U.S. Farm Policy and the Variability of Commodity Prices and Farm Revenues

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Abstract

A dynamic, three-commodity rational-expectations storage model is used to compare the impact of the Federal Agricultural Improvement and Reform (FAIR) Act of 1996 with a free-market policy and with the agricultural policies that preceded the FAIR Act. Results support the hypothesis that the changes made when FAIR was enacted did not lead to permanent significant increases in the volatility of farm prices or revenues. An important finding is that the main economic impacts of the Pre-FAIR scenario, relative to the free-market regime were to transfer income to farmers and to substitute government storage for private storage in a way that did little to support prices or to stabilize farm incomes.

Key words: FAIR Act, farm prices, free-market policy, rational-expectations storage model, revenue

U.S. FARM POLICY AND THE VARIABILITY OF COMMODITY PRICES AND FARM REVENUES

Introduction

Historically, the U.S. government has had a substantial involvement in the agricultural sector. Since 1988, annual U.S. government expenditures in support programs for all crops ranged from a low of $6.3 billion in 1996 to an estimated high of $24.2 billion in 2000 (Food and Agricultural Policy Research Institute [FAPRI]). From 1988 to 1995, government expenditures averaged $3.4 billion per year on corn programs alone. This amount increased to $4 billion per year between 1996 and 2000, after passage of the Federal Agricultural Improvement and Reform (FAIR) Act in 1996.

The FAIR Act represented a major shift in U.S. agricultural policy. It replaced farm price support programs with direct payments, removed restrictions on the types of crops that farmers could plant or the amount of acres that farmers had to idle to qualify for support programs, and introduced an alternative to the loan rate program called the “loan deficiency payment” (LDP).[1] The FAIR Act is likely to have a noticeable impact on U.S. agriculture—in particular, on corn, soybean, and wheat markets as these are the commodities most directly affected by the specific changes introduced by the act.

Interestingly, the markets for corn, soybeans, and wheat have also exhibited extraordinary volatility (in both prices and stocks) in recent years. Many observers have attributed this volatility to the FAIR Act itself. This linking of the act with recent market behavior makes some sense, as the Act reduced the reliance on government storage and eliminated the target price program. However, the FAIR Act also allows producers to respond in a more flexible way to changes in market conditions, thereby dampening the influence of weather shocks. It is also possible that the private sector might undertake the storage activities formerly done by the government and might do so in a way that makes more economic sense. Because these aspects of the FAIR Act may induce lower price volatility, the net effect is unknown. The ultimate impact of the FAIR Act will not be known until the market has reached a new equilibrium, and this will take decades.

The problem addressed here is the behavior of prices, stocks, and other market variables of interest for corn, soybeans, and one other crop under the FAIR Act regime. It is assumed that private market participants hold rational expectations and behave in an optimal fashion. The analysis is conducted by solving for the equilibrium market conditions that satisfy the optimal behavioral patterns of all those involved. The speculative rational-expectations storage model that is used is based on Williams and Wright, Deaton and Laroque (1992, 1996), and Chambers and Bailey.

In addition, the present study is the first one to solve for intertemporal market equilibrium in three markets simultaneously, allowing for storage as well as random shocks in both supply and demand schedules. Modeling three markets simultaneously enables explicit incorporation of potentially important output substitution effects. Endogenous derivation of storage demand ensures the internal consistency of the model, inasmuch as policy changes imply changes in the probability density functions of prices, which in turn should change the demand for storage. Importantly, this analysis avoids the famous "Lucas' critique," because the model built depends only on behavioral parameters that are not affected by shifts in policy regimes such as the one under consideration.

Model Specification

It is assumed throughout that there are three storable commodities: corn, soybeans, and "others." Attention is restricted to three commodities because (a) the study's primary objective is to uncover the potential effects of the FAIR Act on the U.S. markets for corn and soybeans, and (b) explicitly modeling many commodities is computationally intractable due to the "curse of dimensionality" (e.g., Judd, p. 430).[2]

Historically, U.S. agricultural policies directly affected the supply of corn and soybeans (Lee and Helmberger) as well as their storage demand. For this reason, the model specifications under the benchmark setting of no government intervention as well as under the two intervention scenarios of Pre-FAIR and FAIR regimes are discussed in more depth in the next three subsections.

Benchmark Setting: No Government Intervention

Crop production takes one period from planting to harvest. Output of crop j (j = 1, …, J) at time t + 1 (O_{jt+1}) is a function of the acres of all J crops planted at time t ($A_{1t}, \ldots, A_{Jt}$) times the realization of an output shock at time t + 1 (e_{Ojt+1}):

$$O_{jt+1} \equiv O_j(A_{1t}, \ldots, A_{Jt})\, e_{Ojt+1}. \qquad (1.1)$$

Actual production at time t + 1 is random from the perspective of time t because yields are stochastic due to weather, pests, etc. Similarly, actual prices at time t + 1 (P_{jt+1}) are random from the standpoint of time t, due to stochastic output as well as stochastic demand.

Because of output uncertainty, producers are assumed to make their planting/input decisions at time t so as to maximize expected profits at t + 1 (π_{t+1}), conditional on their information at time t ($E_t(\cdot)$) and subject to any existing constraints. That is, at time t producers choose A_{1t} through A_{Jt} to maximize:

$$E_t(\pi_{t+1}) = E_t(\sum_{j=1}^{J} O_{jt+1} P_{jt+1}) - C(A_{1t}, ..., A_{Jt}), \qquad (1.2)$$

$$= \sum_{j=1}^{J} O_j(A_{1t}, \ldots, A_{Jt})\, E_t(e_{Ojt+1} P_{jt+1}) - C(A_{1t}, ..., A_{Jt}),$$

$$= \sum_{j=1}^{J} O_j(A_{1t}, \ldots, A_{Jt})\, P^p_{jt+1} - C(A_{1t}, ..., A_{Jt}), \qquad (1.2')$$

where $C(\cdot)$ is the cost function, and $P^p_{jt+1} \equiv E_t(e_{Ojt+1} P_{jt+1})$ is equal to (a constant times) the producers' incentive price or action certainty equivalent price for commodity j (Wright; Newbery and Stiglitz). In general, $P^p_{jt+1} \neq E_t(e_{Ojt+1})\, E_t(P_{jt+1})$ because producers recognize that their yield disturbance is proportional to the aggregate output, and the latter covaries with the market price. Objective function (1.2') is quite general in that it allows for very complex interactions among individual crop outputs and costs (e.g., Lin and Riley).

Under standard regularity conditions for the output and cost functions, the acreage supply schedules are obtained from the first-order conditions (FOCs) corresponding to (1.2'). Assuming perfectly competitive output markets and no binding constraints at the optimum, the FOCs can be rearranged in a straightforward manner so as to obtain the following first-order logarithmic approximation to the acreage supply schedules (Chambers, p. 167):[3]

$$\ln(A_{jt}) = \alpha_{Oj} + \sum_{k=1}^{J} \beta_{Ojk} \ln(P^{p}_{kt+1}),\ j = 1, \ldots, J. \tag{1.3}$$

Acreage supply schedule (1.3) is suitable for numerical simulations because it constrains planted areas to be strictly positive, allows for cross effects, and requires only the specification of own- and cross-price supply elasticities. For these reasons, and also because of numerical tractability, (1.3) is used in the present study when there are no binding constraints on the acreage planted.

To ensure consistency with stylized facts, the following parameter restrictions are imposed on (1.3): (a) $\beta_{Ojj} > 0$, (b) $\beta_{Ojk\neq j} < 0$, and (c) $\sum_j \beta_{Ojk} > 0$. Condition (a) is necessary and sufficient for the area planted with crop j to respond positively to its own producers' incentive price. Restriction (b) is necessary and sufficient to have crop substitution (through acreage shifts) in response to relative changes in producers' incentive prices. Finally, condition (c) ensures that the total area planted increases if all producers' incentive prices increase by the same percentage amount. Restriction (c) is also sufficient for the acreage planted with a particular crop to expand if the producers' incentive prices for all crops go up by the same percentage amount.

