxford: Oxford University Press, 1981.

Oi, Walter Y., "The Desirability of Price Instability Under Perfect Competition," *Econometrica*, January 1961, *29*, 58–64.

Plato, Gerald and Gordon, Douglas, "Dynamic Programming and the Economics of Optimal Grain Storage," *Agricultural Economics Research*, January 1983, *35*, 10–22.

Reutlinger, Shlomo, "A Simulating Model for Evaluation Worldwide Buffer Stocks of Wheat," *American Journal of Agricultural Economics*, February 1976, *58*, 1–12.

Salant, Stephen W., "The Vulnerability of Price Stabilization Schemes to Speculative Attack," *Journal of Political Economy*, February 1983, *91*, 1–38.

Waugh, Frederick V., "Does the Consumer Benefit from Price Instability?," *Quarterly Journal of Economics*, August 1944, *58*, 602–14.

Wright, Brian D., and Jeffrey C. Williams, "The Economic Role of Commodity Storage," *Economic Journal*, September 1982, *92*, 596–616.

______ **and** ______, "The Welfare Effects of the Introduction of Storage," *Quarterly Journal of Economics*, February 1984, *99*, 169–92.