The Quality of Speculation in the Soybean Complex

by

Roger A. Dahlgran

The Quality of Speculation in the Soybean Complex

Roger A. Dahlgran*

This paper examines the quality of speculation in the soybean, soyoil and soymeal futures markets. High quality speculation is defined as speculative activity that quickly brings markets to equilibrium when economic events dictate that a new equilibrium is required. A model of spot and futures market interaction is developed and estimated using cross sections of time-series data from 1992, 1993 and 1994. The dynamics of market equilibration are simulated by using the estimated parameters and also by using alternative assumptions about speculative and hedging behavior. It is found that hedgers contribute little to market equilibration. Speculative activity consisting of arbitrage between the spot and futures markets based on carrying costs was found to be low in quality and potentially destabilizing. True speculative activity consisting of arbitraging the futures markets against expected futures prices was found to be the highest quality of speculation.

Introduction

Futures market speculators are acknowledged in the industry and in scholarly works as providing socially-beneficial functions of market liquidity and aiding in the price discovery process. However, the recognition of these socially beneficial functions is not nearly as widely understood by the general public. In fact, the general public seems to believe that speculative activity is the source of commodity-price volatility. These two extremes positions have been argued since the inception of futures trading.

A third possibility is that the level of social benefits provided by speculators might lie somewhere between the *prima facia* case made by scholars and the populist case made by casual futures market observers. This notion that speculation might partially or slowly accomplish its socially-beneficial price discovery mission is embodied in a concept that Hieronymus (p 18) refers to as the quality of speculation.

> "The speculative pricing mission of (futures) markets is to discount existing and forthcoming events affecting current and subsequent prices into current prices. That is, optimally (futures) markets would be omniscient and discount their omniscience into current prices. But markets are less than perfect. Nor should we

*Associate Professor, Department of Agricultural and Resource Economics, University of Arizona, Tucson.

expect perfection. Many events such as droughts, flood, hurricanes, revolutions and fickle behavior of consumers and politicians are random and not forecastable. But markets should react quickly, adjust to the appropriate level and stabilize until the next unforeseeable random event occurs. The greater the accuracy with which (futures) markets discount futures events into current prices, the greater their contribution to economic productivity. The question raised is: how well do futures markets perform as devices for planning economic processes? The problem is to establish a reasonable standard of optimum performance and measure actual market performance against the standard. This sounds unreasonable and impractical but quality speculation is what futures markets are really about"

Witherspoon demonstrates that the notion of an intermediate level of speculation's benefits may be well founded. By extending Garbade and Silber's model of the dynamic interaction between spot and futures prices, Witherspoon mathematically demonstrated that under certain conditions, futures markets can cause 1) an increase in long term cash market autocorrelation and long-term volatility, 2) a decrease in cash market liquidity and/or 3) a crash or bubble.

The objective of the research described in this paper is to determine futures markets' price-discovery performance relative to some theoretical maximum. This will be done by fitting an econometric model of cash and futures market price behavior in the soybean complex to daily price data. The model developed is similar to the one employed by Garbade and Silber and Witherspoon but it will be supplemented in ways that will make it is superior to the Garbade-Silber specification. In particular, futures market equilibrium will occur among long hedgers, long speculators, short hedgers and short speculators for each futures contract. Also, the model will be driven by expected future and spot prices rather than the reservation prices employed by Garbade-Silber and Witherspoon. The soybean, soyoil and soymeal spot and futures markets are chosen because 1) the commodities are storable so that the futures markets are well suited to models based on the widely accepted cost of storage, 2) the futures markets are liquid and efficient, 3) both hedging and speculation are important components of price determination in the spot and futures markets, and 4) both time and inter-commodity (crush) spreads are potentially significant factors in price discovery in these markets.

This research will focus on how new information results in speculative activity in the futures markets and how this activity leads the futures and the spot markets to equilibrium Of primary interest is whether speculative activities bring the markets to equilibrium more quickly than they would otherwise attain equilibrium. Also of interest is the path the markets take to equilibrium. *A priori* the possible candidates for price-paths to market equilibrium are (in order of decreasing desirability) 1) immediate adjustment, 2) damped, noncyclical adjustment, 3) damped oscillatory adjustment, 4) continuous cycles and 5) explosive.

Though this analysis focuses on a small set of futures markets, the methodology established and the interpretation of the results will have important implications for public policy toward the futures industry. For example if it is found that futures markets foster high quality speculation and that as a result the price discovery function of futures markets is optimal, current structures and practices can be defended as the best available and that society is currently maximizing or nearly maximizing the benefits of its futures markets. However, if it is found that the price discovery benefits of futures markets are not nearly maximized, then practices can be changed and institutions modified so that society can increase the benefits from futures markets.

Previous Research

Though its theoretical foundations are different, the empirical model developed in this research is not too dissimilar from the model developed by Garbade and Silber and extended by Witherspoon. The Garbade-Silber (GS) model is derived from individual agent's cash market demands for a commodity, individual agent's futures market demands for the commodity and a cash-futures arbitrage schedule. Individual decisions are based on reservation prices and market-price dynamics result from the formation of new reservation prices. The process by which reservation prices are formed is that the reservation price in each market is the previous period's actual price in the respective market plus error terms which reflect the arrival of new information. Witherspoon's extension of the GS model specifies that this period's spot and futures reservation prices are formed from last period's actual respective price and from last period's changes in both the spot and the futures prices. Garbade and Silber estimated their model for wheat, corn oats, orange juice, copper, gold and silver. Witherspoon did not estimate his model but examined its dynamic behavior under a variety of assumptions about the size of the futures market relative to the cash market. Schroeder and Goodwin, Khoury and Yourougou, and Oellermann et al. have applied the GS price discovery model to various other markets and have generally found futures to be a primary source of price discovery.

Though the Garbade-Silber-Witherspoon model serves well for analyzing price discovery, the analysis of the quality of speculation requires a slightly different model because the Garbade-Silber model has shortcomings in three important areas. First, the Garbade-Silber-Witherspoon model over simplifies futures markets. The supply-demand model for the commodity underlying the futures contract is reasonably specified but the futures market is modeled with a supply-demand apparatus similar to that used for the spot market. This specification assumes a demand for futures contracts where higher futures prices result in fewer buyers, and a supply of futures contracts where a higher futures price results in more sellers, *ceteris paribus*. This formulation ignores buyers' and sellers' hedging and speculative motives for participating in futures markets.

The second deficiency of the Garbade-Silber-Witherspoon model is the assumption that all information relevant for price discovery is contained in the price for the single nearby futures contract. Several different futures contract maturities typically trade and each contract's price contains information relevant to price discovery at the contract's maturity. When the nearby contract matures and the next nearby contract becomes the nearby contract the price discovery target has shifted and the shift should be explicitly recognized in the estimation procedure. Also, multiple maturities provide opportunities for intracommodity-spreading which is potentially an important contributor to price discovery. The quality of speculation cannot be addressed without allowing for spread trading.