Realistic modeling also requires that (a) acres planted with individual crops be strictly positive and (b) the total area planted with crops not exceed the total number of acres of arable land ($\overline{A}$).[4] As mentioned earlier, acreage supply schedule (1.3) automatically meets restriction (a). As for (b), it is assumed that when the total acreage constraint is binding, the acreage supply schedules are proportional to the unconstrained acreage supply schedules. That is, acreage supply schedules are given by (1.4) instead of (1.3) when the latter violate the restriction $\sum_j A_{jt} \leq \overline{A}$:

$$\ln(A_{jt}) = \alpha_{Oj} + \sum_{j=1}^{J} \beta_{Ojk} \ln(P^{p}_{kt+1}) + \ln(\overline{A}) - \ln[\sum_{j=1}^{J} \exp(\alpha_{Oj}) \prod_{k=1}^{J} (P^{p}_{kt+1})^{\beta_{Ojk}}],\ j = 1, \ldots, J. \tag{1.4}$$

To derive (1.4), denote acres calculated from (1.3) by $\mathring{A}_{jt}$, to distinguish them from acres obtained by means of (1.4). After omitting nonessential subscripts and superscripts to avoid cluttering, (1.3) may be rewritten as $\mathring{A}_j = \exp(\alpha_j) \prod_k P_k^{\beta_{jk}}$. Hence, total acres from (1.3) are $\mathring{A} \equiv \Sigma_j \mathring{A}_j = \Sigma_j \exp(\alpha_j) \prod_k P_k^{\beta_{jk}}$ (> $\overline{A}$ if total acreage is binding). But $A_j = \mathring{A}_j \overline{A}/\mathring{A}$ if constrained acreage supply schedules (A_j) are to be proportional to unconstrained acreage supply schedules (Å_j) (note that $\Sigma_j A_j = \overline{A}$ by construction). Expression (1.4) is finally obtained by taking natural logarithms on both sides of $A_j = \text{Å}_j \overline{A}/\text{Å}$.

Commodity j's aggregate demand for current consumption is postulated to be as follows:

$$D_{jt} = \alpha_{Dj} + \frac{\beta_{Dj}}{1-\gamma_{Dj}} P_{jt}^{1-\gamma_{Dj}} + e_{Djt}, \tag{1.5}$$

where D_{jt} denotes quantity demanded for current consumption at time t; α_{Dj}, β_{Dj}, and γ_{Dj} are demand function parameters; and e_{Djt} is a zero-mean demand shock in period t. Parameter γ_{Dj} represents the relative curvature parameter of the (direct) demand curve (Wright). Demand curvature increases with $|\gamma_{Dj}|$, demand being linear (strictly convex) when $\gamma_{Dj} = 0$ ($\gamma_{Dj} > 0$). Demand function (1.5) includes both domestic and international components. One could easily include a separate export demand schedule. This would add little to the analysis, however, as long as the export demand is correctly incorporated into the total demand function D_{jt}.

All commodities considered are assumed to be storable, with per-unit storage costs equal to ϕ_j for commodity j. Under competition, expected-profit-maximizing speculators will store commodity j up to the point at which it is no longer profitable to do so. Hence, competitive equilibrium in all markets entails simultaneously satisfying conditions (1.6) through (1.8):

$$I_{jt+1} = O_{jt} + I_{jt} - D_{jt} = Q_{jt} - D_{jt} \geq 0, \tag{1.6}$$

$$\delta\, E_t(P_{jt+1}) - P_{jt} - \phi_j \leq 0, \tag{1.7}$$

$$[\delta\, E_t(P_{jt+1}) - P_{jt} - \phi_j]\, I_{jt+1} = 0, \tag{1.8}$$

for j = 1, 2, 3, where $Q_{jt} \equiv O_{jt} + I_{jt}$ and I_{jt} are commodity j's total supply and inventory on hand, respectively, at the beginning of period t, and δ is the discount factor per period. Output (O_{jt+1}) follows from (1.1), (1.3), and (1.4), whereas demand for current consumption (D_{jt}) is given by (1.5).

Inequality (1.6) says that, in equilibrium, total supply of commodity j must be equal to the total demand for it, where total demand is given by demand for current consumption plus demand for storage. In addition, (1.6) states that carryover inventories cannot be negative. According to (1.7), in equilibrium there cannot be any profitable opportunities from storing an additional unit of commodity. Finally, condition (1.8) implies that (a) no storage will occur

($I_{jt+1} = 0$) if storing leads to expected losses ($\delta\, E_t(P_{j+1}) < P_{jt} + \phi_j$), and (b) there cannot be profitable opportunities available from storage ($\delta\, E_t(P_{j+1}) = P_{jt} + \phi_j$) if storage is strictly positive ($I_{jt+1} > 0$).

Government Intervention Scenario 1: Pre-FAIR Regime

Government intervention in U.S. crop markets evolved gradually through time before passage of the FAIR Act (e.g., see Hoffman or Gisser for a summary of the history of U.S. government feed grain programs up to 1989). For this reason, in the present study the "Pre-FAIR regime" consists of a stylized scenario resembling the major government interventions regarding corn and soybeans in force immediately before the FAIR Act.

Under the Pre-FAIR regime, corn producers participating in the government program have the right to sell their corn and soybeans to the government at a preset "loan rate" (R_{corn} and R_{bean}). This provision of the government program effectively creates a floor price at the loan rate, as participating farmers get $\max(R_{corn}, P_{cornt})$ and $\max(R_{bean}, P_{beant})$ for their time-t output of corn and soybeans, respectively.

In addition to having access to the loan rate for corn and soybeans, participating corn producers get a "deficiency payment" (d_t) provided they "set aside" a certain fraction ($0 \leq S_t \leq 1$) of their "base acreage" ($\overline{B}$). That is, the number of set-aside acres in year t equals $S_t\ \overline{B}$. The base acreage is a preset figure central to the government intervention program and reflects the historical number of acres planted with corn. The deficiency payment is then calculated as

$$d_t \equiv \min[A_{cornt}, (0.85 - S_t)\ \overline{B}] \times \overline{Y}_{corn} \times \max(0, \overline{T} - P_{cornt}), \tag{1.9}$$

where $\overline{T}$ is the "target price" and $\overline{Y}_{corn}$ is the historical yield for corn. In (1.9), the min(·) term means that the number of acres qualified for deficiency payments cannot exceed either the acreage actually planted with corn (A_{cornt}) or the eligible corn acreage ($(0.85 - S_t)\ \overline{B}$). The product $\min(\cdot) \times \overline{Y}_{corn}$ is an artificial corn output figure used for government support purposes. Finally, the max(·) term means that producers are paid the difference (if positive) between the target price ($\overline{T}$) and the market price (P_{cornt}) per unit of supported corn output.[5] In summary, the deficiency payment policy (1.9) ensures that corn producers get a net price of at least $\overline{T}$ for an amount of corn equal to $\min(\cdot) \times \overline{Y}_{corn}$.

The set-aside fraction (S_t) in (1.9) is a key policy instrument and is announced by the government every year before planting time. The 1990 Farm Act stipulates that $0 \leq S_t \leq 0.125$ if the previous year's stock-to-use ratio for corn ($I_{cornt}/D_{cornt-1}$) is less than or equal to 25 percent, and $0.10 \leq S_t \leq 0.25$ if the previous year's stock-to-use ratio is greater than 25 percent. Hence, the government is assumed to follow policy rule (1.10) to calculate the set-aside fraction:

$$S_t = S(I_{cornt}/D_{cornt-1}), \qquad (1.10)$$

where $S(\cdot)$ is a strictly monotonic function, such that $S(\cdot) \to 0$ as $I_{cornt}/D_{cornt-1} \to 0$, $S(\cdot) \to 0.25$ as $I_{cornt}/D_{cornt-1} \to \infty$, and $0.10 \leq S(0.25) \leq 0.125$.

Historically, the number of acres actually planted with corn (A_{cornt}) plus the area considered to be planted with corn for government purposes (i.e., the set aside plus 15 percent of the base acreage) has almost always exceeded the base acreage ($\overline{B}$).[6] Hence, under the Pre-FAIR regime the constraint (1.11) is imposed to model this stylized fact:

$$A_{cornt} + (S_t + 0.15)\,\overline{B} \geq \overline{B}. \qquad (1.11)$$

Given constraint (1.11), the first term in the right-hand side of (1.9) simplifies to $\min(\cdot) = (0.85 - S_t)\,\overline{B}$, which implies that deficiency payments are independent of choice variables (i.e., A_{jt}s). In turn, this means that if the corn acreage constraint (1.11) is not binding, the FOCs for the Pre-FAIR regime are analogous to the FOCs under no government intervention. Hence, the Pre-FAIR acreage supply schedules when the corn acreage constraint (1.11) is not binding are given by (1.3) if total acreage is not binding and by (1.4) if total acreage is binding. Of course, under Pre-FAIR, $P^p_{jt+1} \equiv E_t[e_{Ojt+1} \max(R_j, P_{jt+1})]$ for j = corn and soybeans, and the total acreage constraint is total acres minus set-aside acres ($\Sigma_j A_{jt} \leq \overline{A} - S_t\,\overline{B}$).

If the corn acreage constraint (1.11) is binding but total acreage is not, the corn area is simply $A_{cornt} = (0.85 - S_t)\,\overline{B}$ and the acreage supply schedules for soybeans and others are:

$$\ln(A_{jt}) = \gamma_{Oj} + \gamma_{Ojcorn} \ln(A_{cornt}) + \sum_{k \neq corn} \gamma_{Ojk} \ln(P^p_{kt+1}),\ j, k = \text{beans, others}. \qquad (1.12)$$

In (1.12), $\gamma_{Oj} \equiv \alpha_{Oj} - \gamma_{Ojcorn}\,\alpha_{Ocorn}$, $\gamma_{Ojcorn} \equiv (\kappa_{kcorn}\,\kappa_{jk} - \kappa_{jcorn}\,\kappa_{kk})/(\kappa_{jj}\,\kappa_{kk} - \kappa_{jk}\,\kappa_{kj})$, $\gamma_{Ojj} \equiv \kappa_{kk}/(\kappa_{jj}\,\kappa_{kk} - \kappa_{jk}\,\kappa_{kj})$, $\gamma_{Ojk} \equiv -\kappa_{jk}/(\kappa_{jj}\,\kappa_{kk} - \kappa_{jk}\,\kappa_{kj})$, and κ_{ij} is the ijth element of the inverse of the supply elasticities matrix $\underline{\kappa}_O \equiv \underline{\beta}_O^{-1} = [\beta_{O11} \ldots \beta_{O1J}; \beta_{OJ1} \ldots \beta_{OJJ}]^{-1}$. Supply schedule (1.12) is consistent with (1.3). To see why, note that (1.3) is a rearrangement of the logarithmic first-order approximation to the FOCs: $\ln(P^p_{jt+1}) = \sum_k \kappa_{jk} [\ln(A_{kt}) - \alpha_{Ok}]$, j = corn, beans, others. When the corn acreage constraint is binding, the FOCs for beans and others become $\ln(P^p_{jt+1}) = \sum_k \kappa_{jk} [\ln(A_{kt}) - \alpha_{Ok}]$, j = beans, others, and $A_{cornt} = (0.85 - S_t)\,\overline{B}$. Supply schedule (1.12) may then be obtained by solving the latter two FOCs for the two unknowns $\ln(A_{beant})$ and $\ln(A_{othert})$.

Finally, if both the corn acreage constraint (1.11) and the total acreage constraint are binding, the corn area is also $A_{cornt} = (0.85 - S_t)\,\overline{B}$, but the acreage supply schedules for soybeans and others become:

$$\ln(A_{jt}) = \gamma_{Oj} + \gamma_{Ojcorn} \ln(A_{cornt}) + \sum_{k \neq corn} \gamma_{Ojk} \ln(P^p_{kt+1}) \tag{1.13}$$
$$+ \ln(\overline{A} - S_t\,\overline{B}) - \ln[A_{cornt} + \sum_{j \neq corn} \exp(\gamma_{Oj})\, A_{cornt}^{\gamma_{Ojcorn}} \prod_{k \neq corn} (P^p_{kt+1})^{\gamma_{Ojk}}],$$

for j, k = beans, others. Expression (1.13) may be derived from (1.12) in a manner analogous to the derivation of (1.4) from (1.3).

To determine the market equilibrium under the Pre-FAIR regime, it must be recalled that the government buys all of the corn and soybeans being offered by farmers at the loan rate level. It is assumed that the corn and soybeans bought by the government are stored and sold whenever market prices rise above the corresponding loan rates. Hence, for j = corn and soybeans, the equilibrium conditions analogous to (1.6) through (1.8) are:

$$I^p_{jt+1} + I^g_{jt+1} = O_{jt} + I^p_{jt} + I^g_{jt} - D_{jt} = Q_{jt} - D_{jt} \geq 0, \tag{1.14}$$

$$\delta\, E_t(P_{jt+1}) - P_{jt} - \phi_j \leq 0,\; P_{jt} \geq R_j, \tag{1.15}$$

$$[\delta\, E_t(P_{jt+1}) - P_{jt} - \phi_j]\; I^p_{jt+1} = 0,\; P_{jt} \geq R_j, \tag{1.16}$$

$$I^g_{jt+1} = \max[0, Q_{jt} - I^p_{jt+1} - D_{jt}(R_j)], \tag{1.17}$$

where I^p_{jt} and I^g_{jt} denote storage by the private and government sectors, respectively, and $D_{jt}(R_j)$ is consumption when price equals the loan rate. Total storage is simply the sum of private and government storage ($I_{jt+1} = I^p_{jt} + I^g_{jt}$). Government intervention in corn and soybean markets prevents their prices from ever falling below the respective loan rates; this condition is represented by the constraint $P_{jt} \geq R_j$.

Government Intervention Scenario 2: FAIR Regime

Under the FAIR Act, there are neither deficiency payments nor set-aside provisions. Instead, the FAIR Act lets farmers receive fixed "transition" payments as long as they farm the land that had been eligible for payments under the previous policy regime (i.e., the former base acreage). These transition payments are independent of the level of market prices and of the crop being grown.

The FAIR Act maintains the loan rate program. In addition, it introduces a set of LDPs by which farmers get the difference between the loan rate and the local market price on their output of corn and soybeans. Producers get the same expected profits whether they participate in the loan rate or in the LDP program, because in either instance the net prices received per unit produced of corn and soybeans are $\max(R_{corn}, P_{cornt})$ and $\max(R_{bean}, P_{beant})$, respectively. Given that farmers are indifferent between the two programs, the amount they will sell to the government (under the loan rate program) cannot be defined uniquely. Unfortunately, market equilibrium is not well defined in the presence of such indeterminacy. To see this, consider the polar cases of farmers that participate (a) only in the loan rate program and (b) only in the LDP program. In case (a), market prices will never be below the loan rate. By contrast, in case (b) one may observe market prices well below the loan rate.