A third deficiency of the Garbade-Silber-Witherspoon model is that it ignores intercommodity relationships. Just as cash markets for soybeans, soyoil and soymeal can be arbitraged by crushing soybeans, so too futures markets based on different forms of a commodity can be arbitraged. Intercommodity spreads are important speculative enterprises and should be included in an evaluation of the quality of speculation.

The model developed in this paper will overcome the GS model's shortcomings. Our model is derived from structural market-level relationships which include commodity demand, inventory holding, inventory hedging, and speculation in each of the futures contracts considered. The dynamic aspects of our model result from changes in price expectations which influence hedgers and speculators in their respective markets. Although spread speculation is not explicitly modeled, the availability of multiple contract maturities with highly correlated price changes makes spreads trading implicitly available.

Theoretical Model

Our theoretical model includes both spot (i.e. physical) and futures markets for a commodity. In the spot market, the allocative choice continuously required is whether to use a commodity or hold it for later use. These choices are reflected in spot market equilibrium

$$I_t + D_t = I_{t-1} + Q_t \tag{1}$$

where I_t represents inventories of the commodity held at time t, D_t represents the commodity utilized, consumed or otherwise removed from inventories in time t and Q_t represents the new supplies of the commodity that become available at time t.

Utilization of the commodity is modeled with a demand function

$$D_t = D(P_t\,/\mathbf{P}) \tag{2a}$$

which states that the quantity demanded at time t is a function of the spot price at time t, P_t, relative to its seasonal average, $\mathbf{P}$. Differentiating (2) gives $dD_t = z_t\, D'[z_t]\; dz_t\,/z_t = z_t\, D'[z_t]$ dlog z_t where $D'[z_t] \equiv \partial D[z_t]/\partial z_t < 0$. On average $P_t/\mathbf{P}$ is unity giving the result, to be used shortly, that

$$dD_t \cong D'[z]\; d\log z_t \tag{2b}$$

Inventory holdings can be either hedged or unhedged. Hedged inventories are modeled as

$$H_{Tt} = H_T[\,F_{Tt}\,/\,P_t\, e^{(T-t)(r_{Tt}+\gamma)}\,] = H_T[h_{Tt}] \tag{3}$$

where H_{Tt} represents the amount of inventory at time t that is hedged for delivery at time T and T is a member of a set of possible contract maturities, $M=\{T{:}T\in M\}$, and $h_{Tt} \equiv F_{Tt}/P_t\, e^{(T-t)(r_{Tt}+\gamma)}$. Defining H_{Tt} as hedged inventory balances easily accounts for short hedging. With generalization it also models long hedging. Allow H_{Tt} to represent the net of short and long hedging where long spot positions (short-hedges) are represented by positive quantities and long hedges (short spot positions) are represented by negative quantities. If short hedging exceeds long hedging then H_{Tt} is positive reflecting the net long balance of inventory positions. However, if long hedging exceeds short hedging then H_{Tt} is negative reflecting the short balance of inventory positions. In either case, the hedging decision involves comparing the currently prevailing futures contract price for maturity at time T with the current spot price plus the costs to store the commodity from now until contract maturity The current spot price plus storage costs are computed in the denominator where the terms in the exponential function consist of the storage term (T-t) multiplied by the daily financing cost for the hedge term (r_{Tt}) plus the daily deterioration and insurance charge, (γ). If the argument of H_{Tt} exceeds one, inventories will be held and covered by a short futures market position, whereas if the argument is less than one, inventories will not be held in a short hedge but those with a short position in the spot market will use the futures market to long. hedge the anticipated purchase of the commodity. Accordingly, $H'[h_{Tt}] \equiv \partial H_T[h_{Tt}]/\partial h_{Tt} > 0$.

Unhedged inventories, held at time t for possible use at time T, are designated as U_{Tt} and represented by the behavioral relationship

$$U_{Tt} = U_T[\, P^*_{Tt} / P_t\, e^{(T - t)(r_{Tt} + \gamma)}\,] = U_T[u_{Tt}] \tag{4a}$$

where $u_{Tt} \equiv P^*_{Tt} / P_t\, e^{(T - t)(r_{Tt} + \gamma)}$. The numerator of this function's argument is the spot price (P) currently (t) expected (*) to prevail at the end of storage period (T). Like the hedging functions, the denominator contains the current spot price compounded to account for storage costs. If the spot price expected to prevail at the end of the storage term rises, more commodity will be stored while if the current spot price or storage costs increase less commodity will be stored. Hence, $U'[u_{Tt}] \equiv \partial U_T[u_{Tt}]/\partial u_{Tt} > 0$.

Unlike hedged positions where the contract's maturity defines the time horizon, time horizons for unhedged positions are ambiguous. An unhedged position's time horizon can correspond either to a maturity date for a futures contract or to a maturity date between any two futures contracts. However, if unhedged-inventory holding is treated as day-to-day speculative activity without a predefined time horizon, the unhedged inventory holding becomes

$$U_t = U[\, P^*_t / P_t\, e^{(r_{0t} + \gamma)}\,] = U[u_t] \tag{4b}$$

where $u_t \equiv P^*_t / P_t\, e^{(r_{0t}+\gamma)}$ and P^*_t represents the one-day-ahead price expectation and r_{0t} represents the daily interest rate for one day financing. It is still expected that $U' > 0$.

Total inventory holdings can now be defined as

$$I_t \equiv U_t + \Sigma_{T\in M} H_{Tt} \tag{5}$$

While this is not a constraint on inventories this equation does demonstrate how hedged inventories can substitute for unhedged inventories and how long-hedged future acquisitions ($H_{Tt} < 0$) can be currently held by other agents as unhedged positions or held by other agents in offsetting short-hedged positions.

Differentiating (5) gives

$$dI_t = u_t\, \partial U[u_t]/\partial u_t\, (du_t/u_t) + \Sigma_{T\in M}\, h_{Tt}\, \partial H_T[h_{Tt}]/\partial h_{Tt}\, (dh_{Tt}/h_{Tt}) \tag{6a}$$

Arbitrage between hedged and unhedged storage will tend to drive h_{Tt} and u_t toward unity. Accordingly, (6a) is approximated with

$$dI_t \cong U'\, \text{dlog}\, u_t. + \Sigma_{T\in M}\, H'_T\, \text{dlog}\, h_{Tt} \tag{6b}$$

Substituting (6b) and (2b) into the differential of (1), and incorporating the extended definitions for u_t and h_{Tt} gives

$$\begin{aligned} D'\, p_t + U'[p^*_t - p_t + (T\text{-}t)dr_{0t} - (r_{0t}+\gamma)dt] + \Sigma_{T\in M}\, H'_T[f_{Tt} - p_t + (T\text{-}t)dr_{Tt} - (r_{Tt}+\gamma)dt] \\ = U'[p^*_l - p_l + (T\text{-}t_l)dr_{0l} - (r_{0l} + \gamma)dt_l] + \Sigma_{T\in M}\, H'_T[f_{Tl} - p_{Tl} + (T\text{-}t)dr_{Tl} - (r_{Tl}+\gamma)]dt_l + dQ_t \end{aligned} \tag{7}$$

where $f_{Tt} \equiv$ dlog F_{Tt}, $p_t \equiv$ dlog P_t, $p^*_t \equiv$ dlog P^*_t, and l indicates the previous observation. The lag l is used instead of t-1 because weekends and holidays cause unequally-spaced observations.