In practice, the government has the discretion to modify slightly the specific rules to implement the loan rate and the LDP programs, so as to make one of them preferable over the other.[7] Hence, the market equilibrium indeterminacy may be resolved by assuming that the government has a policy rule to favor one program over the other. In the present study, it is assumed that such a policy rule consists of a minimum or floor price P_j^{min} such that $R_j \geq P_j^{min} \geq 0$, for j = corn and soybeans. This rule is assumed because, as discussed in the previous paragraph, full loan rate program participation entails a minimum price at the loan rate and full LDP program participation yields no minimum price (i.e., a minimum price of zero). Hence, the whole spectrum of possible market equilibrium outcomes may be spanned by letting P_j^{min} range from 0 through R_j.

Under the specified assumptions, the FAIR acreage supply schedules are given by (1.4) if total acreage is not binding and by (1.5) if total acreage is binding (with $P_{jt+1}^{p} \equiv E_t[e_{Ojt+1} \max(R_j, P_{jt+1})]$ for j = corn and soybeans). Furthermore, for j = corn and soybeans, the equilibrium conditions under the FAIR Act scenario are analogous to (1.14) through (1.17), except that the constraint $P_{jt} \geq P_j^{min}$ substitutes for the constraint $P_{jt} \geq R_j$ in conditions (1.15) and (1.16).

Numerical Methods

To analyze the behavior of storage, prices, production, etc., one must first solve for the market equilibrium conditions under each possible state of the world. This is a difficult task because the model has no closed-form solution and is highly nonlinear; the model can only be solved and its properties explored using numerical techniques.

As discussed by Judd (ch. 12 and 17), the storage model may be solved in more than a single way. Here, we adopt the method advocated by Williams and Wright, which consists of solving the model by obtaining an approximation (ψ_j) to the price expectations conditional on carryover storage:

$$\psi_j(I_{1t+1}, I_{2t+1}, I_{3t+1}) = E_t\{P_{jt+1}[I_{1t+1}, I_{2t+1}, I_{3t+1}; \psi_j(I_{1t+1}, I_{2t+1}, I_{3t+1})]\}. \qquad (2.1)$$

Succinctly, the right-hand side of (2.1) is derived by using direct demand function (1.5) to express commodity j's price as a function of its consumption demand, $P_{jt+1} = g(D_{jt+1})$, and solving (1.6) for consumption to get $P_{jt+1} = g(O_{jt+1} + I_{jt+1} - I_{jt+2})$. But j's output ($O_{jt+1}$) is ultimately a function of the current action certainty equivalent prices of all three commodities (from (1.1) and (1.3)), which in turn may be expressed as functions of this period's carryovers (I_{jt+1}, j = 1, 2, 3). Further, next period's carryover of commodity j (I_{jt+2}) is also a function of this period's carryovers. Hence, next period's price of commodity j may be expressed as a function $P_{jt+1}(\cdot)$ of current carryovers (I_{jt+1}) and the expectation operator (ψ_j).

As pointed out by Williams and Wright, a fundamental advantage of this procedure is that $E_t(\cdot)$ is a smooth function of I_{1t+1}, I_{2t+1}, and I_{3t+1}. Hence, highly accurate approximations to $E_t(\cdot)$

may be achieved by means of a relatively low-order polynomial function $\psi_j(\cdot)$. This is very important for our present purposes, because the computational burden of using other methods to achieve the same degree of accuracy with a three-commodity system would be prohibitively high. In the interest of brevity, the full description of the computer algorithm is omitted, but its essence is sketched in chapter 3 of Williams and Wright.

Also for computational efficiency reasons, the function approximation $\psi_j(\cdot)$ consists of a Chebychev polynomial interpolated at Chebychev nodes. In addition, the error probability functions are approximated by means of Gaussian quadrature techniques, which allow exact calculation of the desired number of moments of the random variables with maximum efficiency. Details about Chebychev interpolation and Gaussian quadrature are provided in Judd. The Chebychev interpolation and Gaussian quadrature schemes are calculated by means of the computer routines developed by Miranda and Fackler. The programming language MATLAB version 5.2 is used to solve the model.

Eight interpolation nodes per commodity storage ($n_{I_j} = 8 \; \forall \; j$) are employed, along with three Gaussian quadrature nodes for each of the six error terms ($n_{e_{Oj}} = n_{e_{Dj}} = 3 \; \forall \; j$). The number of nodes is chosen to obtain an acceptable level of accuracy, while maintaining computational feasibility. For any given storage level, the maximum absolute error in the expected price approximation of any commodity is estimated to be less than 0.5 percent. To have an idea of the large magnitude of the problem at hand, consider that the key step in the solution requires solving 1,119,744 ($= J \times \prod_j n_{I_j} n_{e_{Oj}} n_{e_{Dj}}$) nonlinear equations in as many unknowns. For the simplest scenario ("No Government Intervention"), a single additional iteration at the optimum lasts 25 minutes with a Pentium 450 MHz chip and 260 megabytes of RAM.

Model Initialization

Numerical solution to the storage problem is greatly enhanced by "normalizing" the system to avoid variables of significantly different orders of magnitude. For this reason, and also to facilitate the interpretation of the model results and parameters, the behavioral parameters are chosen so that equilibrium acreage, output, and consumption of each commodity is 1.00 when neither supply nor consumption demand are stochastic (and, therefore, there is no storage). Space constraints prevent us from reporting simulation results from all of the parameter combinations analyzed. We show results for only a single set of parameter values for the No Government Intervention and Pre-FAIR regimes. For the FAIR regime, we provide results from four alternative parameterizations. These parameter values were selected so as to be consistent with the corresponding existing literature, and they are discussed next. Results for other parameterizations are available from the authors upon request.

Supply. The own- and cross-price elasticities of supply are assumed to be 0.4 and –0.15, respectively. This implies that $\alpha_{Oj} = 0$, $\beta_{Ojj} = 0.4$, and $\beta_{Ojk} = -0.15$ for $\forall$ j and $\forall$ $k \neq j$. The amount of arable land is hypothesized to be 2 percent greater than the total acreage devoted to crops in the nonstochastic equilibrium scenario, so that $\overline{A} = 3.06$. Finally, output shocks (e_{Ojt+1}) are assumed to be trivariate normally distributed with a mean of one, standard deviations of 0.16 for corn, 0.11 for soybeans, and 0.085 for others, and correlations of 0.8 for corn-soybeans and 0.3 for corn-others and soybeans-others.

Demand. The elasticity of demand for current consumption is set at –0.6, which with isoelastic demand ($\alpha_{Dj} = 0$) implies that $\gamma_{Dj} = 1.6$ and $\beta_{Dj} = -0.6$.[8] Demand shocks are assumed to be independently and identically distributed with a mean of zero and standard deviations of 0.08 for corn, 0.07 for soybeans, and 0.06 for others.

Storage. Annual per-unit storage costs are hypothesized to be 2 percent of the nonstochastic equilibrium price (i.e., $\phi_j = 0.02$), and the discount factor is set at $\delta = 0.95$ (which implies an annual interest rate of $1/\delta - 1 = 5.26$ percent).

Government Intervention under Pre-FAIR Regime. Loan rates for corn and soybeans are assumed to be below the nonstochastic equilibrium price and relatively favorable to corn (i.e., $R_{corn} = 0.90$, $R_{bean} = 0.85$). It is also assumed that the corn target price is 45 percent higher than the corn loan rate (i.e., $\overline{T} = 1.45 \times R_{corn} = 1.305$), the corn base acreage is the same as the nonstochastic equilibrium corn acreage (i.e., $\overline{B} = 1.00$), and the corn historical yield is identical to the mean corn yield ($\overline{Y}_{corn} = 1.00$). Finally, the set-aside function (1.10) used is:

$$S_t = (I_{cornt}/D_{cornt-1})/[1.2 + 4\,(I_{cornt}/D_{cornt-1})]. \tag{3.1}$$

It can be easily verified that the right-hand side of (3.1) satisfies the required conditions for $S(\cdot)$.

Government Intervention under FAIR Regime. The corn loan rate is assumed to be the same as under the Pre-FAIR regime (i.e., $R_{corn} = 0.90$). For soybeans, results are reported for both $R_{bean} = 0.85$ (i.e., the same as in Pre-FAIR) and $R_{bean} = 0.95$. The motivation for this particular sensitivity analysis is that, even with constant nominal loan rates, the level of support for soybeans relative to corn may have increased due to lower production costs associated with the recent introduction of soybean varieties tolerant to the herbicide glyphosate.

Results

The simulation results are presented in Tables 1 through 4. The results in Tables 1 and 2 are based on a loan program that slightly favors corn ($R_{corn} = 0.90$, $R_{bean} = 0.85$). Table 1 shows the specific results for corn, and Table 2 shows the results for soybeans. The first column in Tables 1 and 2 shows the base values of the key economic parameters in the absence of government intervention and without uncertainty. These values are reported for comparison purposes and are normalized to equal 1, 0, or 100. The second column shows how these key variables change when uncertainty is introduced. This scenario has no government intervention and is also used as a basis for comparison. The third column shows the results for the Pre-FAIR regime, and the last two columns show results for two extreme versions of the FAIR program. The first of these (FAIR-min) shows results when the government sets the LDP payments so that farmers always find the loan program to be attractive, thereby allowing the loan program to create a minimum price or price floor. The government would do this by adjusting the LDP payment so that farmers preferred the loan program to the cash LDP, i.e., by setting the payment below the fair premium for the call option implicit in the loan program. The second scenario (FAIR-pay) assumes that the LDP is always the more attractive option, and in this scenario the loan program does not support prices. For each variable of interest, the mean (in bold characters), the 5 percent quantile, the median, and the 95 percent quantile are reported. Whenever useful, the coefficient of variation is also provided.

Table 3 repeats the results shown in scenarios FAIR-min and FAIR-pay using a slightly higher relative loan rate for soybeans ($R_{bean} = 0.95$). The motivation for this sensitivity analysis is that the relative costs of production for corn and soybeans may be changing, as soybean varieties resistant to the herbicide glyphosate come on the market. If this relative production cost adjustment is underway, then the effectiveness of the soybean loan rate will increase relative to corn even if the two nominal rates are constant.

The fourth table shows the two relative loan scenarios (R_{bean} = 0.85 and R_{bean} = 0.95) under an intermediate FAIR program regime in which some grain enters the loan program and the government pays the LDP on the remainder. In this regime, the loan program acts to impose minimum prices, but the minimum price levels are below the loan rates. In order to calculate these results, the model was calibrated so that the resulting minimum prices were halfway between the loan rates and the 5 percent lower price quantiles of the FAIR-pay scenario. For example, as shown in Tables 1 and 2, when the loan rates for corn and soybeans are R_{corn} = 0.90 and R_{bean} = 0.85, the respective 5 percent lower price quantiles under FAIR-pay are 0.82 and 0.85. Therefore, the intermediate scenario for R_{corn} = 0.90 and R_{bean} = 0.85 is calibrated so that the minimum prices for corn and soybeans equal P_{corn}^{min} = 0.86 and P_{bean}^{min} = 0.85, respectively.

Discussion

The most interesting comparison in Tables 1 and 2 is that between the regime with random effects and no government intervention (i.e., the free-market scenario) and the Pre-FAIR regime. These results show that the Pre-FAIR program resulted in a very modest reduction in production and a negligible effect on market prices. This was true despite programs that took land out of production and created large government-controlled stocks. The results indicate that the acreage reduction programs were not effective because they removed land that might not have been farmed under the free-market scenario. The intuition is that land allocation decisions responded to prices, and when programs pulled some land out of production, other (possibly less productive) land came into production. This similarity would have been compounded by a government program that took land out of production when stocks were high (as was the case for corn under Pre-FAIR), because the free market would also have pulled land out of production in these surplus periods. In addition, the amount of private storage of corn under the free-market scenario is double that under the Pre-FAIR regime, again suggesting that some of the government intervention was crowding out an activity that the private sector would have undertaken in a normally functioning free market.

The greatest impact of the Pre-FAIR program is that farm revenues from corn are substantially higher than under the free-market regime. This additional income is a result of the target price program, which provides farmers with free "in-the-money" put options. Because of the way the target price program was modeled, high target prices did not have an impact on acreage at the margin. This is true because deficiency payments were based on 85 percent of historic production and not on the actual acreage planted with corn, as long as the latter exceeded the eligible corn acreage (recall discussion of expression (1.9)). The coefficient of variation of farm incomes in the Pre-FAIR scenario (12 percent for corn and 11 percent for soybeans) is lower than that in the free-market scenario (14 percent for corn and 11 percent for soybeans). This reduction, however, seems too small to justify the Pre-FAIR regime as a means to provide income stability. Further evidence in this regard is that the difference between the median and the lower 5 percent quantile of farm revenues from corn was actually smaller under the free-market regime (0.20 = 1.00 – 0.80) than under Pre-FAIR (0.24 = 1.28 – 1.04). One reason for the Pre-FAIR program failure to stabilize income is that deficiency payments tend to be negatively correlated with market prices (see (1.9)) but are correlated with production only indirectly, to the extent that the latter is correlated with prices. Therefore, deficiency payments sometimes come at a time when corn revenues were high and sometimes fail to come when crop yields were low. This effect is almost enough to offset the other revenue stabilizing effects of the Pre-FAIR program.

In summary, the key economic impacts of the Pre-FAIR scenario were to transfer income to farmers and to substitute government storage for private storage, in a way that did little to distort prices or to stabilize farm incomes.

The remaining results in Tables 1 and 2 show the effect of the two extreme versions of the FAIR program. In the first of these (FAIR-min), the program is operated to provide a minimum price equal to the loan rate, by making it optimal for farmers to put grain in the loan program. In the second (FAIR-pay), the program is run so that all farmers find it optimal to take the LDP payment instead of the loan. This is modeled as a choice between the call-option premium that is implicitly included in the loan program and the direct payment that is the LDP. Whenever the government offers a direct payment that is greater than the fair option premium, farmers are assumed to response optimally by taking the direct payment.

The principal impact of the assumption about the way the FAIR program is run shows up in the amount of storage. As might be expected, whenever the government runs the FAIR program to prop up prices, the government ends up storing a lot of grain. Another difference between the FAIR-min and the FAIR-pay regimes is that the latter exhibits higher price volatility for corn, as evinced by a coefficient of variation of 23 percent versus 20 percent for FAIR-min. This is to be expected because prices under FAIR-min are not allowed to drop below the minimum level and are usually prevented from taking high values because of the significantly higher (mostly government) stock levels. The impact of the FAIR program assumptions on other economic parameters is relatively muted, in large part because market forces adjust to offset the impact of the program changes.

Table 3 shows the two extreme FAIR regimes with a higher support level for soybeans. The impact of this change is to dramatically increase government storage of soybeans in the FAIR-min scenario and to increase loan deficiency payments for soybeans in the FAIR-pay scenario. It is interesting to note the degree to which government storage crowds out private storage when government storage of soybeans increases. For FAIR-min, increasing the loan rate for soybeans from R_{bean} = 0.85 to R_{bean} = 0.95 induces a fall in the average private storage from 0.05 to 0.01 and an increase in government storage from 0.01 to 0.16. Averages can be very misleading in both cases, because the storage distributions have very long tails.[9] As may be inferred from the storage quantiles, average government storage is so high because there are a few years when stocks keep accumulating, which is something that is possible without any mechanism to restrict production. These few years will greatly inflate the average.