Futures market speculation is modeled with a net speculation function

$$S_{Tt} = S_T(F_{Tt}/F^*_{Tt}) = S_T(s_{Tt}) \tag{8}$$

where S_{Tt} represents speculators' net futures market positions, and $s_{Tt} \equiv F_{Tt}/F^*_{Tt}$. Speculators can be long ($S_{Tt} > 0$) or short ($S_{Tt} < 0$) but a rise in a futures contract's price will generate more short (fewer long) positions, *ceteris parabus*, while an increase in the current expected futures price will tend to generate more long (fewer short) positions, *ceteris parabus*. Thus, $S'_{Tt} < 0$.

Market equilibrium for the futures contract that matures at time T requires

$$S_{Tt} = \rho_T\, H_{Tt} \tag{9}$$

where ρ_T is the actual hedge ratio $\rho_T > 0$. Suppose hedgers in contract T are net short (i.e. on balance using short futures positions to hedge long ($N_{Tt} > 0$) inventory positions). Then for the futures market to be in equilibrium, the speculators must be long by $\rho_T\, N_{Tt}$

Differentiating (9) gives

$$s_{Tt}\, \partial S_T/\partial s_{Tt}\, ds_{Tt}/s_{Tt} = \rho_T\, \partial H_T/\partial h_{Tt}\, dh_{Tt}/h_{Tt} \tag{10a}$$

Arbitrage will drive s_{Tt} toward unity, so (10a) can be rewritten as

$$S'_T\, [f_{Tt} - f^*_{Tt}] = \rho_T\, H'_T\, [f_{Tt} - p_t - (T\text{-}t)dr_{Tt} - (r_{Tt} + \gamma)dt] \qquad T \in M \tag{10b}$$

Equations (7) and (10b) constitute the core of the empirical model. This model will be estimated for the spot market and the January and March futures markets which will be designated with T=1 and T=3, respectively. Collecting the endogenous variables (p_t, and f_{Tt} $T \in M$) then normalizing by dividing (7) by $D' - U' - \Sigma_T H'_{T\in M}$ and (10b) by $S'_T - \rho_T H'_T$ gives

$$
\begin{aligned}
p_t = &- (\alpha_0 + \alpha_1 + \alpha_2)\, p_l - \alpha_1 (f_{1t} - f_{1l}) - \alpha_3 (f_{3t} - f_{3l}) + \alpha_0\, d\{dr_{0t} - r_{0t}\, dt\} \\
&+ \alpha_1\, d\{(T_1 - t)dr_{1t} - r_{1t}\, dt\} + \alpha_3\, d\{(T_3 - t)dr_{3t} - r_{3t}\, dt\} - \gamma(\alpha_0 + \alpha_1 + \alpha_2)\, d^2t + \theta\, dQ_t \\
&- \alpha_0 (p^*_t - p^*_l)
\end{aligned} \tag{11a}
$$

and $$f_{Tt} = - \phi_T [p_t + (T_T - t)dr_{Tt} - (r_t + \gamma)dt] + (1 + \phi_T) f^*_{Tt} \qquad T \in M \tag{11b}$$

where $\alpha_0 \equiv U'/(D' - U' - \Sigma_{T\in M} H'_T)$ $\quad -1 < \alpha_0 < 0 \qquad \alpha_T \equiv H'_T/(D' - U' - \Sigma_{T\in M} H'_T)$ $\quad -1 < \alpha_T < 0$

$\theta \equiv 1/(D' - U' - \Sigma_{T\in M} H'_T)$ $\quad \theta < 0$, and $\qquad \phi_T \equiv \rho_T H'_T/(S'_T - \rho_T H'_T)$ $\quad -1 < \phi_T < 0$

The error terms in this empirical specification are first-order percentage changes in expected futures-prices, f^*_{Tt} and the second-order percentage changes in the expected spot price, $p^*_t - p^*_l$. These terms have expected values of zero, unique variances and are generated by the random occurrence of price-influencing events and the random arrival of new information to the markets.

Equation (11b) immediately shows some possible connections between the spot and futures prices. If $\phi_T = -1$, futures price changes are caused solely by changes in spot prices and carrying costs. At the other extreme, if $\phi_T = 0$, the futures price changes result solely from changes in speculators' price expectations and are unrelated to the changes in the spot price. Intermediate values of ϕ_T indicate conditions between these extremes.

The structural model can be expressed in matrix notation as

$$
\begin{bmatrix} 1 & \alpha_1 & \alpha_3 \\ \phi_1 & 1 & 0 \\ \phi_3 & 0 & 1 \end{bmatrix}
\begin{bmatrix} p_t \\ f_{1t} \\ f_{3t} \end{bmatrix}
=
\begin{bmatrix} -(\alpha_0 + \alpha_1 + \alpha_3) & \alpha_1 & \alpha_3 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}
\begin{bmatrix} p_l \\ f_{1l} \\ f_{3l} \end{bmatrix}
+
$$

$$
\begin{bmatrix} \alpha_1 & \alpha_3 & \alpha_0 & -\gamma(\alpha_0 + \alpha_1 + \alpha_3) & \theta & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\phi_1 & 0 & \gamma\phi_1 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\phi_3 & \gamma\phi_3 \end{bmatrix}
\begin{bmatrix} d[(T_1 - t)d\, r_{1t} - r_{1t}\, dt] \\ d[(T_3 - t)d\, r_{3t} - r_{3t}\, dt] \\ d[d\, r_{0t} - r_{0t}\, dt] \\ d^2 t \\ dQ_t \\ (T_1 - t)d\, r_{1t} - r_{1t}\, dt \\ (T_3 - t)d\, r_{3t} - r_{3t}\, dt \\ dt \end{bmatrix}
+
\begin{bmatrix} -\alpha_0 (p^*_t - p^*_l) \\ (1 + \phi_1) f^*_{1t} \\ (1 + \phi_3) f^*_{3t} \end{bmatrix} \tag{12a}
$$

and the reduced-form model can be represented with

$$\begin{bmatrix} p_t \\ f_{1t} \\ f_{3t} \end{bmatrix} = \left(\frac{1}{1-\phi_1\alpha_1-\phi_3\alpha_3}\right)\left\{\begin{bmatrix} -(\alpha_1+\alpha_3+\alpha_0) & \alpha_1 & \alpha_3 \\ \phi_1(\alpha_1+\alpha_3+\alpha_0) & -\phi_1\alpha_1 & -\phi_1\alpha_3 \\ \phi_3(\alpha_1+\alpha_3+\alpha_0) & -\phi_3\alpha_1 & -\phi_3\alpha_3 \end{bmatrix}\begin{bmatrix} p_l \\ f_{1l} \\ f_{3l} \end{bmatrix} + \text{A dx}\right.$$

$$\left.+\begin{bmatrix} -\alpha_0 & -\alpha_1(1+\phi_1) & -\alpha_3(1+\phi_3) \\ \alpha_0\phi_1 & (1-\phi_3\alpha_3)(1+\phi_1) & \alpha_3\phi_1(1+\phi_3) \\ \alpha_0\phi_3 & \alpha_1\phi_3(1+\phi_1) & (1-\alpha_1\phi_1)(1+\phi_3) \end{bmatrix}\begin{bmatrix} (p_t^*-p_l^*) \\ f_{1t}^* \\ f_{3t}^* \end{bmatrix}\right\} \tag{12b}$$

where A is the matrix of reduced form coefficients on the exogenous variables and dx represents changes in these exogenous variables.

According to Hieronymus's definition of high quality speculation, the "markets should react quickly, adjust to the appropriate level and stabilize until the next unforseeable random event occurs." The unforseeable random events enter the model through the change in the logarithmic price expectations (p^*_t, f^*_{1t}, f^*_{3t}). The quick reaction, adjustment to the appropriate level and stabilization requires that the change in expectations must be fully incorporated in the present period and the previous period's reactions must not create further adjustments. Thus, Hieronymus's definition of high quality speculation high-quality speculation is equivalent to short-run integration between the cash and futures markets (Ravallion, Dahlgran and Blank).

The quality of speculation can be demonstrated with the reduced form model. The reduced form indicates that conditions for high quality speculation are met if $\alpha_0 = -1$ while $\alpha_1 = \alpha_2 = \phi_1 = \phi_3 = 0$. However, the discussion of (11b) indicated that $\phi_1 = \phi_3 = 0$ means futures prices reflect only futures-market speculators' price expectations. Alternatively, if $\phi_1 = \phi_3 = -1$, the pricing behavior of the system is also perfect as changes in expectations are instantly and completely reflected by the system.

While the pricing behavior of these two cases is identical, they differ according to whose expectations are reflected by the system. When $\alpha_1 = \alpha_2 = \phi_1 = \phi_3 = 0$, the spot market reflects unhedged-inventory holders' expectations while the futures markets reflect futures-market speculators' expectations. But if $\alpha_1 = \alpha_2 = 0$ and $\phi_1 = \phi_3 = -1$, all three markets reflect only unhedged-inventory holders' expectations. Recognition that unhedged-inventory holders are simply spot-market speculators makes the qualitative distinction between the two cases straightforward. If the two sets of expectations are formed by processing common information in identical fashions then the two cases are logically inseparable and in both cases the markets fully and immediately reflect common expectations about a set of prices at future times. Paradoxically, the quality of speculation does not seem to depend on speculators' responses ($\phi_1 = \phi_3 = 0$ versus $\phi_1 = \phi_3 = -1$) but instead depends on hedgers' responses (i.e. $\alpha_1 = \alpha_2 = 0$). If hedgers' responses are not price inelastic, then the path to equilibrium will depend on speculators' reactions to new price information. Econometric estimation will help determine hedges' and speculators' responsiveness.

Data

Equations (11a) and (11b) will be estimated for soybean, soyoil and soymeal cash and futures markets using price data covering the period from the end of August through the first full week of December for 1992, 1993 and 1994 (table 1). The choice of the data used is influenced by several considerations. First, daily data for several futures contracts have already been collected and used in a futures markets course that was taught in the fall semesters of these years. The January and March soybean, soyoil and soymeal contracts were included in this data set so the model can be estimated easily for these commodities. Second, these data surround the soybean harvest. New supplies were hypothesized to play a role in spot price determination and the time span selected covers the North American harvest period when new supplies become available. Finally, data for all three commodities are used because speculative spread-trading is one form of intermarket arbitrage which tightly links the markets for the three commodities.

Cash market prices for the three commodities comes from the Chicago cash market which trades adjacent to the futures markets. These price were obtained from CompuServe Information Services. Interest rates for the term to contract maturity were computed by interpolating as necessary federal funds yields, and spot US treasury bill yields for 91 days, 182 days and one year. The interpolation consisted of 1) determine which two terms to maturity of the four possible securities bracket the term to maturity of the futures contract and 2) construct a linear combination of the two yields surrounding the futures contract's term to maturity so that the linear combination corresponds future contract's term to maturity.

Data for new supplies of soybeans were obtained from the Weekly Weather and Crop Bulletin published by the USDA. This publication contains the Crop Condition Reports and Crop Harvest Reports that are announced at 1:00 p.m. EST on Tuesdays throughout the fall season. Daily estimates of new supplies were obtained by fitting a quadratic logistical function to the weekly data and using the resulting parameter estimates to generate daily data. The quadratic logistical function estimated was

$$\log [s_t/(1- s_t)] = \beta_0 + \beta_1 t + \beta_2 t^2 + \varepsilon_t$$

Table 1. Data used in model estimation.

	1992	1993	1994
First observation	8/31 (Mon)	8/30 (Mon)	8/29 (Mon)
Last observation	12/9 (Wed)	12/10 (Fri)	12/9 (Fri)
Number of observations	71	73	73
Holidays:	Labor day and Thanksgiving day.		

where s_t represents the proportion of harvest completed. The estimation results are shown in table 2. As can be seen, the model fit the data well. However, the quadratic characteristic of the model predicted that harvest completion would decline ($ds_t < 0$) toward the end of the harvest season. When this occurred, it was assumed that harvest was complete and dQ_t was set to zero. Otherwise, $dQ_t = ds_t$.

Table 2. Parameter estimates used to estimate daily new supplies from weekly data.

Year	Estimated model				R^2
1992	$\log [s_t/(1-s_t)] =$	-139.270	+ 0.8472 t	- 0.0012643 t^2	0.9964
		(12.569)	(0.08401)	(0.0001400)	
1993	$\log [s_t/(1-s_t)] =$	-225.687	+ 1.4103 t	- 0.0021809 t^2	0.9907
		(34.717)	(0.2363)	(0.0004010)	
1994	$\log [s_t/(1-s_t)] =$	-72.845	+ 0.4148 t	- 0.0005587 t^2	0.9988
		(6.5470)	(0.04420)	(0.00007439)	

Empirical Results

The matrix representation of the simultaneous system of equations in (12a) reveals that, as a theoretical matter, identification of the system is not a problem because each equation has excluded from it a unique set of variables. As a practical matter, however, estimation as a simultaneous system is difficult because the available data are not suitable for generating a set of instrumentals that correlate highly with the endogenous variables (i.e. lagged logarithmic price changes do not accurately predict the current logarithmic price changes). Setting aside this difficulty but acknowledging the potential for biased parameter estimates, the system was estimated with nonlinear seemingly-unrelated regressions so that the model's implications can be tentatively examined. Tables 3 and 4 show the estimation results.