The results just discussed show how important it is to have a feedback mechanism built into government programs involving minimum prices. Note that under Pre-FAIR, mechanisms were in place to restrict production that are absent under FAIR. Under FAIR, farmers find it profitable to produce soybeans at the minimum price of 0.95 (as median soybean production is 1.00 and median soybean price is 0.95), so farmers get neither a signal to reduce production nor are ever forced to reduce production.[10] The FAIR-min program, results of which are shown in Table 3, does not have this built-in feedback mechanism; hence, there is a potential for large accumulations of government stocks. The reason why the average private storage is 0.01 and not 0.00 in this scenario is that there may be a string of poor harvests, in which case government will store nothing but private storage will be profitable. Private storage never coexists with government storage; i.e., there can be private storage only in those years in which there is no government storage.

Comparison of Tables 1 and 3 reveals that increasing the soybean support from R_{bean} = 0.85 to R_{bean} = 0.95 has a very small impact on corn. There is a very small increase in the average price of corn in the FAIR-pay scenario (from 1.02 to 1.03) and an offsetting reduction in the government expenditures on corn LDP.

Table 4 shows a more realistic intermediate FAIR scenario. The first and third columns of results can be compared with the Pre-FAIR and free-market scenarios in Tables 1 and 2. Considering corn first, the intermediate FAIR regime results in more government storage and total average storage, slightly lower prices, and an offsetting deficiency payment not in the free-market scenario. Price volatility is slightly lower under the FAIR scenario because of the increased storage. Comparing FAIR with the Pre-FAIR scenario, the most noticeable effect is a one-to-one substitution of government storage and private storage (0.06 and 0.08 versus 0.08 and 0.06). The level of price volatility is almost unchanged, with coefficients of variation of 21 percent for Pre-FAIR and 22 percent for FAIR. Farm revenues under Pre-FAIR are remarkably higher because of the transfer effect of the Pre-FAIR deficiency payments. However, farm revenue volatility (as measured by the coefficient of variation) is relatively constant across the two government-intervention scenarios.[11]

Unsurprisingly, soybean results for the intermediate scenario with a loan rate of R_{bean} = 0.85 are almost the same as for the free-market and Pre-FAIR regimes. This is true because such a soybean loan rate level under Pre-FAIR had little impact on the soybean market relative to the free-market scenario (see Table 2). An increase in the soybean loan rate from R_{bean} = 0.85 to R_{bean} = 0.95 causes average total storage of soybeans to increase from 0.06 to 0.08. Such growth in storage is a consequence of the great expansion in government stocks (from 0.01 to 0.05), inasmuch as private stocks actually decrease from 0.05 to 0.03. Government storage expands due to the purchases required to support the minimum price, which is increased (from 0.85 to 0.89) along with the loan rate increase.

The soybean loan rate increase also causes average soybean price and its volatility to fall slightly (from 1.02 to 1.01 and from 17 percent to 16 percent, respectively). The reduction in average price is a direct consequence of the higher level of stocks, which translates into larger total supply. Further, because of the reduction in average soybean price and the higher soybean loan rate, deficiency payments shoot up from 0 to 0.02. Finally, average farm revenues from soybeans increase by the same amount as the increase in government deficiency payments. The reason for this, as is apparent from Table 4, is that most of the government expenditures occur as deficiency payments as opposed to storage operations.

Figures 1, 2, and 3 show the corn price distributions that are generated under the free-market, Pre-FAIR, and intermediate FAIR scenarios, respectively.[12] Each figure shows the price distribution under low, median, and high beginning storage levels for corn. It is immediately clear that all of the distributions are skewed to the right. Deaton and Laroque explain why these skewed price distributions occur in commodity markets. Large upside price movements will occur when supplies are tight because storage cannot be negative. Symmetrically low prices do not occur because speculative storage will take place when prices drop below the level at which one can rationally expect to profit from storage.

Under the free-market scenario, both the skewness and the mean price level increase as storage falls. When corn yields are high, the absence of any price support policy allows market prices to fall as low as about 75 percent of the (unconditional) expected level, even if beginning stocks are low. The distributions for the FAIR and Pre-FAIR scenarios are truncated at the price level at which government storage occurs. The Pre-FAIR results show that in years when carry-in corn stocks are high, there is about a 61 percent probability that the loan program will support corn prices. The comparable value for the intermediate FAIR scenario is about 53 percent. However, this value depends on the arbitrary assumption about the way the LDP program is implemented.

Concluding Remarks

A dynamic, rational-expectations model of commodity markets allowing for storage and output substitution among three commodities is advanced to analyze the impact of the Federal Agricultural Improvement and Reform (FAIR) Act of 1996. The advantage of this model being used for the intended purposes is that the well-known "Lucas' critique" does not apply, because the model built depends only on behavioral parameters that are not affected by changes in policy regimes such as the one being studied.

It is found that the transitional payments created to replace the Pre-FAIR deficiency payments are much lower than the payments they replace and this does reduce farm revenues. But these revenue losses are not a result of low market prices. The results also lend support to the hypothesis that the changes made when FAIR was enacted did not lead to a permanent significant increase in the volatility of farm prices or revenues.

An important finding is that the main economic impacts of the Pre-FAIR scenario, relative to the free-market regime, were to transfer income to farmers and to substitute government storage for private storage in a way that did little to distort prices or to stabilize farm incomes.

Table 1. Steady-state simulation results for corn, corresponding to $R_{bean} = 0.85$[a]

	No Government Intervention		Government Intervention		
	Regime without Random Effects	Regime with Random Effects	Pre-FAIR Regime	FAIR Regime: FAIR-min[b]	FAIR Regime: FAIR-pay[b]
Planted Acres	**1**	**1.00** (0.02)	**0.99** (0.03)	**1.00** (0.02)	**1.00** (0.02)
		[0.96, *1.00*, 1.03]	[0.94, *1.00*, 1.03]	[0.97, *1.00*, 1.03]	[0.97, *1.00*, 1.03]
Production	**1**	**1.00** (0.16)	**0.99** (0.16)	**1.00** (0.16)	**1.00** (0.16)
		[0.74, *1.00*, 1.27]	[0.73, *0.99*, 1.26]	[0.74, *1.00*, 1.27]	[0.74, *1.00*, 1.27]
Total Supply	**1**	**1.12**	**1.14**	**1.17**	**1.12**
		[0.79, *1.12*, 1.46]	[0.80, *1.13*, 1.51]	[0.81, *1.15*, 1.59]	[0.79, *1.12*, 1.47]
Current Consumption	**1**	**1.00** (0.10)	**0.99** (0.09)	**1.00** (0.09)	**1.00** (0.10)
		[0.79, *1.02*, 1.12]	[0.80, *1.02*, 1.06]	[0.81, *1.03*, 1.06]	[0.79, *1.02*, 1.13]
Private Storage	**0**	**0.12**	**0.06**	**0.05**	**0.12**
		[0.00, *0.10*, 0.34]	[0.00, *0.04*, 0.19]	[0.00, *0.02*, 0.17]	[0.00, *0.10*, 0.34]
Government Storage	**0**	**0**	**0.08**	**0.12**	**0**
			[0.00, *0.00*, 0.44]	[0.00, *0.00*, 0.53]	
Total Storage	**0**	**0.12**	**0.14**	**0.17**	**0.12**
		[0.00, *0.10*, 0.34]	[0.00, *0.11*, 0.44]	[0.00, *0.12*, 0.53]	[0.00, *0.10*, 0.34]
Years without Storage (%)	100	23	21	20	23
Price	**1**	**1.03** (0.23)	**1.03** (0.21)	**1.02** (0.20)	**1.02** (0.23)
		[0.83, *0.97*, 1.48]	[0.90, *0.97*, 1.46]	[0.90, *0.96*, 1.43]	[0.82, *0.96*, 1.48]
Government Deficiency Payments	**0**	**0**	**0.27**	**0**	**0.02**
			[0.00, *0.31*, 0.40]		[0.00, *0.00*, 0.09]
Government Storage Net Expenditures	**0**	**0**	**0.003**	**0.005**	**0**
			[–0.001, *0.00*, 0.03]	[–0.002, *0.00*, 0.03]	
Farm Revenues	**1**	**1.00** (0.14)	**1.28** (0.12)	**1.00** (0.13)	**1.02** (0.14)
		[0.80, *1.00*, 1.22]	[1.04, *1.28*, 1.52]	[0.78, *1.00*, 1.23]	[0.81, *1.01*, 1.24]