Table 3 summarizes the SUR residuals for the nine equations (spot, Jan futures, and Mar futures for soybeans, soymeal and soyoil). The R-squares for the nine equations range from 0.47 to 0.86 and are mainly due to the high degree of correlation between price changes across the spot and futures markets. Table 3 also shows that correlations between residuals are higher within a spot-futures market complex for a commodity (for example within the spot, January futures, March futures markets) than across markets for different commodities (for example among the January futures contracts for soybeans, meal and soyoil).

Table 4 shows the parameter estimates for the model. Generally, 1) the parameters corresponding to unhedged stock-holding (α_0) are statistically significant but disagree with *a prori* expectations about signs, 2) the parameters corresponding to January hedging are mostly significant,

Table 3. Nonlinear SUR Summary of Residual Errors.

Commodity Market	DF Model	DFE	SSE	MSE	RMSE	R-Square	Durbin Watson
Soybeans							
Spot	5	206	0.0117	0.0000568	0.007533	0.4719	2.560
Jan futures	2	209	0.005215	0.0000250	0.004995	0.6980	2.687
Mar futures	2	209	0.005134	0.0000246	0.004956	0.6930	2.584
Soymeal							
Spot	5	206	0.009551	0.0000464	0.006809	0.5534	2.508
Jan futures	2	209	0.003364	0.0000161	0.004012	0.7670	2.565
Mar future	2	209	0.003696	0.0000177	0.004205	0.7133	2.558
Soyoil							
Spot	5	206	0.0109	0.0000530	0.007279	0.7048	2.706
Jan futures	2	209	0.004731	0.0000226	0.004758	0.8601	2.258
Mar futures	2	209	0.005605	0.0000268	0.005179	0.8136	2.170

Correlation of Residuals

	Soybeans			Soymeal			Soyoil		
	Spot	Jan futures	Mar futures	Spot	Jan futures	Mar futures	Spot	Jan futures	Mar futures
Soybeans									
Spot	1.0000	-0.6624	-0.6354	0.1871	0.0676	0.0662	0.1438	0.0869	0.1122
Jan futures		1.0000	0.9845	0.0881	0.1148	0.1493	0.1180	0.0214	0.0676
Mar futures			1.0000	0.1066	0.1144	0.1564	0.1206	0.0449	0.1001
Soymeal									
Spot				1.0000	-0.6741	-0.5622	0.1196	-0.0121	0.0297
Jan futures					1.0000	0.9218	0.0344	0.0819	0.1175
Mar futures						1.0000	0.0628	0.0649	0.1020
Soyoil									
Spot							1.0000	-0.6903	-0.5642
Jan futures								1.0000	0.9336
Mar futures									1.0000

Table 4. Nonlinear SUR Parameter Estimates.

Commodity	Parameter[a]	Estimate	Approx. Std Err	'T' Ratio	Approx. Prob>|T|
Soybeans	α_0	0.302511	0.03682	8.22	0.0001
	α_1	-0.282436	0.20304	-1.39	0.1657
	α_3	-0.431638	0.20788	-2.08	0.0391
	ϕ_1	-0.799989	0.02371	-33.73	0.0001
	ϕ_3	-0.776670	0.02340	-33.20	0.0001
	θ	0.043617	0.02981	1.46	0.1449
	γ_{92}	-0.00022266	0.0003504	-0.64	0.5259
	γ_{93}	0.00056779	0.0003484	1.63	0.1047
	γ_{94}	-0.00009509	0.0003494	-0.27	0.7858
Soymeal	α_0	0.307134	0.03533	8.69	0.0001
	α_1	-1.110170	0.11272	-9.85	0.0001
	α_3	0.311081	0.11359	2.74	0.0067
	ϕ_1	-0.782078	0.02114	-37.00	0.0001
	ϕ_3	-0.698281	0.02369	-29.48	0.0001
	θ	-0.014450	0.02663	-0.54	0.5880
	γ_{92}	-0.00008836	0.0002825	-0.31	0.7548
	γ_{93}	0.00019892	0.0002821	0.71	0.4816
	γ_{94}	-0.00056788	0.0002820	-2.01	0.0453
Soyoil	α_0	0.119392	0.02752	4.34	0.0001
	α_1	-1.282033	0.11609	-11.04	0.0001
	α_3	0.443227	0.11694	3.79	0.0002
	ϕ_1	-0.936685	0.02055	-45.57	0.0001
	ϕ_3	-0.844568	0.02286	-36.95	0.0001
	θ	0.00061646	0.02822	0.02	0.9826
	γ_{92}	0.00028197	0.0002686	1.05	0.2950
	γ_{93}	0.000077742	0.0002665	0.29	0.7708
	γ_{94}	0.000032841	0.0002687	0.12	0.9028

a/ $\alpha_0 \equiv U' / (D' - U' - \Sigma_{T \in M} H'_T)$, $\alpha_T \equiv H'_T / (D' - U' - \Sigma_{T \in M} H'_T)$, $\theta \equiv 1 / (D' - U' - \Sigma_{T \in M} H'_T)$ $\phi_T \equiv \rho_T H'_T / (S'_T - \rho_T H'_T)$, γ_{yy} $\equiv$ daily deterioration and insurance cost per \$ of commodity value in year yy.

have correct signs but are below their theoretical lower bound of -1, and 3) the coefficients corresponding to March hedging are mixed with respect to signs and significance.

The parameters for the impact of harvest on the spot market prices bear the incorrect sign but the effect is not statistically significant. This could be due to the fact that the prices are Chicago prices and harvest, as it proceeds, first affects country prices with latter diffusion as supplies become available in Chicago. Also, it is possible that harvest is widely anticipated and independently monitored so that harvest progress reports from independent sources have already been absorbed into the markets by the time USDA reports are released.

The parameters reflecting speculative activity in the futures markets are uniformly of the expected negative sign and are uniformly statistically significant. These parameters also display a pattern whereby the parameter for the January contracts is larger in absolute value than the parameter for the March contract. According to the discussion of (11b), this indicates that cost of storage is more important and speculators' expectations are less important the closer the contract is to maturity. More generally, this result would indicate that nearby maturity contracts are more strongly influenced by arbitrage and more distant maturity contracts are less strongly influenced by arbitrage and more strongly influenced by speculators' expectations.

The final set of parameters in table 4 reflect the nonfinancial carrying costs (deterioration and insurance). Nine of these parameters were estimated to obtain unique values for each year for each commodity. Five of the nine estimates are positive and four are negative with none of the estimated parameters achieving a notable level of statistical significance. This might indicate that the convenience yields of holding these stocks are roughly equal to the costs associated with the stockholding.

Figure 1 simulates the price dynamics implied by the estimates. This figure contains three panels, one each for soybeans, soymeal and soyoil and traces the dynamic impact of a one percent increase in all expected prices. It reveals that the general impact of an increase in all expected prices is consistent across all the markets. The figure shows damped oscillatory price adjustments with the immediate impact being negative, with the secondary impact being larger and positive, and subsequent impacts alternating between positive and negative but becoming successively smaller. Figure 1 also shows that a one percent increase in all price expectations affects the spot market slightly more than the nearby futures market and the nearby futures market is affected slightly more than the more distant futures market. Cross-commodity comparisons indicate the largest relative impacts occur in the soyoil market with soymeal affected to a smaller degree and soybeans affected the smallest degree.

One unintuitive feature of figure 1 is that it shows the immediate impact of an increase in price expectations to be an initial decrease in all prices. This is caused by the positive estimates of α_0, which are contrary to *a priori* expectations. This condition is not likely independent of the larger than expected (in absolute value) coefficients on the nearby (January) futures contract and incorrectly signed coefficients on the next most distant (March) contract. These results might be due to the multicollinearity that exists between the three set of prices. Alternatively, these estimates might be displaying simultaneous equations bias although the pattern seems to persist under

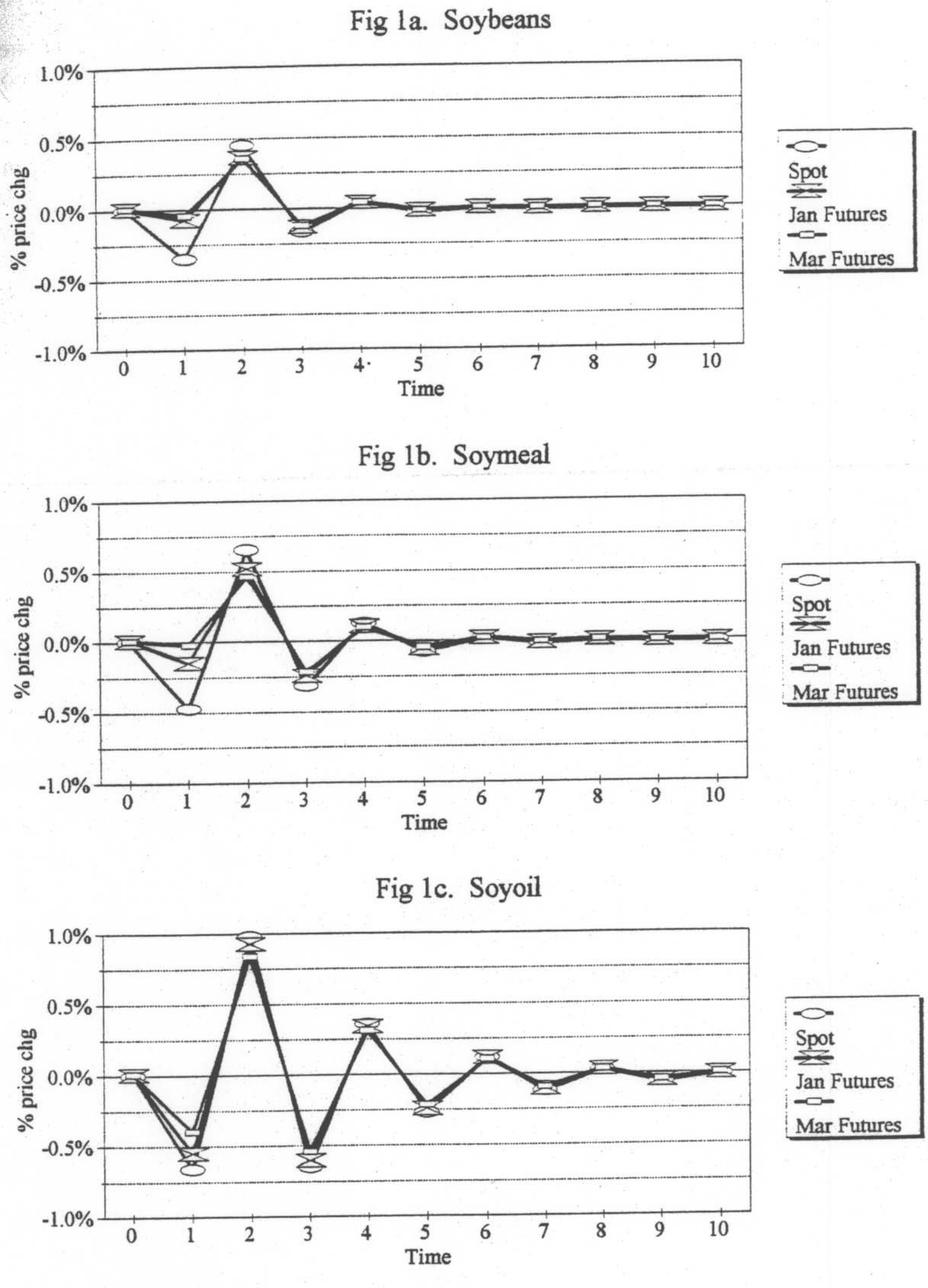

Figure 1. Simulated 1% change in price expectations using parameter estimates.

alternative estimation techniques. Yet another possibility is that the theoretical model overlooks market behaviors such as the tradeoffs between hedged and unhedged stocks or the flight of positions from the maturing nearby futures contract.

Figure 2 assumes that multicollinearity causes difficulties in estimating the αs. Each of the three αs is replaced with the average of the three αs. The oscillatory nature of equilibrium attainment is eliminated, and the initial impact of an increase in price expectations is positive. The relative volatility of the three prices within commodities is reversed from what is seen in figure 1 in that the spot price becomes slightly less volatile than futures prices. The cross-commodity comparison remains valid in that soyoil is still the most volatile of the three, soybeans the least volatile and soymeal is intermediate. The volatility of soymeal and soyoil prices relative to soybeans seems consistent so that in further comparisons the behavior of soymeal and soyoil is left to be inferred from the price behavior of soybeans.

Figure 3 addresses the quality of speculation. This figure graphs the simulated impact of a one percent increase in all soybean price expectations assuming either a) hedgers do not use futures prices to signal whether to hedge inventory holdings (i.e. $\alpha_1 = \alpha_2 = 0$, shown in figure 3a), or b) that that futures market speculators do nothing more than speculate on their price expectations (i.e. $\phi_1 = \phi_2 = 0$, shown in figure 3b), or c) that futures market speculators do nothing more than arbitrage the spot and futures markets (i.e. $\phi_1 = \phi_2 = -1$, shown in figure 3c). The explosive price cycles in figure 3c demonstrate rather dramatically that the worst possible outcome occurs when speculators do nothing more than arbitrage the futures against the spot markets. On the other hand, if speculators react only to expectations about future futures contract prices, the initial price impact of a change in those expectations is fully reflected in the futures markets and also influences the spot market but the change in expectations is permanent and the markets rapidly converge to a new equilibrium. The spot price volatility in this case (figure 3b) is roughly the same as when hedgers ignore futures prices when making inventory-hedge decisions (figure 3a).