[a]Bold numbers denote mean values, numbers within parentheses are coefficients of variation, and the three numbers within brackets are, respectively, the 5 percent quantile, the median (in italics), and the 95 percent quantile.

[b]FAIR-min denotes the scenario in which $P^{min}_{corn} = R_{corn}$ and $P^{min}_{bean} = R_{bean}$. FAIR-pay denotes the scenario in which $P^{min}_{corn} = P^{min}_{bean} = 0$.

Table 2. Steady-state simulation results for soybeans, corresponding to $R_{bean} = 0.85$[a]

	No Government Intervention		Government Intervention		
	Regime without Random Effects	Regime with Random Effects	Pre-FAIR Regime	FAIR Regime: FAIR-min[b]	FAIR Regime: FAIR-pay[b]
Planted Acres	**1**	**1.00** (0.01) [0.98, *1.00*, 1.02]	**0.99** (0.02) [0.96, *1.00*, 1.01]	**1.00** (0.01) [0.97, *1.00*, 1.02]	**1.00** (0.01) [0.97, *1.00*, 1.02]
Production	**1**	**1.00** (0.11) [0.82, *1.00*, 1.18]	**0.99** (0.11) [0.81, *0.99*, 1.18]	**1.00** (0.11) [0.82, *1.00*, 1.18]	**1.00** (0.11) [0.82, *1.00*, 1.18]
Total Supply	**1**	**1.06** [0.83, *1.06*, 1.30]	**1.06** [0.82, *1.05*, 1.29]	**1.06** [0.83, *1.06*, 1.30]	**1.06** [0.83, *1.06*, 1.29]
Current Consumption	**1**	**1.00** (0.08) [0.83, *1.02*, 1.10]	**0.99** (0.08) [0.82, *1.02*, 1.09]	**1.00** (0.08) [0.83, *1.02*, 1.10]	**1.00** (0.08) [0.83, *1.02*, 1.10]
Private Storage	**0**	**0.06** [0.00, *0.03*, 0.20]	**0.05** [0.00, *0.03*, 0.17]	**0.05** [0.00, *0.03*, 0.15]	**0.06** [0.00, *0.03*, 0.20]
Government Storage	**0**	**0**	**0.01** [0.00, *0.00*, 0.00]	**0.01** [0.00, *0.00*, 0.11]	**0**
Total Storage	**0**	**0.06** [0.00, *0.03*, 0.20]	**0.06** [0.00, *0.04*, 0.20]	**0.06** [0.00, *0.04*, 0.20]	**0.06** [0.00, *0.03*, 0.20]
Years without Storage (%)	100	35	34	35	35
Price	**1**	**1.02** (0.17) [0.85, *0.96*, 1.37]	**1.03** (0.17) [0.86, *0.97*, 1.38]	**1.02** (0.17) [0.85, *0.96*, 1.37]	**1.02** (0.17) [0.85, *0.96*, 1.38]
Government Deficiency Payments	**0**	**0**	**0**	**0**	**0.001** [0.00, *0.00*, 0.00]
Government Storage Net Expenditures	**0**	**0**	**0.0002** [0.00, *0.00*, 0.00]	**0.0003** [0.00, *0.00*, 0.00]	**0**
Farm Revenues	**1**	**1.01** (0.11) [0.86, *0.99*, 1.21]	**1.01** (0.11) [0.86, *1.00*, 1.21]	**1.00** (0.10) [0.85, *0.99*, 1.21]	**1.01** (0.11) [0.86, *1.00*, 1.21]

[a]Bold numbers denote mean values, numbers within parentheses are coefficients of variation, and the three numbers within brackets are, respectively, the 5 percent quantile, the median (in italics), and the 95 percent quantile.

[b]FAIR-min denotes the scenario in which $P_{corn}^{min} = R_{corn}$ and $P_{bean}^{min} = R_{bean}$. FAIR-pay denotes the scenario in which $P_{corn}^{min} = P_{bean}^{min} = 0$.

Table 3. Steady-state simulation results for corn and soybeans under the FAIR regime, corresponding to $R_{bean} = 0.95$[a]

	Corn		Soybeans	
	FAIR-min[b]	FAIR-pay[b]	FAIR-min[b]	FAIR-pay[b]
Planted Acres	**1.00** (0.02) [0.97, *1.00*, 1.03]	**1.00** (0.02) [0.97, *1.00*, 1.03]	**1.00** (0.01) [0.98, *1.00*, 1.02]	**1.01** (0.01) [0.99, *1.01*, 1.02]
Production	**1.00** (0.16) [0.74, *1.00*, 1.27]	**1.00** (0.16) [0.74, *1.00*, 1.27]	**1.00** (0.11) [0.82, *1.00*, 1.18]	**1.01** (0.11) [0.82, *1.01*, 1.19]
Total Supply	**1.17** [0.81, *1.15*, 1.58]	**1.12** [0.79, *1.12*, 1.46]	**1.17** [0.86, *1.14*, 1.62]	**1.06** [0.83, *1.06*, 1.30]
Current Consumption	**1.00** (0.09) [0.81, *1.03*, 1.06]	**1.00** (0.10) [0.79, *1.02*, 1.12]	**1.00** (0.06) [0.86, *1.03*, 1.03]	**1.01** (0.09) [0.83, *1.03*, 1.11]
Private Storage	**0.05** [0.00, *0.02*, 0.17]	**0.12** [0.00, *0.10*, 0.34]	**0.01** [0.00, *0.00*, 0.05]	**0.06** [0.00, *0.03*, 0.19]
Government Storage	**0.12** [0.00, *0.00*, 0.52]	**0**	**0.16** [0.00, *0.10*, 0.59]	**0**
Total Storage	**0.17** [0.00, *0.12*, 0.52]	**0.12** [0.00, *0.10*, 0.34]	**0.17** [0.00, *0.10*, 0.59]	**0.06** [0.00, *0.03*, 0.19]
Years without Storage (%)	20	23	22	35
Price	**1.02** (0.21) [0.90, *0.96*, 1.43]	**1.03** (0.23) [0.83, *0.96*, 1.48]	**1.01** (0.13) [0.95, *0.95*, 1.29]	**1.01** (0.17) [0.84, *0.96*, 1.37]
Government Deficiency Payments	**0**	**0.01** [0.00, *0.00*, 0.09]	**0**	**0.03** [0.00, *0.00*, 0.13]
Government Storage Net Expenditures	**0.005** [–0.002, *0.00*, 0.03]	**0**	**0.01** [0.00, *0.004*, 0.04]	**0**
Farm Revenues	**1.00** (0.13) [0.78, *1.00*, 1.23]	**1.02** (0.14) [0.81, *1.01*, 1.24]	**1.00** (0.10) [0.83, *1.00*, 1.19]	**1.03** (0.10) [0.88, *1.02*, 1.22]

[a]Bold numbers denote mean values, numbers within parentheses are coefficients of variation, and the three numbers within brackets are, respectively, the 5 percent quantile, the median (in italics), and the 95 percent quantile.