Implications and Conclusions

An empirical model was developed and estimated and the resulting estimates were used to examine the issue of the quality of speculation in the soybean futures complex. According to the resulting estimates, speculation is currently of high quality in that spot market is quickly guided to equilibrium whenever events alter current expectations. Variations in the parameters revealed that price-responsive hedging activity adds little to market stability implying that the market would still function well if "selective" hedging is eliminated. On the speculative side, we found that "true" futures-market speculators who take positions based solely on their expectations of future futures contract prices create volatility in the futures markets because the futures markets will totally reflect these expectations. However, these true speculators do not seem to wreck much havoc on the spot market as the spot market volatility is not increased much by their activity. If however futures market speculators behave as spot-futures arbitrageurs, the markets become less stable. This condition results because inventory-holders are sensitive to futures prices and are constantly adjusting short-run inventories in response to speculators' long-run price forecasts which are

Fig 2a. Soybeans

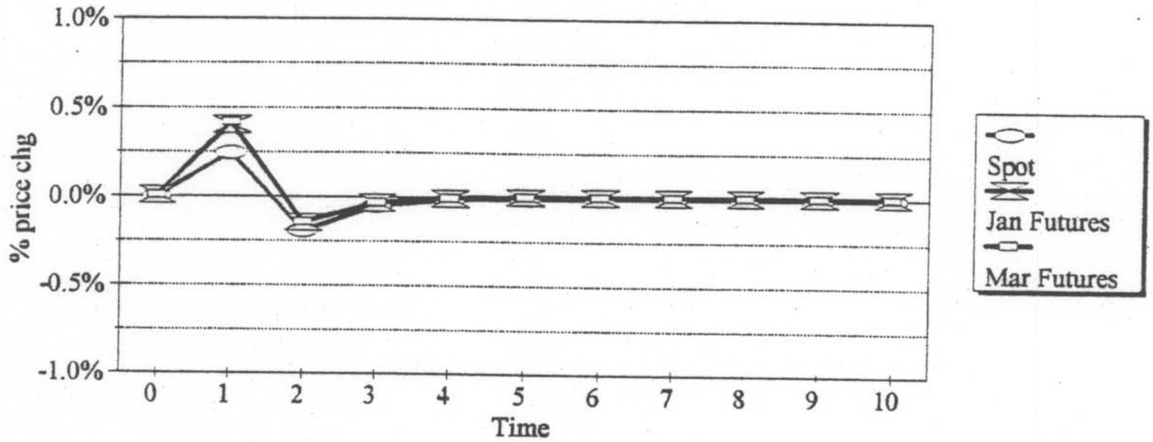

Fig 2b. Soymeal

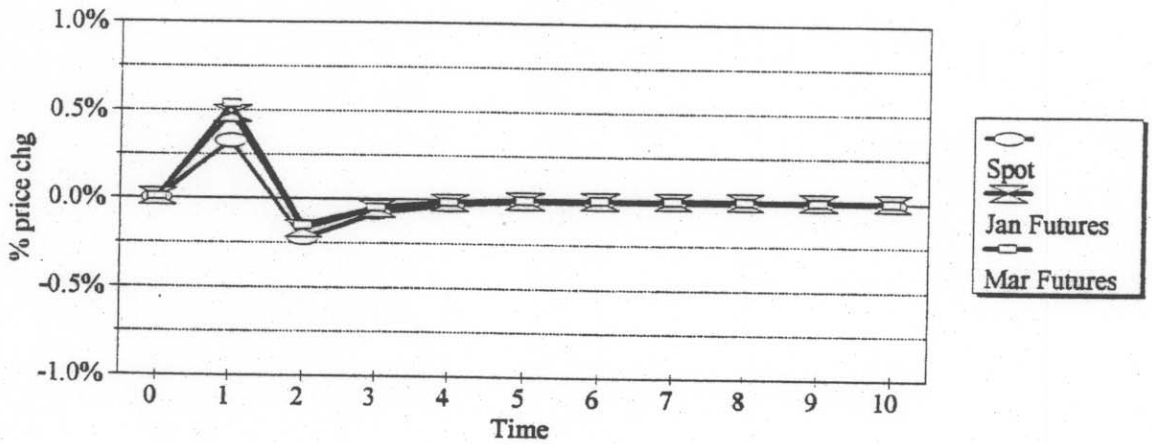

Fig 2c. Soyoil

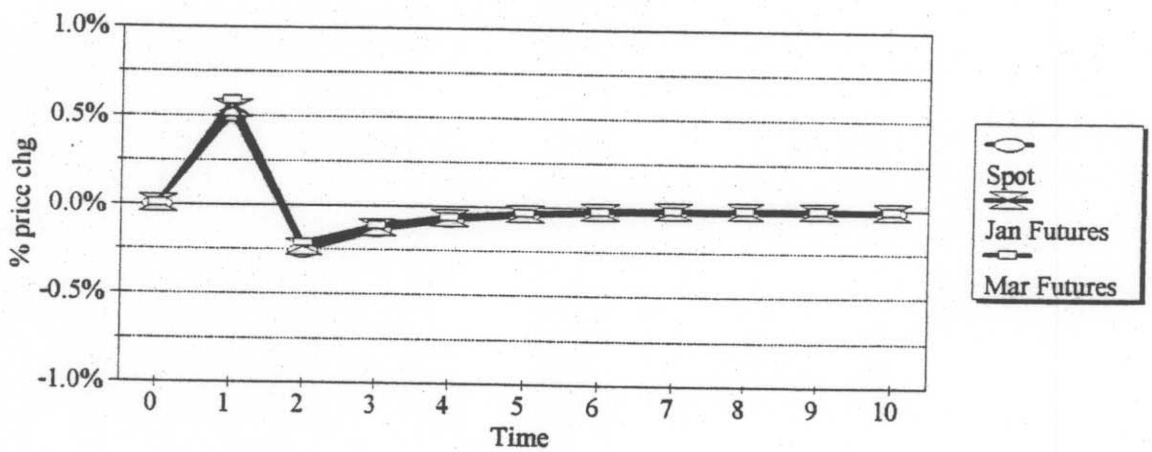

Figure 2. Simulated 1% change in price expectations using average hedging parameter estimates.