[b]FAIR-min denotes the scenario in which $P^{min}_{corn} = R_{corn}$ and $P^{min}_{bean} = R_{bean}$. FAIR-pay denotes the scenario in which $P^{min}_{corn} = P^{min}_{bean} = 0$.

Table 4. Steady-state simulation results for corn and soybeans under the FAIR regime, corresponding to intermediate floor prices[a]

	Corn		Soybeans	
	P^{min}_{corn} = 0.86, P^{min}_{bean} = 0.85, R_{bean} = 0.85	P^{min}_{corn} = 0.86, P^{min}_{bean} = 0.89, R_{bean} = 0.95	P^{min}_{corn} = 0.86, P^{min}_{bean} = 0.85, R_{bean} = 0.85	P^{min}_{corn} = 0.86, P^{min}_{bean} = 0.89, R_{bean} = 0.95
Planted Acres	**1.00** (0.02) [0.97, *1.00*, 1.03]	**1.00** (0.02) [0.97, *1.00*, 1.03]	**1.00** (0.01) [0.97, *1.00*, 1.02]	**1.00** (0.01) [0.98, *1.00*, 1.02]
Production	**1.00** (0.16) [0.74, *1.00*, 1.27]	**1.00** (0.16) [0.74, *1.00*, 1.27]	**1.00** (0.11) [0.82, *1.00*, 1.18]	**1.00** (0.11) [0.82, *1.00*, 1.19]
Total Supply	**1.14** [0.80, *1.13*, 1.52]	**1.14** [0.80, *1.13*, 1.50]	**1.06** [0.83, *1.06*, 1.30]	**1.09** [0.84, *1.08*, 1.37]
Current Consumption	**1.00** (0.09) [0.80, *1.02*, 1.10]	**1.00** (0.10) [0.80, *1.02*, 1.10]	**1.00** (0.08) [0.83, *1.02*, 1.10]	**1.00** (0.08) [0.84, *1.03*, 1.07]
Private Storage	**0.08** [0.00, *0.06*, 0.22]	**0.08** [0.00, *0.06*, 0.23]	**0.05** [0.00, *0.03*, 0.15]	**0.03** [0.00, *0.00*, 0.10]
Government Storage	**0.06** [0.00, *0.00*, 0.42]	**0.05** [0.00, *0.00*, 0.41]	**0.01** [0.00, *0.00*, 0.10]	**0.05** [0.00, *0.00*, 0.30]
Total Storage	**0.14** [0.00, *0.11*, 0.42]	**0.14** [0.00, *0.10*, 0.41]	**0.06** [0.00, *0.04*, 0.20]	**0.08** [0.00, *0.05*, 0.30]
Years without Storage (%)	22	22	35	32
Price	**1.02** (0.22) [0.86, *0.96*, 1.46]	**1.02** (0.22) [0.86, *0.96*, 1.46]	**1.02** (0.17) [0.85, *0.96*, 1.37]	**1.01** (0.16) [0.89, *0.95*, 1.35]
Government Deficiency Payments	**0.01** [0.00, *0.00*, 0.05]	**0.01** [0.00, *0.00*, 0.05]	**0.00** [0.00, *0.00*, 0.00]	**0.02** [0.00, *0.00*, 0.07]
Government Storage Net Expenditures	**0.002** [0.00, *0.00*, 0.02]	**0.002** [0.00, *0.00*, 0.02]	**0.0003** [0.00, *0.00*, 0.00]	**0.002** [0.00, *0.00*, 0.02]
Farm Revenues	**1.01** (0.13) [0.80, *1.01*, 1.24]	**1.01** (0.13) [0.80, *1.01*, 1.24]	**1.00** (0.10) [0.85, *0.99*, 1.21]	**1.02** (0.10) [0.86, *1.02*, 1.21]

[a]Bold numbers denote mean values, numbers within parentheses are coefficients of variation, and the three numbers within brackets are, respectively, the 5 percent quantile, the median (in italics), and the 95 percent quantile.

Endnotes

1. The loan rate program in place before the FAIR Act allowed farmers to borrow (at a county-specific loan rate per bushel) against stored grain and to repay this loan only when market prices made it worthwhile to the farmer. This program resulted in government-owned storage and may have put a floor under commodity prices. Under FAIR, the LDP program was introduced to reduce government involvement in stocks and to offer farmers a choice between the loan program and a direct payment equal to the difference between local cash prices (as measured by the government) and the loan rate.

2. For example, the commodity problem analyzed here requires us to solve for $J \times 72^J$ unknowns in $J \times 72^J$ nonlinear equations for each scenario, where J is the number of commodities analyzed. That is, going from 3 to 4 commodities implies a 96-fold increase in the number of unknown variables that have to be solved for, from 1,119,744 to 107,495,424.

3. This logarithmic approximation implies expansion around a vector of ones, which is consistent with the normalization used for the present simulations (see the "Model Initialization" section).

4. Restriction (b) is also required to model meaningfully the Pre-FAIR regime's set-aside policy (see the discussion in the "Government Intervention Scenario 2: FAIR Regime," section).

5. Technically, the max(·) term in (1.9) should have $\max(R_{corn}, P_{cornt})$ instead of P_{cornt}. But in market equilibrium $P_{cornt} \geq R_{corn}$ because corn producers will never sell their corn at prices below the loan rate R_{corn}.

6. It is often argued that the main explanation for this fact is the producers' fear of losing their base acreage.

7. The LDP payment is supposed to equal the difference between local cash prices and the local loan rate. In reality, the program has been run so that the federal government has had a high level of control over the way the local cash prices were measured. It has done this by calculating local cash prices as the difference between prices at export destinations less some county-specific transportation costs. The government has adjusted these transportation costs to obtain local cash prices yielding the desired LDP payments. For example, in 1998 there were many instances in which actual local cash prices were between $0.15/bushel and $0.20/bushel above the government estimates of local cash prices. This resulted in artificially large LDP payments and caused most producers to take the LDP payment rather than to participate in the loan program.

8. Results show that the level of price volatility (though not the cross-policy comparison) is very sensitive to the magnitude of the demand elasticity. Therefore, the reported results correspond to a demand elasticity that gave a price volatility similar to that experienced during the pre-FAIR period. The sensitivity of the price volatility to the magnitude of the demand elasticity may suggest a more accurate way of estimating price elasticities when volatility levels are known.

9. Average storage is calculated by adding up the amounts stored each year and dividing this sum by the number of years.

10. It could be argued that the actual FAIR regime has such a built-in mechanism. If stocks do start to accumulate, the government can change the parameters of the LDP program to make the LDP payment preferable to the loan program. To do this it would report a posted cash price (PCP) that is lower than actual cash prices in that county on that date. Because the LDP payment equals the loan rate minus the PCP, the use of a smaller PCP will increase the incentive to take the cash payment instead of putting the grain under loan. However, this feedback mechanism is not described in any official publications, so it is difficult to incorporate this possible feedback mechanism in the present analysis.

11. The analysis excludes the direct transition payments included in the actual FAIR program. These payments are equal to about 10 percent of the value of corn output. If transition payments were included in the FAIR farm revenues, the Pre-FAIR program would continue to have substantially higher farm revenues.

12. Figure 3 depicts the intermediate FAIR regime with the high soybean loan rate (R_{bean} = 0.95). The graph for the low soybean loan rate (R_{bean} = 0.895) is omitted in the interest of space, as it is similar to Figure 3.

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