Fig 3a. Soybeans without hedging

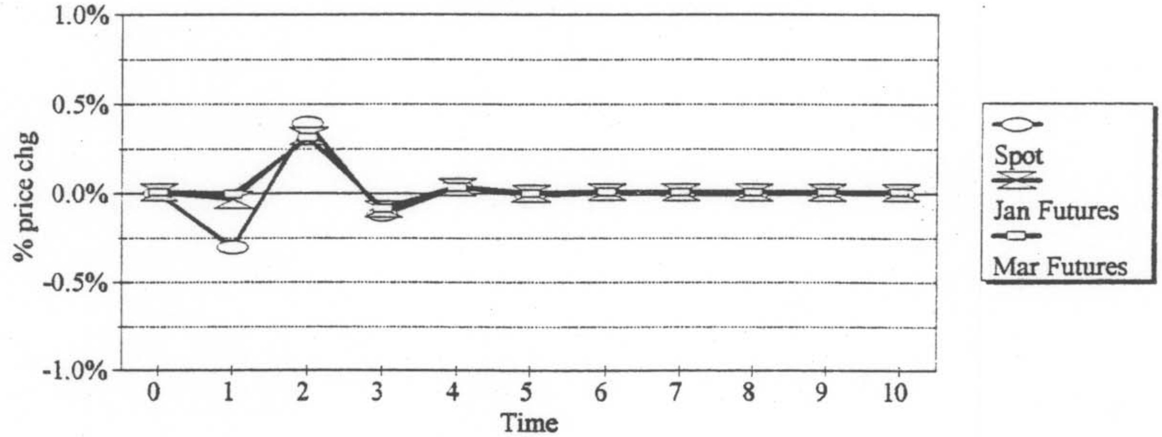

Fig 3b. Soybeans - pure speculation

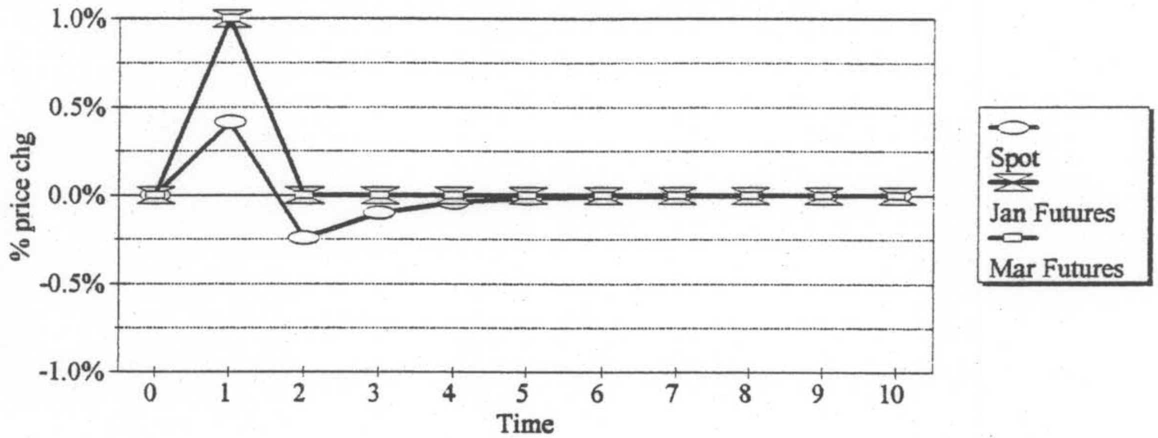

Fig 3c. Soybeans without speculation

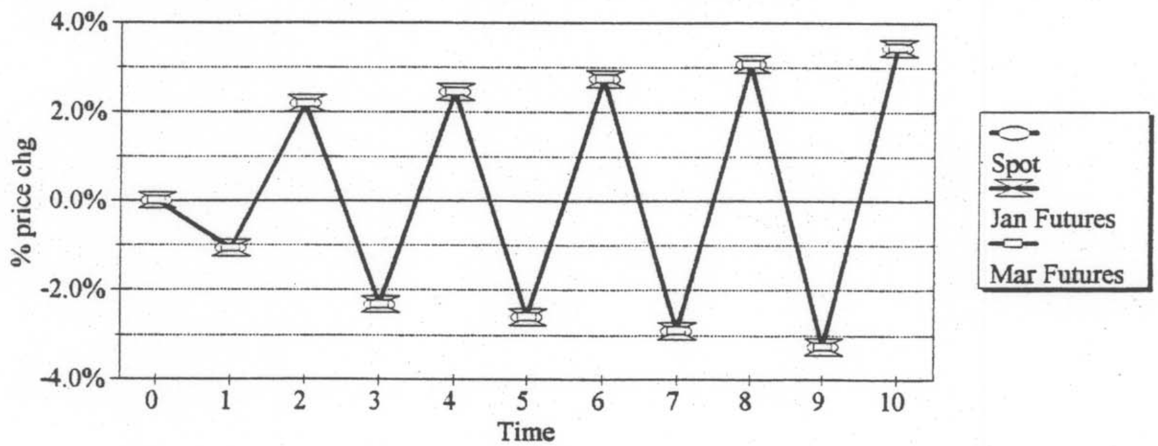

Figure 3. Simulated 1% change in price expectations under different hedging/speculation assumptions.

based on current spot prices plus storage costs. Clearly, "true" speculators can contribute additional information that will help bring the market to equilibrium.

Another quality of speculation issue apparent from the model developed in this paper is that market adjustments must be driven by somebody's expectations of future prices. This somebody must be either unhedged-inventory-holders or futures-market speculators. One might be tempted to couch the notion of quality of speculation in terms of quality of expectations so that the focus becomes, "Who has the better expectations, spot market speculators or futures market speculators?" Such questions as whose opinion is better is best avoided with a pragmatic response that there is no reason for these opinions to diverge and both should and can help guide the spot market to equilibrium.

Finally, this paper leaves several alternative model specifications to be unexplored. Foremost is estimation to account for the possible bias in the parameter estimates resulting from sidestepping the simultaneity of the system of equations. Perhaps one principal component from the soybean, soyoil and soymeal prices could be used to construct appropriate instruments. Additional methods to account for the impact of supply changes on the spot market need to be investigated. Additional contracts might be included to support detection of the tendency for speculators to de-emphasize arbitrage with more distant contracts. If such a tendency is empirically valid, then time varying parameters can also be incorporated because the arbitrage function becomes stronger as contract maturity draws near. Lastly, a more complete structure of expectational change might be incorporated to account for greater uncertainty about expected price changes for more distant maturity futures contracts than for nearby futures contracts.

References

Dahlgran, R.A. and S.C. Blank. "Evaluating the Integration of Contiguous Discontinuous Markets." *American Journal of Agricultural Economics*, 74(1992):369-79.

Garbade, K.D. and W.L. Silber. "Price Movements and Price Discovery in Futures and Cash Markets." *Review of Economics and Statistics*, 65(1983):289-97.

Hieronymus, T.A. "The Role of Futures Markets and Opportunities for OFOR." in *Research Frontiers in Futures and Options: An Exchange of Ideas*. Office of Futures and Options Research, University of Illinois, Urbana, 1993.

Khoury, N.T. and P. Yourougou. "The Informational Content of the Basis: Evidence from Canadian Barley, Oats and Canola Futures Markets." *Journal of Futures Markets*, 11(No. 1, 1989):69-80.

Oellermann, C.M., B.W. Brorsen and P.L. Farris. "Price Discovery for Feeder Cattle." *Journal of Futures Markets*, 9(No. 2, 1989):113-121.

Ravallion, M. "Testing Market Integration." *American Journal of Agricultural Economics*, 68(1986):102-9.

Schroeder, T.C. and B.K. Goodwin. "Price Discovery and Cointegration for Live Hogs." *Journal of Futures Markets*, 9(No. 2, 1989):113-121.

Witherspoon, J.T. "How Price Discovery by Futures Impact the Cash Market." *Journal of Futures Markets*, 13(1993):469-96.